EVALUATION OF TELEDERMATOLOGY IN THE VETERANS HEALTH ADMINISTRATION

by

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ABSTRACT

Telehealth technologies are being employed to increase access, quality of care, and cost containment. However, there are no widely accepted measures of telehealth performance and little information about long-term changes in access. The Veterans Health Administration (VHA) is advantageous for telehealth research because of the widespread implementation, organic development of multiple distinctively structured programs, and national electronic medical records. Using teledermatology, one of the earliest and most widely adopted uses, a set of recommended performance metrics are established and a select few are evaluated across the different programs.

Store and forward (SF) teledermatology, taking a picture and sending it to a dermatologist for asynchronous evaluation, is the prominent method of care. In SF programs there is variation in the level of follow-up care available locally. Some locations have "surrogate dermatology providers" that are trained to do basic treatments and procedures.

Based on four site visits and twenty-five interviews with stakeholders, recommendations for performance measurements were created. VHA is already in the process of executing three of the measures nationally: image quality, time to consult response, and patient satisfaction. Additionally, VHA has the data available to measure time to treatment, post-teledermatology utilization of care, travel distance, and wait-times. Finally, VHA should improve data to create future metrics regarding: cost, particularly payment for outside dermatologists; provider satisfaction; and quality of care through chart review or adverse event reporting.

Using administrative databases, the metrics for which data were available were retrospectively evaluated. At a national level for 2013, entry into the care process through teledermatology is associated with faster time to treatment than entry from an in-person referral for both melanoma (teledermatology median: 62 days; in-person consult median: 70 days; p=0.002) and non-melanoma skin cancer (teledermatology median: 79 days; in-person consult median: 88 days; p<0.001). There was little consistency in the post-teledermatology care utilized across programs. Testing three programs with different resources used for local follow-up care, travel distance saved over 2013 was calculated.

The program with surrogate dermatology providers had the most travel saved per patient. Implementation of teledermatology had no statistically significant impact on in-person wait times for dermatology clinics.

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Disclaimer

The views expressed in this manuscript do not necessarily represent the views of the Department of Veterans Affairs or the United States Government.

Approvals

Human subject work for this thesis project was reviewed and approved by the Boston VA's Institutional Review Board (study #2712) and MIT's Committee On the Use of Human as Experimental Subjects (protocol # 1301005471).

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1 Introduction

1.1 Research Questions

This thesis focused on understanding and measuring the success of teledermatology in the Veterans Health Administration (VHA). The first aims of this research were to use qualitative techniques to understand the current state of the national teledermatology system and determine appropriate metrics for the teledermatology. Based on the information from the first aims, an analysis plan was created for a selection of the identified metrics using VHA's electronic medical records. Figure 1-1 is a diagram of the research design.

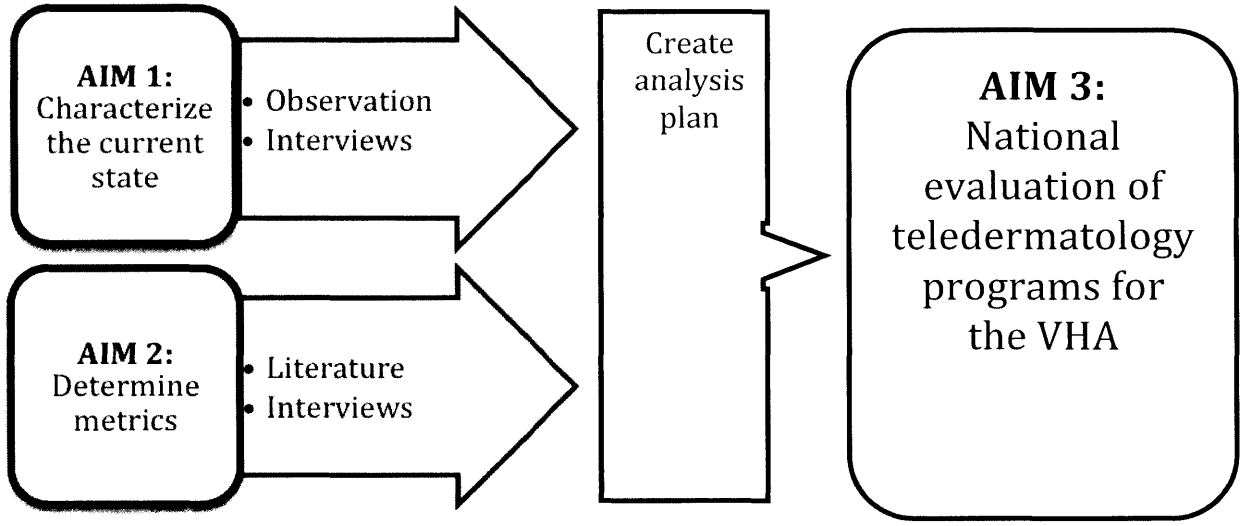


Figure 1-1. Diagram of research aims

The specific research aims addressed were:

Aim 1. Characterize the utilization of teledermatology in VHA.

Teledermatology program site visits and interviews of key telehealth stakeholders were performed to understand the variations in teledermatology program operations, the skin

conditions treated using the new technology, and the stakeholders' views on the current state of the programs.

Aim 2. Establish appropriate metrics for telehealth performance analysis.

The selection of appropriate metrics is essential for improvement processes in healthcare. Qualitative analysis of telehealth literature, data gathered in Aim 1, interviews, and expert opinion guided selection of a holistic set of performance metrics.

Aim 3. Analyze telehealth performance using retrospective data.

The data from Aims 1 and 2 were used to create an evaluation plan of a few selected teledermatology metrics. The hypotheses these metrics tested are below:

- *Hypothesis 1: Teledermatology increases access to dermatology care for Veterans by decreasing time to treatment for skin cancer patients.* Using retrospective administrative data, the time from identification of a lesion by the referring physician to the time to treatment for melanoma and non-melanoma skin cancer patients were compared nationally and at a program level between teledermatology and in-person only care in VHA.
- *Hypothesis 2: Teledermatology increases access to dermatology care for Veterans by decreasing the need to see a dermatologist in-person for quality dermatology care and overall travel for dermatology care.* Using retrospective administrative data, the utilization of post-teledermatology care was characterized for each teledermatology program. Select programs underwent further analysis on the total travel distance patients need for dermatology care under the teledermatology program.
- *Hypothesis 3: Teledermatology increases access to dermatology care for Veterans by decreasing the wait time to see a dermatologist in-person, even for those not using teledermatology.* Using retrospective clinical data, the change in wait time for in-person appointments at dermatology clinics after the implementation of teledermatology was assessed.

1.2 The Promise of Telehealth

The term telehealth is used to describe any healthcare measurement, assessment, or treatment for a patient by a clinician separated geographically and/or temporally.[1,2] As early as 1925 people saw the benefits of technology for telehealth when Hugo Gernsback conjectured that in the future a doctor will be able to see a patient miles away through a view-screen and use a robot arm to touch and interact (Figure 1-2).[3] With improvements in technology, his visions have come to life with video-chat medical interactions[4] and surgical robots[5] available to patients today.

Figure 1-2. The predication of telemedicine in 1925[3]

Advocates of telehealth claim that it can decrease cost and increase quality of and access to care within the healthcare system. The current climate of increasing healthcare costs[6] and inequitable distribution of medical care[7–12] is creating more demand for telehealth technologies. However, the technologies have not been widely implemented because of a few different barriers: providers need to be licensed or credentialed in any state a patient is treated, the malpractice and legal liability of practicing telemedicine has been unclear, and reimbursement for telehealth consultations from insurance companies has been adopted slowly and only for interactions that mimic traditional service.

1.3 The Veterans Health Administration Background Information

The Veterans Health Administration (VHA) is one of the largest health care providing networks in the United States. With a medical care appropriation of more than $47 billion, VHA serves 8.3 million enrolled Veterans and employs more than 239,000 staff at over 1,400 sites, including 152 medical centers and 802 Community-Based Outpatient Clinics.[13] VHA is a capitated care organization with a budget set from Congress. The financial model is more comparable to national single-payer government healthcare organizations, Accountable Care Organizations, and integrated care delivery programs like Kaiser Permanente than the fee-for-service financial model dominant in the United States. Additionally, VHA medical care providers only need to be registered in one state and their licenses carry with them wherever they practice.

Believing that telehealth may increase the quality of care, satisfaction levels, access to care, and cost control, VHA's strategic goal is that 30% of all unique patients treated experience some aspect of virtual care, specifically 16% through telehealth, in fiscal year 2014. Currently, there are three modes of telehealth within VHA: Clinical Video Telehealth (CVT), Store and Forward (SF), and Home Telehealth.[14] Both Clinical Video Telehealth and Store and Forward are used in the VHA teledermatology program. Clinical Video Telehealth is a synchronous videoconferencing appointment between a patient and clinician.[14] Store and Forward is an asynchronous analysis of a patient's clinical information (e.g. image, data, sound) by a specialist.[14] For almost all Clinical Video Telehealth and Store and Forward Telehealth services, patients must be at VHA site of care.

VHA is divided by region into 21 semi-autonomous geographical networks. The autonomy is cited as the reason for recent improvements in healthcare services[15–17] and has enabled the creation and growth of independent, varied telehealth programs throughout the nation which are supported nationally by the Office of Telehealth Services. All hospitals within the VHA system use the same medical record system. VHA's electronic medical record system (EMR),[18] widespread telehealth use,[19] and regional variation in telehealth usage combine to offer resources for telehealth theory development and comparative analysis.

1.3.1 Teledermatology at the Veterans Health Administration

In 2012, VHA treated over 820,000 patients in the dermatology departments across the country. Within dermatology, both Clinical Video Telehealth (~2,000 patients) and Store and Forward (~18,000 patients) are used. The use of Store and Forward teledermatology is still growing within VHA, as seen in Figure 1-3.

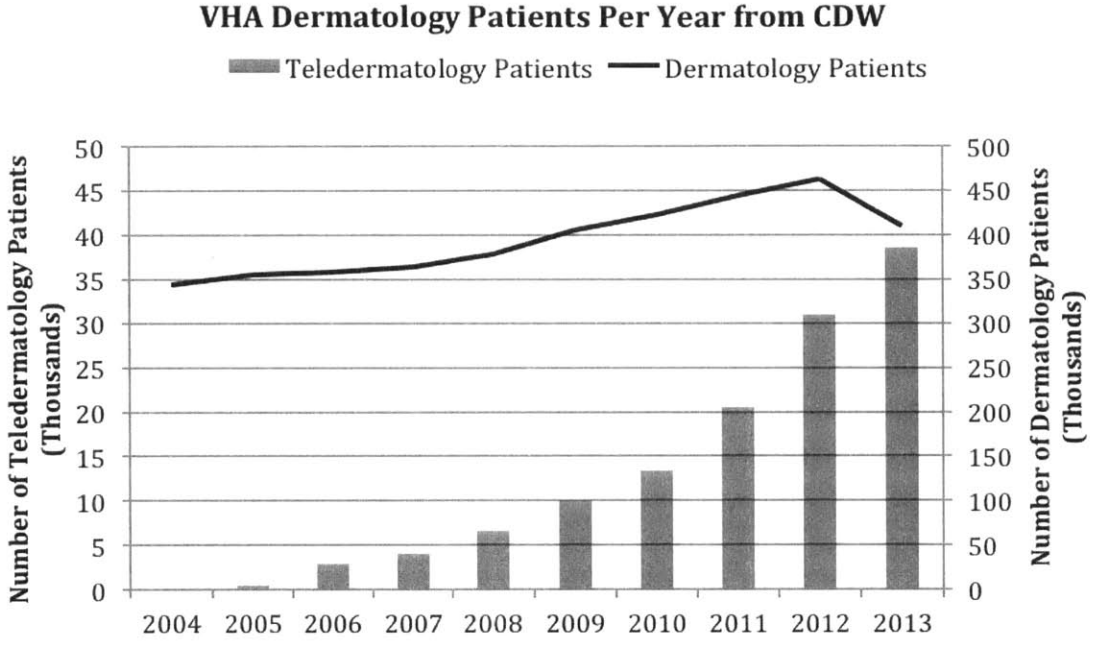


Figure 1-3. Size of dermatology and teledermatology within VHA 2004-Mid 2013

In 2011, the Office of Telehealth Services, a national office responsible for providing guidance, training programs, and policy for telehealth, released an operations manual for Store and Forward teledermatology.[20] This training manual describes care processes for four different models of teledermatology care delivery (Table 1-1). In all four programs the first step of the care process is that the patient and primary care provider (PCP) identify a skin concern that needs to be seen by a dermatologist. The four programs differ in who takes the picture of the skin image and who offers follow-up care to the patient. A surrogate provider is a non-dermatologist who is trained in basic dermatology treatments and procedures.

Table 1-1. Four models of teledermatology care from the VHA operations manual[20]

Model Name	Image sent to dermatologist by:	Image responded to by:	Follow up care given to patient by:
Model A: Surrogate Care	Surrogate Provider	Teledermatologist	Surrogate Provider Dermatologist
Model B: Direct Consult	Imager	Teledermatologist	PCP Surrogate Provider Dermatologist
Model C: Triage	Imager	Teledermatologist	PCP Dermatologist
Model D: Follow-up	Imager	Teledermatologist	Dermatologist

Each teledermatology program within VHA is set up as an agreement between participating PCP clinics and the dermatology department who serves them. In general, teledermatology programs are "hub and spoke" operations where the teledermatology program serves the Community Based Outpatient Clinics whose patients are treated at the dermatology programs' medical center. The teledermatology service treats the same patients that would feed into the dermatology department's in-person services. The exception to this structure in the operations manual is Model A: Surrogate Care because the surrogate care provider may be serving the same role as a dermatologist at a medical center. In this case a dermatologist from another VHA medical center analyzes the teledermatology images. The dermatology service may or may not be the primary source of in-person care.

1.3.2 Classification of VHA teledermatology programs

The specific teledermatology programs within VHA were identified using internal reporting tools. This thesis focuses primarily on the 19 programs started before 2012 to allow for full implementation of the programs before analysis. The programs were given labels A-S instead of the location name to protect the identity of staff within the programs. All programs started before 2012 were classified by the number of patients seen in fiscal year 2012 and the rural nature of those patients' addresses (Table 1-2). Further details about the classification can be seen in Appendix A.

Table 1-2. Number of VHA Store and Forward teledermatology programs by category

	Urban	Rural	Mixed	TOTAL
Small	1	2	1	**4**
Medium	1	4	3	**8**
Large	2	5	0	**7**
TOTAL	**4**	**11**	**4**	**19**

1.4 Thesis Structure

This thesis begins with a summary of literature to date about healthcare metrics, telehealth metrics, and teledermatology measurement (Chapter 2). Within the teledermatology segment, there is a structured review and analysis of teledermatology metrics currently in the literature.

Chapter 3 covers the qualitative work focused on the current state of the teledermatology system (Aim 1) and the metrics to evaluate teledermatology (Aim 2). The conclusion of Chapter 3 contains recommendations for a holistic set of performance metrics for VHA teledermatology programs.

A few of these metrics were chosen for further investigation and form Chapters 4-6. Chapter 4 compares the time to treatment for melanoma and non-melanoma skin cancer patients for teledermatology and traditional in-person consult patients. Chapter 5 characterizes the post-teledermatology care that patients receive in the 19 different programs and goes into greater detail about the travel distance for dermatology care in 3 of the programs. Chapter 6 evaluates the influence of teledermatology implementation on wait times for in-person dermatology care.

The results of the qualitative experiences in the VHA teledermatology system and the quantitative results from the metrics evaluated are synthesized in Chapter 7. This conclusion section contains recommendations for VHA on metrics, discussion of the generalizability of the work of the thesis, and thoughts on the components of successful teledermatology programs.

2 Literature Review

2.1 Introduction

This chapter focuses on the current literature available relevant to this thesis. There is an overview of healthcare performance metrics and telehealth evaluation studies. Next, there is a detailed analysis of the metrics in the teledermatology literature and how they fit into the identified evaluation categories. The chapter will conclude with a synthesis of the literature and the gaps this thesis will address.

2.2 Healthcare performance metrics

An Institute of Medicine (IOM) report identified not just a gap, but a "chasm" between the potential value the national healthcare system can deliver and the benefits it currently delivers. The report identified six core goals of care that together will help "foster innovation and improve the delivery of care." These goals, seen in Figure 2-1, are the ability to deliver care in a safe, effective, patient-centered, timely, efficient, and equitable manner.[21]

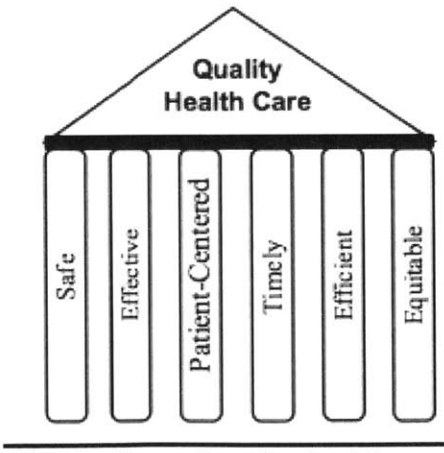


Figure 2-1. Institute of Medicine (IOM) pillars of quality health care from *Crossing the Quality Chasm*[21]

From these categories, the Institute of Healthcare Improvement (IHI) developed a "balanced set of system-level measures, to supply health care leaders and other

stakeholders with data that enables them to evaluate their health systems' overall performance on core dimensions of quality and value, and that also serves as inputs into strategic quality improvement planning."[22] The purpose of the project was to create a small set of measures to reflect the system performance organized around IOM's six quality dimensions (Figure 2-2). This thesis will take a similar approach in defining a small set of metrics to evaluate the performance of a teledermatology system.

Whole System Measure	IOM Dimension of Quality
1. Rate of Adverse Events	Safe
2. Incidence of Nonfatal Occupational Injuries and Illnesses	Safe
3. Hospital Standardized Mortality Ratio (HSMR)	Effective
4. Unadjusted Raw Mortality Percentage	Effective
5. Functional Health Outcomes Score	Effective
6. Hospital Readmission Percentage	Effective
7. Reliability of Core Measures	Effective
8. Patient Satisfaction with Care Score	Patient-Centered
9. Patient Experience Score	Patient-Centered
10. Days to Third Next Available Appointment	Timely
11. Hospital Days per Decedent During the Last Six Months of Life	Efficient
12. Health Care Cost per Capita	Efficient
13. Equity (Stratification of Whole System Measures)	Equitable

Figure 2-2. Institute of Healthcare Improvement (IHI)'s metrics for whole hospital system performance measurement from *Whole System Measures*[22]

Performance improvement metrics motivate and track change in the system due to alterations in the current state. The metrics are usually used internally and are able to be evaluated regularly. These improvement measurements differ from measurements published in research in that research aims to create more generalizable knowledge about new methods of providing care. The research may focus on longer-term clinical outcomes and is usually done one time, making it possible to have more complex data collection and evaluation.

2.3 Telehealth metrics from research

Scott and colleagues (2007) used the literature to understand how telehealth is currently being evaluated. They found four main categories of evaluation for telehealth technologies: clinical outcomes, changes in access, satisfaction, and cost.[23] These four categories have some overlap with the IOM's six measures of quality; for example, cost is a measure of efficiency and satisfaction is related to patient centeredness. Though, the two measurement systems are not identical because the purpose of the literature is to document changes due to a new technology and the IOM focuses more on continuous quality improvement.

Currently, within the telehealth evaluation categories, investigations are inconsistent in the analysis measures chosen, hindering meta-analysis attempts.[24–30] Choosing appropriate metrics for telehealth investigations is vital to demonstrating and tracking the healthcare improvement due to altering delivery of care.[31,32]

In addition to the wide variability in metrics, telehealth studies have been criticized for their evaluation methodologies. Though telehealth studies are numerous (~15,000 journal articles published), proof of the technologies' beneficial effects remains weak.[33] Reviewers have called for larger, more rigorous studies[24,33–36] that combine qualitative and quantitative measures.[24,36] Based on the large number of successful feasibility trials, the staged analytical frameworks of DeChant et al. (1996) and Bashshur (1995) support the need for larger trials evaluating multiple facets of telehealth effects.[37,38] With the increasing use of electronic medical records, like those in VHA,[18] large longitudinal retrospective studies have the potential to expand current knowledge.[33,34]

Using the current evaluation framework for telehealth (clinical outcomes, access, satisfaction, and cost)[23], a breakdown of specific measures and results in telehealth studies are listed in the following sections. This is followed by how large telehealth systems have been characterized.

2.3.1 Clinical Outcomes

Clinical outcomes of telehealth interventions are evaluated in stages.[23] First, process measures track safety in diagnostic and management decisions with measures such as diagnostic accuracy[39-41] and management concordance.[42] Second are surrogates or intermediate measures of disease progression such as patient self-care adherence[43] and time to treatment.[44] Long term clinical outcome measures such as diabetic retinopathy[45] and overall health status[46-49] are measured least often because of the difficulty in measurement and extensive resources required. The most common tools of quality evaluation in the literature were assessments of health services utilization and questionnaires, such as Short Form 12 or 36 (SF-12, SF-36),[43,47-49] evaluating overall health status.[23] While these measures are suitable for chronic diseases, they are not appropriate for acute or transient conditions.

2.3.2 Access

In telehealth literature, access is defined as the "relative ease or difficulty of obtaining health services" taking into account the "geographical, economical, architectural, cultural, and social" barriers to care.[50] Measures of access include perception of the availability of care[51,52] and access surrogates such as timeliness of service[42,53-55] and travel distance reduction.[56,57] There have been no investigations in the equity of access between rural and urban areas.[23] Equity is of particular interest to VHA given 38% of the Veteran population lives in rural areas. Comparing utilization rates of a certain service in a population using telehealth versus a non-telehealth population is a possible indirect access measurement that could address this issue.[45]

2.3.3 Satisfaction

Nearly half of all telehealth surveys attempt to study satisfaction or acceptability.[23] Patient and provider satisfaction are both important, but patient satisfaction dominates the literature. The current data on patient satisfaction are primarily short quantitative questionnaires which often lack standardization and validation.[23,58] The satisfaction surveys have also been criticized for weak methodology,[59] addressing acceptability more

than satisfaction,[23] and neglecting to assess preference between telehealth and face-to-face consultations.[58]

2.3.4 Cost

Current economic assessments lack consistency and do not follow standard economic evaluation techniques, often merely summarizing costs.[23,60] Common costs measured include: travel, accommodation and meals, equipment cost, communication costs, staffing costs, administration, cost of time, personal costs, hospital and care costs, overall costs, and project establishment costs.[23] Recent economic investigations performed primarily on immature and under-utilized programs[61] cannot account for the decreases in cost due to system efficiencies with increased utilization and improved technology.[62] In addition to examining maturity, there are specific calls for longer term studies to address the possibility of an eventual decrease in service utilization due to primary care provider learning[63] or an increase in utilization due to pent-up demand.[38]

2.3.5 Telehealth system-level characterization

Understanding the current state of a system is important to any research design. A previous characterization of the non-VHA Arizona Telemedicine clinical video telehealth network described a consistent increase in volume of consultations over a 40 month period.[64] An investigation based on Current Procedural Terminology (CPT) and International Classification of Disease, 9th Revision (ICD-9) coding specifically about clinical video telehealth in dermatology found similar rates of diagnosis and complexity of consultation between rural telehealth patients and rural traditional care patients.[65] There are also descriptions of diagnoses seen in store and forward telehealth,[53] clinical video telehealth,[66] and home telehealth[67] programs in other telehealth networks but no comparison to what is seen in non-telehealth clinics for similar populations. Darkins *et al.* (2008) described the demographics of VHA's home telehealth program but fell short of describing how the patient volume compared to the others with similar diagnoses in the VHA population.[68] There is a clear literature gap in the understanding of how the volume of

all types of telehealth appointments and type of patients for telehealth compare to the populations being treated in traditional clinics.

2.3.6 Teledermatology Measures

An extensive, structured literature review was conducted to understand which metrics are being used specifically for teledermatology.

2.3.6.1 Methods

In August 2012, PubMed and Web of Knowledge were searched for articles with the following terms: Teledermatology, "Store and Forward" AND Dermatology, Telehealth AND Dermatology, and Telemedicine AND Dermatology. Removing duplicates, non-English language papers, and conference papers, there were 667 articles examined. The abstracts of these papers were read, and papers were included in the final set if 1) they presented new data about performance of a teledermatology program, 2) teledermatology was the main focus of the article instead of an entire telehealth system, and 3) teledermatology was used to replace a traditional doctor to patient in-person consultation. The specific exclusion categories can be seen in Figure 2-3. One hundred fifty-seven papers were included in the final literature analysis.

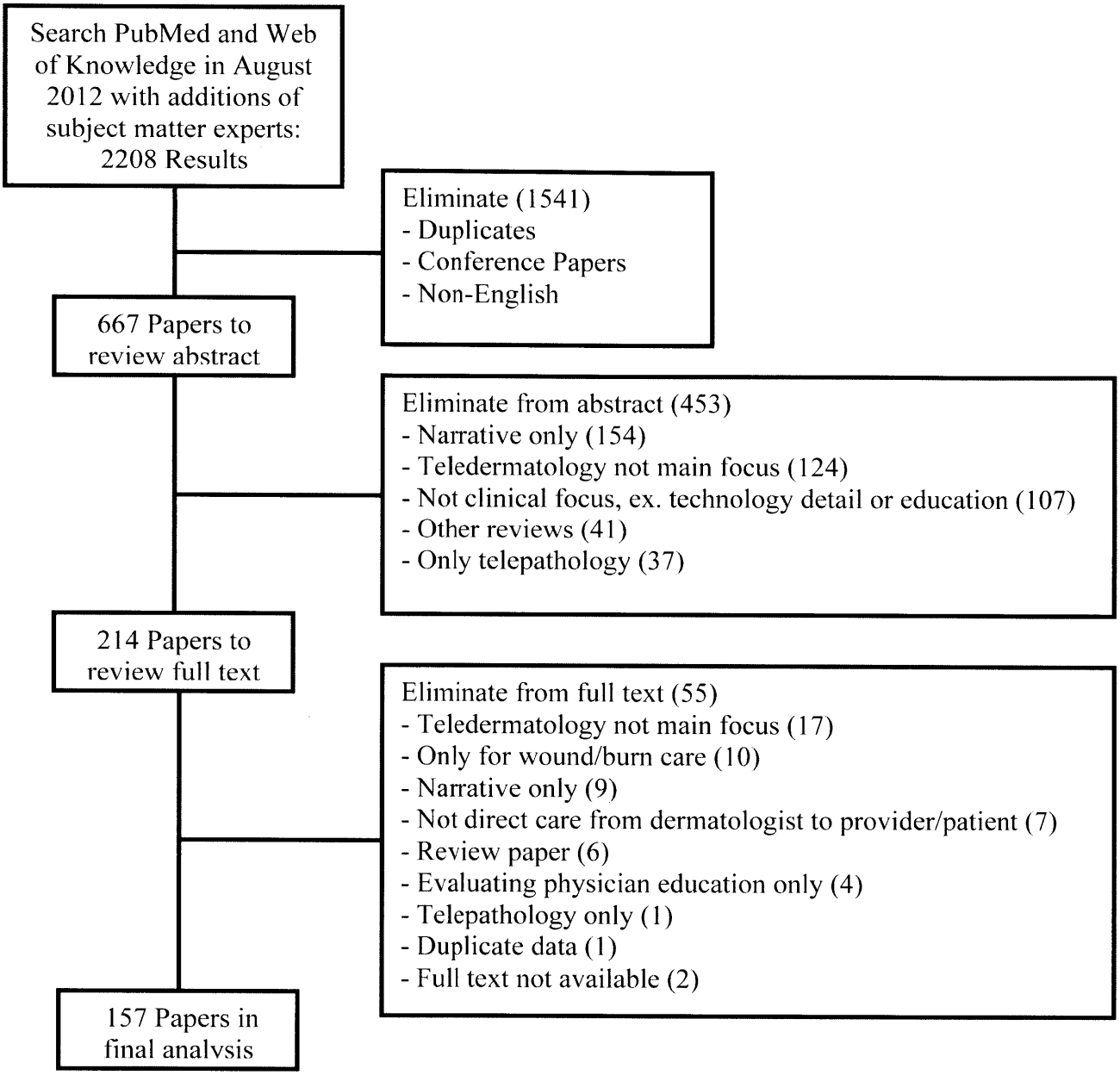


Figure 2-3. Literature review exclusion summary

All of the metrics evaluated in the 157 papers on teledermatology were compiled into a spreadsheet. The metrics were then manually sorted into categories, and these categories were in turn matched to the IHI evaluation categories and the telehealth evaluation categories.

2.3.6.2 Results

From the 157 full text articles included in the literature review, 370 different metrics of teledermatology programs were recorded. Some of these metrics only had small differences among them. For example, agreement between two teledermatology providers on whether to biopsy a lesion was considered different from agreement between two teledermatology providers on whether to request diagnostic tests because the latter category included more than just biopsies.

The 370 metrics were grouped into 9 different categories. "Structure Measures" were those recording information about the technology behind the teledermatology program, including the quality of the images and videos that were recorded and opinions about the software used for teledermatology. "Process Measures" were those that explained how the system works but not outcomes of the process. Process measures in the teledermatology literature described the time impact of teledermatology workflows, the number of virtual and in-person visits needed for teledermatology patients, and information about the teledermatology appointments such as the types of disease treated. Actual outcomes in the teledermatology literature were split into 7 different categories: economic measures; safety measures, such as the number of malignant lesions missed by teledermatology analysis; accuracy and concordance of diagnosis in teledermatology; the physicians' confidence in the diagnoses; clinical outcomes, such as chart review and standardized disease assessment tools; patient satisfaction and opinions; and provider satisfaction and opinions. Table 2-1 describes how the categories created fit into the six IOM dimensions of care the four categories of telehealth evaluation along with the number of different metrics within each category and the number of papers that report metrics in the category.

Table 2-1. Summary of teledermatology categories developed through literature review

Teledermatology Literature: Category of Measure	Related IOM Dimension of Care	Related Telehealth Category	Number of Measures	Number of Papers
Structure Measures			6	37
Process Measures	Timeliness		67	97
Cost	Efficiency	Cost	45	25
Safety Measures	Safety	Clinical Outcomes	13	19
Accuracy/Concordance	Safety, Effectiveness	Clinical Outcomes	74	63
Confidence in Diagnosis	Effectiveness	Clinical Outcomes	5	23
Clinical Outcomes	Effectiveness	Clinical Outcomes	35	41
Patient Satisfaction	Patient Centeredness	Satisfaction	71	39
Provider Satisfaction		Satisfaction	54	30

The high number of measures used within each category confirms that teledermatology studies, like telehealth in general, have little agreement about the most important metrics to report. The two largest areas of study in terms of number of papers are the process measures, likely because they are the easiest to capture, and the diagnostic ability of dermatologists, one of the most important sources of evidence to establish the potentials success of teledermatology.

Process measures, diagnostic accuracy, and patient satisfaction had the highest number of individual metrics within a category. There were many process measures for two reasons: 1) there were several different ways of determining if a face-to-face visit was necessary after teledermatology and 2) numerous other topics were included in this category such as the various time impacts of teledermatology on the stakeholders and the administrative information recorded about appointments. There were a high number of metrics about diagnoses in teledermatology because of the variation in the way accuracy is determined. Diagnoses in teledermatology were evaluated by the concordance with other teledermatologists' diagnoses, concordance with in-person evaluation by a dermatologist, and comparison to histological examination of the lesion. The evaluations also varied on the inclusion of primary diagnoses only, all differential diagnoses, or the management decisions that would be made based on the diagnoses. Patient satisfaction had many

metrics because the questionnaires used multiple questions with very little overlap in the questions between studies.

None of the categorizations of the teledermatology metrics directly addresses access to care, an important topic in telehealth evaluation, or equity of care, one of the IOM dimensions of quality. While access to care was not an exact match in the categories, some of the clinical outcomes metrics and cost evaluation metrics such as time to treatment and cost of transportation address it indirectly. Equity, however, is not addressed in the teledermatology literature at all. It is possible to look at this topic in the future with stratification of other metrics into different demographic groups.

Specific details about the metrics in each category and the papers that contain evaluation of each metric can be found in Appendix B. The following is a brief summary of the study results that are important to the analysis in the following chapters.

Accuracy and concordance of diagnostic decisions:

Reviewers have concluded that both clinical video telehealth and store and forward telehealth modalities of teledermatology have highly reliable diagnoses.[69,70] This conclusion is based on similar levels of inter-observer agreement between teledermatologists and clinical dermatologists and agreement levels between clinical dermatologists.[18,70] However, in the specific case of pigmented lesions one study found teledermatology was inferior in management decisions for malignant neoplasms.[40] For the purpose of the remainder of the thesis, the diagnostic ability of dermatologists using teledermatology will not be challenged.

Patient satisfaction

Similar to all telehealth literature, teledermatology studies have reported patient satisfaction with results ranging from ambivalent to satisfied for image and video modalities.[69] The most recent store and forward patient satisfaction survey within VHA reported positive results: initial teledermatology satisfaction scores were no different from face-to-face satisfaction scores, 66% of patients preferred teledermatology over face-to-

face consultation, and 77% of patients were highly satisfied or satisfied with teledermatology after a year of follow-up.[71] Previous studies had not found as much preference for teledermatology over traditional care processes.[54,72]

One store and forward teledermatology study found that patients were more willing to pay for telehealth when it ensured earlier interaction with their physician as compared to just avoiding an in-person appointment with the specialist.[73] The preference for faster treatment was again demonstrated in a study by Lim, *et al.* (2012) in which patients are more satisfied with the shorter wait time for a teledermatology consult than face to face patients are with the wait time for an in-person visit.[74] Having an initial teledermatology consult may also change the satisfaction in the longer wait times for in-person visits to a dermatologist. A study comparing teledermatology and traditional in-person referrals found patients who had to attend an in-person appointment after teledermatology were more satisfied with the wait time than people schedule right into the clinic.[54]

Patients' satisfaction with teledermatology is related to the quality of life, as measured by the Dermatology Life Quality Index, and patients with more severe conditions may prefer to see a dermatologist in-person.[75]

Clinical outcomes

Surprisingly, to date only one study for store and forward and two studies for clinical video telehealth address long-term clinical outcomes for multiple diseases. This was confirmed by recent reviews,[69,70] and a subject matter expert. Using photos taken before and 3 months after treatment, Pak *et al.* (2007) found no significant difference in improvement between store and forward telehealth and traditional treatment.[76] Marcin *et al.* (2005) subjectively rated improvement of clinical video telehealth patients based on chart review.[77] Lamel *et al.* (2012) found 66% of the small portion of the patients who had repeat video teledermatology visits had clinical improvement in their condition.[78]

Intermediate outcome measures for teledermatology include wait time for contact with a dermatologist and time until the initial intervention. Studies report that time to

intervention or dermatologist contact can be significantly reduced with telehealth.[69] Within VHA, time to initial treatment defined as time from initial PCP referral to face-to-face dermatologist appointment or time to teledermatology consult if no dermatology appointment occurs was faster for teledermatology than for traditional referrals (median 41 days versus 127 days, $p < 0.0001$, log-rank test).[44] For another VHA program, Oh et al. (2008) reported a statistically significant reduction in time from presentation to skin cancer removal from 125 days with traditional care to 104 days with teledermatology. [79] Faster initial access to care for all teledermatology patients because of the speed of consult response[71,80] and for skin cancer patients due to appropriate triaging[74,81-83] has been reported in the literature.

Reduction in appointments

One prominent measure of teledermatology system efficiency was the reduction in face-to-face visits with a dermatologist. With Landow *et al.* this structured literature review was used to identify store and forward teledermatology studies reporting a reduction in face-to-face visits and qualitatively assess the characteristics of programs that create high avoidance of post-teledermatology face-to-face dermatology care.[84] The face-to-face avoidance rates ranged from 8 to 88%.[44,53,72,74,81,83,85-105] Four factors were identified as key to reducing the need for post-teledermatology care by a dermatologist: 1) effective pre-selection of patients for teledermatology, 2) high quality photographic images, 3) dermoscopy if pigmented lesions are evaluated, and 4) effective infrastructure and culture in place to implement teledermatology recommendations.[84]

Wootton *et al.* (2011) attempted to study travel distance saved by store and forward and clinical video teledermatology but found that the information available in the literature was not sufficient for meta-analysis and relied on the appointment avoided information alone.[56] This structured literature review confirmed the lack of information; travel distance was only reported as an average value as part of cost analysis for teledermatology programs.

2.4 Current addressable gaps in the literature

While there are numerous teledermatology studies, the literature can be enhanced by larger retrospective trials[24,33-36] that combine qualitative and quantitative measures.[24,36] The numerous metrics used in the teledermatology also leave room for clarification of the most appropriate measures of success within teledermatology programs. Additionally, some studies compare store and forward telehealth to clinical video telehealth, but there is no comparison of different store and forward telehealth programs.

In the teledermatology literature the time to consult is compared only with the wait time for an in-person appointment though there is an indication that teledermatology can filter appointments out of in-person care. This knowledge can be combined to understand the influence of teledermatology on a clinic's total wait time. Additionally, for the patients that do not receive care from a dermatologist, there is little information available on the follow-up care received from other care providers.

3 Qualitative Evaluation of Teledermatology Programs in VHA

3.1 Introduction

The qualitative analysis of the VHA teledermatology system has two objectives: 1) to understand the current state of the teledermatology system in the VHA and 2) to determine the various stakeholders' views on the appropriate metrics to evaluate the teledermatology system.

Important aspects of the current state of the teledermatology system that were investigated with qualitative methods include how patients are flowing through the teledermatology programs at different sites, if there is variation between the executions of the teledermatology system in different locations, and if there are differences in dermatology populations between those who use in-person services only and those who use teledermatology. Understanding these aspects was a critical to building an analysis plan for the teledermatology programs.

Investigation of metrics for teledermatology focused on three different questions:

1. *What are the goals of the teledermatology program?* This is used to help understand what motivated the use of the technology and to later create categories of evaluation that are important for understanding success.
2. *What metrics are currently collected and regularly used?*
3. *What do stakeholders believe would be the ideal metrics for success of the teledermatology program?*

Answers to these three questions are combined with literature about telehealth and health system evaluation to create a recommended set of metrics for teledermatology.

3.2 Methods

The qualitative study of the teledermatology system involved both visits to teledermatology programs and semi-structured interviews with key stakeholders. The site visits gave the opportunity to observe teledermatology in practice and interact with the stakeholders of the program in an informal way. This information was combined with formal interviews at site visits to validate that the interview protocol was sufficient to gather information from sites without visiting.

3.2.1 Site visit methods

Based on length of teledermatology programs, volume of patients, technology use, and geographical setting, a list of sites to contact was generated (Table 3-1).

Table 3-1. Selection criteria for interviewees

Site Visit Selection Criteria	Reason for Criteria
The sites have been using teledermatology since at least VHA fiscal year 2012	The site will not be affected by possible instability and inefficiency that comes with a new program implementation
The sites have a large volume of teledermatology activity	There will be sufficient opportunity for observation of teledermatology patients in a short visit
There is a mix of CVT and SF	Both technologies are important to the telehealth system
There is a mix of urban and rural settings	Urban and rural programs may have different structures and nuances due to geographic factors

The telehealth facility coordinator and dermatologists were contacted via email with an information sheet and request to participate in the study. Respondents were contacted with follow up questions and to schedule a visit to the dermatology reading site and, when possible, to an associated patient care delivery site. Site visits were 1-2 days at the dermatologist and patient sites. Site visits consisted of informal conversation with identified stakeholders (Table 3-3), informal conversation with others involved in the teledermatology and dermatology programs, observation of teledermatology reading, observation of teledermatology imaging, observation of dermatology appointments, observation of meetings between teledermatology staff, and formal interviews with

stakeholders when possible. The informal conversation and observation focused on the following: how patients flow through the teledermatology system, any systematic difference between in-person dermatology and teledermatology patients, what data is recorded for each patient and why, the role each stakeholder plays, what knowledge personnel have on available metrics, and stakeholders thoughts on appropriate metrics for teledermatology programs. During site visits the researcher took notes on observations and conversations, which were used for later analysis.

3.2.2 Interview methods

Interviewees were selected for recruitment based on similar selection criteria to site visit locations. The main differences between the selection criteria are the expansion to lower volume teledermatology sites and the requirement that all stakeholder groups be represented (Table 3-2).

Table 3-2. Selection criteria for interviewees

Site Visit Selection Criteria	Reason for Criteria
Personnel are from sites have been using teledermatology since at least VHA fiscal year 2012	The site will not be affected by possible instability and inefficiency that comes with a new program implementation
Specific stakeholder categories are met	Representation from all stakeholders is key to a holistic understanding of the system
There is a mix of small, medium, and large volume programs represented in interviewees	Low volume and high volume programs may have different patient flow patterns
There is a mix of urban and rural settings represented in the interviewees	Urban and rural programs may have different structures and nuances due to geographic factors

The stakeholder groups were chosen to represent the many different participants based on current knowledge of the teledermatology system at VHA with input from subject matter experts and qualitative methods experts (Table 3-3).

Table 3-3. Stakeholder groups targeted for interviews

Stakeholder Position	# Interviews Desired
Primary Care Clinician	4
Primary Care Clinician NOT Using Telehealth	2
Dermatology Specialist Clinician	4
Dermatology Specialist Clinician NOT Using Telehealth	2
Telehealth Technicians	4
Local Hospital Administrators	4
Telehealth Local/Regional Administrators	4
Telehealth National Leadership	3
Total	**27**

The dermatology specialist clinician group included dermatologists and specialized nurse practitioners trained in dermatology and working in teledermatology programs.

The only group not represented in this design was the teledermatology patients themselves. Receiving the proper permissions and approvals to include a randomized sample of teledermatology patients was too time intensive for this thesis project. This shortfall and how it is addressed are discussed in more detail in the limitations section.

Potential interviewees were contacted to request an interview via email with an information sheet about the study. If there was no response, potential subjects were contacted a second time after at least one week from the first contact.

Subjects that responded were scheduled for phone or in-person interviews depending on the proximity to site visits and researcher's location. Interviews followed a semi-structured format based on the interview protocol in Table 3-4. Not all questions were asked of all participants or with the exact wording that is seen. Also, there was opportunity for subjects to contribute their thoughts on teledermatology that were not specifically asked for in the questions. Current state questions targeted clinicians and technicians because of their particular knowledge domains. Interviews were recorded and transcribed.

Table 3-4. Semi-structured interview questions

Stakeholders Targeted	Question
ALL	How long have you been practicing in VHA? Using teledermatology?
Current State Questions	
ALL	Can you describe how you use the telehealth technology to interact with patients? • VHA has 4 teledermatology care models, which of these models fits your practice most closely? Are there any differences, if so please describe them? • What do you consider your responsibilities after the telehealth appointment?
PCP, Dermatologist	How do you differentiate between patients who should be seen by telehealth versus those who should go see a dermatologist in person? • Do you know which patients are urban/rural? Does that matter when you decide to use telehealth?
PCP, Dermatologist, Technician	Do you have any examples of an unsuccessful telehealth visit? What would that mean to you?
PCP, Dermatologist	If you were to match patients to evaluate any telehealth outcome, what characteristics would you use to match them?
PCP & Dermatologist NOT using TeleDerm	Have you considered using teledermatology, and if so what was the reason you decided not to?
PCP & Dermatologist NOT using TeleDerm	What change in conditions would encourage you to start using teledermatology?
Measurement Questions	
ALL	Do you currently measure performance of the teledermatology program? If so can you describe the measures you use? • Who is responsible for collecting these measures? • How often to you get feedback? • Are there measures at different levels (individual, program, region)? • Does this data reflect your performance well?
ALL	What are the current goals of the teledermatology program? • What are the benefits to the patient and VHA from the telehealth programs? • What do you think are the best ways to understand if you are accomplishing these goals? • How would you measure changes in access to care with your patients? • How would you measure the cost benefit of using teledermatology?

Stakeholders Targeted	Question
ALL	What do you think are the best way to understand if you are actually accomplishing these goals? • How would you measure changes in access to care with your patients? • How would you measure changes in clinical outcomes with your patients? • Are there certain populations you would isolate for measurement? For example, chronic conditions and skin cancers? • How would you measure quality in the teledermatology program? • Given the constraints of the current data collect in the EHR, how would you create these measures for the whole system?

3.2.3 Response rate and alterations to methodology

3.2.3.1 Site visit

A total of 5 teledermatology programs were invited to participate in the study, with 4 resulting site visits. The site that was recruited because it has a high volume of CVT did not respond to multiple email contacts. Therefore, no sites were visited that relied only on the video technology; though two sites were visited that used the video technology with the asynchronous photograph consults. During the site visits notes on informal conversations were recorded from the following stakeholders: primary care clinicians (2), dermatologists (4), telehealth technicians (5), hospital administrator (1), telehealth administrators (3), a patient/employee (1), surrogate and advanced practice providers (5), dermatology residents (3), program/ administrative assistants (2), and an educational program administrator (1).

3.2.3.2 Interviews

A total of 25 interviews were performed with stakeholders in the teledermatology program (Table 3-5).

Table 3-5. Summary of interviewees

Position	Number of Interviews Desired	Number of Interviews Preformed	Number of Participants Invited	Response Rate
Primary Care Clinician	4	3	34	8.8%
Primary Care Clinician NOT Using Telehealth	2	1	4	25.0%
Dermatology Specialist Clinician	4	4	12	33.3%
Dermatology Specialist Clinician NOT Using Telehealth	2	2	2	100.0%
Telehealth Technicians	4	4	10	40.0%
Hospital Administrators	4	2	11	18.2%
Telehealth Local/Regional Administrators	4	7	11	63.6%
Telehealth National Leadership	3	2	2	100.0%
Total	**27**	**25**	**86**	**29.1%**

The selection of interviewees deviated from the desired plan in a few ways. First, the hospital administrators that were contacted had limited knowledge of the teledermatology program because it was managed at a lower level. Instead of continuing to contact hospital administrators, more local and regional telehealth administrators were contacted to get an administration stakeholder view. Additionally, it was very difficult to get a response from primary care providers. Because there were informal conversations with primary care providers in the site visits, attempts to reach more providers were discontinued. The clinicians not using teledermatology were found through recommendations and were very familiar with teledermatology because they had done research in the area or participated in a teledermatology program in the past. These were not the ideal people to recruit but were considered sufficient because of the difficulty in getting response from people not involved in telehealth in any way. Finally, it was only deemed possible to reach two of the national leadership for teledermatology. The distribution of the interview subjects across the different program sizes and program rurality can be seen in Table 3-6. The criteria that the subjects should be from different size programs and different rurality were met. Definitions of telehealth program categorizations can be found in Appendix A.

Table 3-6. Break down of subjects by stakeholder category, rurality, and size.

Position	Number of Interviews Preformed	Categorization of Telehealth Program of Subject					
		Urban	Mixed	Rural	Small	Medium	Large
Primary Care Clinician	3	2	1		1		2
Primary Care Clinician NOT Using Telehealth	1		1				1
Dermatology Specialist Clinician	4	1	2	1	1		3
Dermatology Specialist Clinician NOT Using Telehealth	2						
Telehealth Technicians	4	1	2	1	1	1	2
Hospital Administrators	2		1	1		2	
Telehealth Local/Regional Administrators	7						
Telehealth National Leadership	2						
Total	**25**	**4**	**7**	**3**	**3**	**3**	**8**

Interview subjects were asked how long they had been working with teledermatology or telehealth and how long they have been working with VHA to establish their expertise in the area. Combined, the subjects who responded to this question had over 110 years of experience with teledermatology (5.1 ± 5.5 years)[1] and 250 years of experience within the VHA healthcare system (11.6 ± 9.6 years).

3.2.4 Qualitative Data Analysis Methods

For each question a set of expected answers was compiled into a code for analysis. Each response to a question was put into a separate line of a spreadsheet noting the subject number, the location of the response in the transcript, and the subject's stakeholder role. The content of the response was coded if possible. In some cases an answer would cover multiple codes, resulting in the response being split into different lines. If some additional information regarding the question was given in other parts of the interview, it was also included in the analysis. After all of the answers to a question were added to the spreadsheet, the original coding structure was examined and changed when necessary to

[1] Average ± standard deviation, unless otherwise noted.

represent the answers given by the stakeholders. Following any change in coding structure all responses were re-coded.

In a few cases a coding structure could not be predetermined from the literature. An example of a question that could not be answered: what would encourage those not using teledermatology to start using teledermatology? For these questions, the subjects' answers were compiled and then a coding structure was created after analyzing and grouping the responses.

Any important comments that subjects made that did not directly answer one of the questions was listed in a separate spreadsheet. These responses were also grouped to look for further themes that emerged from the qualitative data collection.

Notes from the site visits were included in the analysis of the current state and program structure, with each visit representing one unit of analysis. However, individual stakeholder thoughts on the proper metric section were not used from the site visits because they would create an overrepresentation of the site visits relative to the other programs. The site visit notes were reviewed after the analysis of the formal interviews to make sure there was no conflicting evidence or themes that were not captured by the individual interviews.

3.3 Results

3.3.1 Characterization of the current state of teledermatology programs

The site visits and the first part of the interview were used to understand the current operation of the teledermatology program. The purpose was to understand any nuances that would impact the way the teledermatology system is evaluated.

3.3.1.1 VHA teledermatology program structures

The VHA teledermatology operations manual explains four different models of store-and-forward care delivery (Section 1.3.1, pg. 23). Participants were asked to explain the way they delivered teledermatology care and their responses were fit to these four models of care. Eighteen subjects gave descriptions of their programs (Table 3-7). Some subjects' descriptions of the programs fit into more than one model of care, so the total number of responses for the question was larger than the subject pool. Additionally, some subjects responding to this question were from the same teledermatology program. These duplicate subjects were subtracted to give the total number of programs interviewed of each type, though again some programs fit into multiple categories (Table 3-7).

Table 3-7. Types of teledermatology programs in VHA, coded subject responses (18 subjects)

Model	Number of Interviewees	Number of Programs* (includes site visits)
Model A: Surrogate	1	1
Model B: Direct Care	12	7
Model C: Triage	8	7
Model D: Follow up	0	0
Clinical Video	2	2
** Only representative of interview sample, not entire VHA*		

The distribution of programs in Table 3-7 is not representative of all of the VHA teledermatology programs. This study looked at programs that were started before FY 2012 and may be biased by that fact. As teledermatology programs gain more experience and resources they may shift models of care delivery.

From analysis of the responses and descriptions of programs a few key conclusions were made: 1) the programs do not fit well into the separate categories and are instead a combination of the models described, 2) no one is doing follow up care as described in the manual, 3) there are regional reading centers in addition to pure hub-and-spoke teledermatology programs, and 4) there is variation in programs beyond the structure of patient flow through the system.

Few of the program descriptions fit into one singular model of teledermatology care delivery. For example, one teledermatology program offers direct care through a surrogate provider in some community clinics but because of lack of resources only offers triage services at other clinics. Within the direct care programs there is an additional level of variation in the type of care that a surrogate dermatology practitioner is able to provide varying from only cryo-therapy to small surgical excisions. Finally, some programs offer CVT as a supplement to the store and forward programs offered allowing time-synchronous virtual follow-up appointments for patients who have significant travel.

Through analysis of the interviews, it was found that no program gave follow up care as described in the teledermatology operations manual. In the model the patient is sent to a teledermatologist appointment by the dermatologist without any interaction with the primary care provider. Often there was follow-up care given by teledermatology for a dermatology concern initially treated by teledermatology, but it was always done through an intermediary: a new referral from the primary care provider or a new request from the surrogate care provider.

Starting the project, the assumption was that the teledermatology care operated under a hub and spoke model, meaning each hospital gave teledermatology care to its own surrounding outpatient clinics to which it would normally supply dermatology care. However, this was not always the case. Some programs operated with dermatologists acting as "regional readers" that answered the teledermatology consults for multiple hospitals. In some cases the reader is responsible for multiple hospitals each with their own dermatology care providers, other times for hospitals without dermatology services, and occasionally for both. The number of hospitals covered by these regional programs ranged from 2 to 8.

Through analysis of the program descriptions, variations in the programs were found that were not represented by the four models of patient care. The most important noted differences were in the training programs for surrogate dermatology providers, participation of dermatology and family physician residents, and the availability of

protected time for the surrogate dermatology providers. These differences cannot be tracked electronically and may create facility level differences in program performance.

3.3.1.2 Teledermatology patient selection

To determine if there were any differences between teledermatology patient populations and in-person only patient populations, clinicians were asked which patients were not appropriate for the teledermatology program. During interviews, a total of 8 people responded to this question. Their responses fell into the following categories in Table 3-8.

Table 3-8. Qualities of patients who should not use teledermatology, coded responses (8 participants)

Who should NOT use teledermatology	Number of people with answer
Someone who needs a full skin exam	3
Certain widespread rashes	3
Someone who will need a procedure	2
Many lesions	2
Patient prefers/requests it	2
"Something pressing" by clinical judgment	1
Complex cases	1
Failed previous telehealth treatment	1
Cysts and lipomas	1
Issues in photographically sensitive areas	1
Acute problems	1

These responses indicate that, by both diagnosis and severity, the conditions seen in teledermatology programs are different from the conditions seen in a dermatology-only clinic.

3.3.1.3 Un-solicited themes that developed about the current state

During the semi-structured interview, participants brought up some points that were not directly answering interview questions. These responses, which are considered informative of the current state but not a methodologically rigorously representative of the whole system, were recorded and analyzed for emerging themes. Reported below are the themes that were mentioned by more than one respondent.

Table 3-9. Emerging themes from miscellaneous responses

Emerging theme	Number of respondents in category
Patients like teledermatology	5
Concern about whether patients are being lost in consults, biopsies, and follow up	4
Programs need support to be successful • Dedicated personnel to track follow up • Protected time for advanced practice provider	4
Comfort level of physician with not doing a whole skin exam/ infrastructure for creating that skin exam somewhere else	3
Clinical champions important	3
Because of education, advance practice practitioners and PCPs start to handle more dermatology concerns themselves without consults	2
Workload shift from dermatology to primary care or advanced practice provider	2

Many interview participants were eager to discuss the patients' positive experiences with teledermatology. This addition mainly came in the form of stories of particular individuals who had a melanoma diagnosed early or were saved the time and stress of traveling. For example, one participant said:

> *"I've heard somebody who- a friend of mine, ... he had a spot, he went to the local clinic, ... they went through the process, he ended up going down to CITY and getting everything done, and it turned out [his lesion] was cancerous but it got treated and it got caught at a very early stage. And on a personal level, a friend, you know, the process is working. And I hear other patients and see them come back after they have had something done, and ah, like I said, it's caught at an early stage and they seem to be grateful for that."*
>
> –Technician

This may be a biased result because the people who volunteered for this study are likely to have polarized view about teledermatology, but the result is consistent with many patient satisfaction surveys that find patients overall are satisfied with teledermatology.[69]

A few of the themes weave together to depict an interesting aspect of teledermatology. The SF teledermatology programs create a shift of the workload, particularly follow-up on simpler cases, from the dermatologist to lower-level providers such as the primary care provider or a nurse practitioner serving as a surrogate dermatologist. In some cases this workload shift and transition to a virtual dermatology service has created an ambiguity in who is supposed to follow up with the patients to make sure things like biopsies and

medication education actually happen. Participants expressed some concern that patients are not being tracked well enough to make sure that all consults are answered and patient follow-ups completed. The workload shift and the follow up concern together related to an expressed desire to have support for the person now responsible for follow up. This support would give protected time for advanced practitioners responding to teledermatology consultations by performing procedures and also dedicating personnel to the task of making sure people do not get lost in the teledermatology system. The level of concern was variable by location and facility, and some teledermatology programs already have personnel and processes dedicated to tracking patient follow up.

Some primary care practitioners and advanced practitioners discussed their new ability to treat dermatology concerns. The teledermatology consults or training have enabled them to treat dermatology concerns that they would not have treated before without consulting a dermatologist. In one case, after "graduating" from a teledermatology training program, a surrogate practitioner had started handling almost all of the dermatology concerns and procedures for his rural clinic without using the teledermatology service. The physician learning effects may impact the total demand for dermatology services.

A few different participants mentioned clinical champions as being key to the success and implementation of teledermatology programs.

3.3.2 Metrics for evaluating the teledermatology programs

This section reviews the results of the series of questions to help understand the current teledermatology evaluation system and the ideal evaluation system. The results are used to create a teledermatology evaluation framework and recommended set of metrics for VHA teledermatology programs.

3.3.2.1 Goals of the teledermatology programs

The interview subjects were asked about the goals and benefits of the teledermatology program to better understand the perceived purpose of this technology. Understanding

the goals of the system will help create metrics for teledermatology under the theory that a measure of effectiveness of a program is the ability to meet its goals.

Twenty-two subjects responded to the question about the goals of the teledermatology program or mentioned the goals and benefits while answering other questions. All responses were coded and both the number of times a benefit was mentioned and the number of people responding are summarized in Table 3-10. In some cases, when subjects were not mentioning things that had been prominent in the literature and were related to their role, prompts were given to ask whether something was a goal. Whether or not a response was prompted is also summarized in Table 3-10.

Table 3-10. Goals and benefits of teledermatology, coded results (22 subjects)

CODES	Total Mentions	Total Respondents	Required Prompting
1- Access Total	**67**	**20**	
1.0 Access, general comment	9	7	
1.1 Travel distance	24	13	
1.2 Earlier treatment	4	3	
1.21 Timely diagnosis	16	13	2
1.22 More likely to seek care	2	2	1
1.23 Reduced wait time in clinics	9	8	1
1.3 Can't recruit physician	3	2	
2- Cost Total	**16**	**12**	**5**
2.0 Cost general	1	1	
2.1 Cost to hospital	12	11	7
2.2 Cost to patient	3	2	
3- Patient satisfaction	**5**	**5**	
4- Education program, residents	**2**	**2**	
5- New clinical perspective	**3**	**3**	
6- Education, satisfaction for primary care	**3**	**3**	**1**
7- Provide quality care	**2**	**2**	

Access to dermatology care was the most frequently mentioned benefit of teledermatology with 67 mentions. When access was described in more specific terms it was identified as a reduction in travel distance for Veterans to get dermatology care, earlier treatment for dermatologic concerns, and ability to offer dermatology care when it was difficult to recruit

a dermatologist to a location. Travel distance, the most frequently identified component of improved access, involved the reduced time burden of large travel distance, cost of transportation, and the impact of not having to be in a congested city. For example, here is one representative description of this benefit to Veterans by a subject:

> *"And then they don't have to drive all the way up there.... It's their time... just with gas and everything being so high as it is right now. It is a day up there- I mean you're talking a day. Plus look at the traffic. You know if you live in a rural area and you go to [BIG CITY] to drive or any big city it can be really overwhelming."*
>
> –Technician

The next part of improved access, earlier treatment, is broken down into three separate components: 1) the ability to give the Veterans using teledermatology a diagnosis and treatment quickly, 2) the ease of the teledermatology system encouraging Veterans not to wait to get a dermatology concern addressed, and 3) the ability of the clinic to filter out unnecessary appointments with the teledermatology system and in turn reducing wait times and providing faster dermatology care to all of their patients.

The second most mentioned category of benefits of teledermatology was reduced cost of dermatology care. This is an important aspect of teledermatology in the literature, but it did not come up unprompted as much as was expected, even from the viewpoint of the administration. The difference could be because VHA has specific funds allocated for telehealth programs by Congress and VHA looks at expenses differently than other hospitals. They have a mission of financial stewardship and using their resources in the best way give high quality care to all of the Veterans. When prompted, one subject responded that they were not sure that the teledermatology system was less costly than traditional dermatology care, particularly in cases where there was not a high volume of teledermatology patients.

One unanticipated result, and a code that had to be added in, was the benefit of teledermatology in educating residents and primary care providers. This benefit is not as prominent in the literature but was important to a few of the interviewed stakeholders. Subjects mentioned the importance of training residents on this new technology and the

increased satisfaction that primary care providers got from the sense of community, variation in daily tasks, and new clinical abilities they received as part of the program.

Another surprise was the description physicians gave of the clinical benefits of having a picture. It allowed dermatologists to spend more time with a lesion in cases where it was in an uncomfortable place for the patient to reveal or when it was particularly perplexing. It also creates a visual history of a lesion to compare with in years to come, which is even more helpful when there is a change in providers.

The ability to provide quality of care was not frequently mentioned by the participants. This could have been because the question was phrased using benefits and goals interchangeably with different participants and also because of an underlying assumption by some participants that teledermatology was providing a similar quality of care as face-to-face dermatology care.

Overall, it is important to remember that the total number of mentions can give clues to the importance of different benefits but is not necessarily representative of the overall view of the system participants. For example, as an observer I saw that most system participants were motivated by the ability to give high quality of care to Veterans, but that did not necessarily come through in the count of people who mentioned it as a benefit.

3.3.2.2 Current measures within teledermatology programs

Interviewees were asked about any current performance measures and evaluations done within their teledermatology program. The purpose was to understand the variation in measures and compare the current performance measures to interviewees' ideal measures.

Twenty-two interviewees responded to this question. Two of the respondents did not have any knowledge about any current performance measures. Other interviews and investigation revealed there were measures being recorded within the programs of the 2 who were unable to respond. This indicates that the performance measures were not

driving the behavior of these participants which may be a broader issue among other participants.

Participants often responded to this question with measurements that were not used regularly for performance improvement. For example, they spoke of information that had been collected once as part of a research study or part of a pilot project or of performance measures that they were planning to implement. These responses are important to the analysis because they show what information people consider useful, but they do not have the same power to impact behavior and overall program performance as regularly measured and reported metrics.

The responses from the 20 participants who had knowledge of performance measures were coded according to the type of measure and also by whether it was currently performed regularly, performed as a one-time study, or not yet implemented (Table 3-11).

Table 3-11. Current teledermatology performance measures, coded results (20 subjects)

CODES	Currently Done	One Time Study	Planned	Total Respondents
Workload/volume	14	1	0	**15**
Image quality	9	0	0	**9**
Photos are deleted	4	0	0	**4**
Orphans left in system	4	0	0	**4**
Timeliness of reading	4	0	1	**5**
Number of face-to-face visits required	3	1	1	**5**
Patient satisfaction	2	2	2	**6**
Consults pending	1	0	0	**1**
Equipment costs incurred	1	0	0	**1**
Qualitative national review	1	0	0	**1**
Track patients who need follow up (internal list)	1	0	0	**1**
Types of diagnosis	0	1	2	**3**
Number of patients who need biopsies	0	1	1	**2**
Chart review	0	1	1	**2**
Time to appointment	0	1	0	**1**
Diagnostic accuracy	0	1	0	**1**
Travel cost avoided	0	1	0	**1**
Resident satisfaction	0	0	1	**1**

The number of teledermatology appointments and teledermatology patients (workload/volume code) was the most commonly cited metric for teledermatology programs. This is unsurprising because it is something that is automatically captured and reported in the electronic record system and is considered a key metric of teledermatology performance by the national office. It is likely that the volume of patients is tracked for all of the interviewees but not mentioned by the remaining five because it does not drive their behavior.

Another performance metric frequently used for teledermatology programs was the quality of the teledermatology images. In many cases this can be done automatically with a new template that is being implemented for teledermatology consults. However, many programs were measuring it before the template by having the dermatologist who is reading images flag particularly bad images and report them to an administrator. This performance measure was associated with a feedback loop that immediately allowed retraining and help for imagers taking low quality images. Examples below are two detailed descriptions of how this performance metric works in two different VISNs.

> *"Image quality is ... determined by the reader and um, we do collect that information by the imager to be able to determine if there are areas that we need to provide more training to our imagers."*
>
> –Telehealth Administrator, VISN F

> *"We have done on an ongoing basis ... oversight [with] reviews quality of the image based on the imager. Specifically looking at color balance, focus, um, appropriate anatomical capture of lesions, things like that. And then the dermatologist would give feedback to me as the facility telehealth coordinator. And I would then track it and per imager so then I could work with the imagers directly, either for you know, adjusting their practice, adjusting their environment, adjusting cameral settings, that type of thing. And then we incorporated that into the telederm imagers', um, performance plan. So they are allowed X amount of outliers per quarter."*
>
> –Telehealth Administrator, VISN B

These descriptions are great examples of how performance measures in the teledermatology programs are being used to drive the behavior of the imagers and improve the quality of the teledermatology program.

Some programs have begun regular measurement of whether or not photos are being deleted from the cameras and computers used. The latent photos left on cameras and computers are a privacy risk to the patient. Here is an example description of what such a performance metric is and how it is used.

> *"Ah, we do monitor ourselves on the aspect of making sure we have no latent photos on the cameras. We do a- I do a daily check as well as we have a weekly check that we have a weekly log that we do here in the VISN that all people are certified to do telederm have to ah log on a weekly basis. Now once every three months I go through, because I am the master preceptor, I go through once every three months and double check everybody's cameras and make sure there are no latent pictures on the cameras or their computer systems."*
>
> -Technician

Similar to teledermatology patient volume, the number of "orphan" appointments, those appointments for which a match cannot be made between the entry for the patient having an image taken and the entry for the provider analyzing the image, are automatically tracked and reported by the electronic records system. For those that used the "orphan" appointments as a performance measure, it was generally in the context of making sure all images had been analyze and all appointments coded correctly. Other interviewees were aware of the "orphan" reports but did not feel they adequately tracked whether all patients were seen and did not use it as a performance metric. They only found the metric useful for administrative purposes such as catching coding mistakes.

The final metric that is used with some frequency is the time it takes for teledermatologists to respond to a consult or, in other words, the timeliness of reading the images. Programs measuring timeliness believe that it is important to quickly get a response to the primary care provider so they can take necessary action to treat a patient. They often have a deadline for how long teledermatologists have to respond, ranging from 2 to 7 days. This performance metric can influence the speed at which patients get treatment when it is driving behavior change, though some interviewees pointed out that it also depends on the primary care provider taking action quickly.

The number of required face-to-face visits is a metric that examines what percentage of the time a dermatologist recommends that the patient come to the clinic for care. This metric was tracked officially by one clinic, though it was unclear that the information was shared with the teledermatology team to change behavior and the interviewee was unable to recall any current data for the metric. Another clinic claimed it was reducing visits by 64% from the Community Based Outpatient Clinics to the main medical center, though no detail was given about how this metric is determined or used. It was unofficially tracked for years in another program by a technician wanting to know how many of the Veterans he imaged needed to travel. He believes the rate of significant travel for dermatology dropped to 5% of the Veterans in his teledermatology service. This program, however, was very rural and had primary care on-site capable of doing biopsies and other small procedures. When discussing the number of face-to-face appointments, there were differences between subjects on whether or not a surrogate dermatologist at a local site was counted as a face-to-face appointment or not. Other relevant missing information is how many patients had to have another non-specialist appointment with their primary care provider for the skin concern seen over teledermatology.

Patient satisfaction is a driver of teledermatology care as seen by its prominent position on the list of benefits of teledermatology and the overall frequency it was mentioned in the current measures. A few of the interviewees were actively measuring patient satisfaction with regular surveys. One teledermatology group created questions so they were able to "identify issues maybe we think are areas for improvement and then solicit Veterans', you know, feedback." Another program reported in a one-time study that 66% of the patients said they would choose teledermatology over face-to-face dermatology if given the choice. Each program that gave details on their patient satisfaction surveys developed their own questions. Others interviewees talked about stories of patient satisfaction but did not have a consistent and systematic way of engaging patients to get feedback; these were not counted as measuring patient satisfaction. In the VHA teledermatology programs this performance measure is in the process of being standardized and implemented nationally as a patient questionnaire. The national leadership noted the anticipated launch. So it is likely this measure will start to play a more significant role in the future.

Similar to orphans, one teledermatology group runs a "consults pending" report from the medical record system. This report identifies any teledermatology patient consult that has not been responded to by a dermatologist. It is slightly different from an orphan report in terms of where data is pulled from and matched, that it looks for missed patients at an earlier stage in the process, and that it does not require matching two stages. The interviewee admits that this had a weakness of not identifying any consults that are not sent to teledermatology at the consult stage.

> *"Um, that, that works for those clinics that have them specifically built as imaging. Um, some of our facilities actually have all of their consults going to dermatology and then they will screen true dermatology to see which ones are appropriate to be done as store and forward. Um, so we are not going to catch those that are going to dermatology first. So they are sent strictly for imaging we would be able to identify if we have any that have not been completed."*
> –Telehealth Administrator, VISN Y

One hospital administrator mentioned that he looked at costs incurred by the teledermatology program for purchasing equipment. He looks at this when any new equipment is proposed and not at the total cost overall.

The national teledermatology office does a qualitative review of each teledermatology program once every two years. This review is currently a conversation to assess how the program is running, but it will be shifting an assessment of the ability to meet the criteria in the national conditions of participation of teledermatology programs as standardization is rolled out to the programs. Surprisingly, the interviewees from teledermatology programs did not mention this as a program measure though each of them must be reviewed. Perhaps this is the case because the review was not used as a metric on a regular basis at the program level but only at the national level.

One teledermatology group mentioned that they used an internal list to check weekly and make sure those patients who were recommended for specific follow-ups, particularly biopsies and excisions, were having those follow-ups scheduled and completed. This could be considered a process and not a metric, but it was included because the participants mentioned the importance of getting people treated within a certain time frame and this list was a representation of those who are above that limit.

One teledermatology program reported doing a one-time study about the rates of certain diagnoses in teledermatology appointments. Two other participants reported the intention to do some sort of analysis on the types of teledermatology diagnosis in the future. One future analysis was specifically to identify rates of incidental skin cancer diagnosis, those not in the primary lesion or those that were not identified in the referral as being potentially malignant. There was no indication that this would be a regularly used metric.

On two occasions participants mentioned recording the number of biopsies that occurred or were recommended after a teledermatology appointment: once in the context of a completed one-time study and once in the context of a proposed future measurement.

Chart review was mentioned as a way to validate that patients are not having bad outcomes because of teledermatology. One group looked at the outcomes for a set of patients with chart review for a random set of patients as part of a pilot program. Another is collecting data and starting a chart review, the interviewee described the process in the following way:

> *"[W]e have tried to figure out for ourselves how we are doing, how we compare to face to face.... looking at things like, complications for procedures. When we direct the primary care provider to perform a procedure, a biopsy or a wide local excision, what are their complication rates compared to all other complication rates for cases under our care?"*
> – Teledermatology Program Manager

In this case, the metric is being used to evaluate the performance of the primary care providers that had been trained as part of the teledermatology program to be surrogate dermatology care providers.

A pilot study measured the time for a teledermatology patient to be seen in the dermatologist office when it was recommended.

Similarly during a pilot study, the accuracy of teledermatology diagnoses was evaluated. The group compared the clinicians' diagnosis in teledermatology to any biopsies that were done and found a 99.2% accuracy rate.

One VISN had done analysis on the travel cost avoided for all of their telehealth programs. The telehealth administrator described the calculation in the following way:

> *"So we know that it is 120 miles round trip between the medical center and XYZ CBOC so 120 mile round trip at X amount cents per mile is X amount of dollars per travel pay. But then it gets into, well which patient is eligible and which patient isn't eligible... I took my standardized round trip distance, my standardized pay per mileage and then I tried to determine, okay, patients in priority groups 1-6 have the potential to be travel pay eligible. And so this clinic, at this location, during this time frame, this was the percentage of all patients seen that were priority groups 1-6. So if 35% of all you know, 800, 900 encounters during the quarter, 35% of those were in groups 1-6, they're potentially travel pay. These were the ones that were seen in telehealth. And I just kind of tried to reverse engineer it. And we averted X amount of dollars in travel pay for telehealth services. But again, it's not specific to dermatology. It was just telehealth overall."*
>
> –Telehealth Administrator, VISN

This calculation was only done once and is not regularly used as part of the program assessment.

Resident satisfaction surveys were being formed by one teledermatology program that also served as an education program. The intention was to understand what impact the teledermatology experience had on the education of future doctors and to better understand the experience from that stakeholder's perspective.

A few of the measurements can be grouped together into larger categories. One set reports on the impact of teledermatology on patients' need to return to the dermatologist for an in-person follow up. This took a few different forms: number of face-to-face visits required, number of patients who need biopsies, and tracking of patients who need follow up. They are listed separately because there are a few subtle differences in the way the need for in-person follow-up is reported. Another set reports the timeliness of care including both timeliness of reading the consult and timeliness of getting an in-person appointment when needed.

Overall, even when the groups considered similar measures, there is little consistency among the different teledermatology programs with which measures are used. Only two measures (workload and image quality) were reported more than 25% of the time.

3.3.2.3 Ideal metrics for teledermatology

To end the section on teledermatology metrics, interviewees were asked about the ideal information they would like to have measured about the programs. Subjects were asked to disregard current system limitations. Twenty-three people were asked this question. Of those 23 people, one hospital administrator did not wish to have more information about the teledermatology program. The subject expected others to keep track of program performance and report it to him. The remaining responses were coded (Table 3-12) and analyzed. Because this question was answered after discussion about benefits of teledermatology which included some prompted discussions and current measures, the answers may have been influenced by the topics the interviewer had previously prompted and also by the omission of current metrics already discussed.

Table 3-12. Ideal teledermatology measures, coded results (22 subjects)

CODES	Number of Comments	Number of Respondents
Timeliness (All)	23	14
Cost (artificially high due to previous prompting)	*12*	*11*
Travel distance & reduced face-to-face	11	9
Patient satisfaction	10	9
General clinical outcomes	11	7
Reduced wait times in clinics	8	6
Method for tracking patient follow up completion	6	5
Provider satisfaction	4	4
Adverse events	3	3
Correct diagnosis made	3	3
Chart review	4	3
General access	2	2
Types & rates of diagnoses	2	2
Reduced fee basis	2	2
Resident satisfaction & training	2	2
Effective utilization of preventative medicine	2	1
Image quality (reimage rate)	1	1
Patient demographics	1	1

The metric mentioned most frequently was the timeliness of care within the teledermatology program. This code, however, was a summation of measurements about the timeliness of care at different points. It included general comments (6 respondents) and responses about the time it takes to respond to a consult (2 respondents), the time it

takes to diagnose the patient with an emphasis on earlier detection because it is easier to seek care (2 respondents), time to get a patient an appointment in the clinic (4 respondents), and the time it takes to get the patient some definitive treatment (4 respondents). All of these are related to each other, as one cannot get to the definitive treatment without the consult being complete with the correct diagnosis; however, measuring the time of the earlier steps without the final endpoint may be misleading of the entire picture. One physician pointed this out:

> *"I think [measuring access to care] has been done with... time to the consult being completed, but again that's just one thing, it needs to be time to the communication of the results of the consult ... maybe time to medication received or definitive treatment. We used that outcome [in a study] because if it was a suspected skin cancer then it would be time to biopsy."*
>
> –Dermatologist

Additionally, four different participants mentioned specifically the timeliness of treating patients with malignancies. Malignant processes, particularly melanoma, have more urgency for treatment than benign dermatological conditions. A different dermatologist described the complexity of the measurement of timeliness:

> *"[T]he trouble is that wait times, waiting six months for a benign condition is not the same as waiting six months for a malignancy. So it would have to be a very sophisticated person doing [the analysis]. You would have to cross correlate that with diagnosis, ... other medical conditions... medications... age, and distance from [place of treatment]. There are lots of variables... [W]aiting three months for somebody who is 30 with a melanoma is not the same as waiting three months for someone who is 95 with actinic keratosis. So, it would require a lot more sophistication than most people are willing to put into it to address those questions in a thoughtful way."*
>
> –Dermatologist

In whatever method timeliness was described, the emphasis from a majority of the respondents indicates that it is an important metric of success for teledermatology programs.

The second most mentioned metric of teledermatology was the cost of giving the care. For many subjects, this measurement was prompted into the discussion by the interviewer in earlier discussion of the goals of teledermatology, and its importance to the subjects may have been inflated by previous discussions. Specific details participants mentioned when discussing the costs of the program are the unknown number of employee hours or Full Time Equivalents it takes to support the teledermatology program, the amount of money

VHA saves by not having to pay for travel costs of the Veterans, and the cost savings available by making use of lower-level providers to do some of the work and procedures previously done by dermatologists.

The reduction in Veterans' need to travel was emphasized not just as a way to reduce cost but also to measure the change in access to care. If every patient who has an image analyzed by the dermatologist then has to then see the dermatologist in-person, the program is creating a new barrier to access the dermatologist and increasing the amount of dermatologists' time used for each patient. Reducing the number of patients who have to see the dermatologist by having treatment given by primary care or lower-level providers trained in dermatology procedures is one important measure of success for teledermatology patients. Many of the participants expressed the desire to know how many of the teledermatology patients were being seen by dermatologist after the virtual encounter.

Patient satisfaction was also frequently mentioned as an important aspect of teledermatology success. Interviewees mentioned anecdotal stories of satisfied patients but thought systematic measurement of patient satisfaction would allow exposure of potential problems with the program such as delays in getting in-person appointments, delays in returning results to the patients, or feelings that the non-dermatologist providers are not giving as competent care as dermatologists.

Many of the participants believed that teledermatology programs should be measuring the clinical outcomes of the teledermatology patients but did not give examples of specific measures. This was noted in the findings despite the lack of specificity because clinical outcomes were considered very important, even to those who did not focus on clinical care and did not have the domain knowledge. An example of such a general comment that emphasized clinical importance is a VISN administrator saying that clinical outcome measures are "first and foremost." As part of general outcome measures, one dermatologist specified that final clinical outcomes are more important than getting the diagnosis right because they tell a more complete picture.

The suggested measurements of teledermatology went beyond just the program to include the measurement of wait time in the in-person dermatology clinic for all patients, not just teledermatology ones. Interviewees mentioned that successful teledermatology programs should be able to triage-out many of the people who do not need face-to-face care and free up appointments for those who do. A dermatologist described the impact on wait time in the following way:

> *"The telederm is a minor piece of the entire process of care... [F]rom the time the patient comes in and says I have a spot until that problem is resolved, I am sure that on average, in 50% of the sites, we're slower than that patient would be treated in a dermatology clinic. But, the other side of that is, if we weren't there to take care of all these patients, the dermatology clinics would be flooded with patients. And so I believe that the bottom line is that we probably improve access to face to face by offloading a lot of the cases into our program."*
>
> –Dermatologist

This metric may be more important for tele-triage of local clinics than long distance treatment of patients who would otherwise see a different dermatologist.

Some clinicians believed that there may be a gap between what the dermatologist recommends and the actual treatment and communication to the patient. For this reason, they request one metric be a method of tracking if patients receive the follow-up that was recommended.

> *"I think sometimes things fall between the crack and we don't get quite the follow up we would like, or someone does really well or patients are not complying or they're like, or the don't really do it or you know. You can never quite tell. We don't get the follow up. It would be great to know how things always panned out if we recommend a certain follow up. But you know, once we put out a telederm response, it goes away from the queue. And we could back into certain places within telereader to find these old ones to follow up ourselves, but we don't really have this continuing, running list of "oh yeah, I read, I recommended this, what happened to this person?" We don't get a lot of that."*
>
> -Dermatology Provider

> *"It's not lost, but you know, I usually I like to call the patient to let him know about whatever treatment the dermatologist recommended. Because usually they send more than one cream with different instructions and our main population are very elderly patients so, since it's hard for them. So I like to contact them and tell them. If it's been a very busy day sometimes I forget to check, to check back whatever the dermatologist said."*
>
> –PCP

This may not be true for all programs, but it is a significant issue that should be addressed within the teledermatology programs.

Just as systematic collection of patient satisfaction data can expose program weakness, regular evaluation of providers' opinions can help improve the performance of teledermatology programs. Interviewees mentioned they were particularly interested in knowing if physicians feel their patients are getting the best treatment, if they have the support and education they need, and if the process is "seamless" and "easy to do."

As one of the indicators of clinical outcomes, three respondents mentioned that one metric should be reporting of adverse events in the teledermatology program. Specific examples of adverse events to be reported are teledermatology patients that end up having a malignant condition that was diagnosed as benign, teledermatology patients that end up seeking care in the emergency department, and teledermatology patients that are found later to have been misdiagnosed after the condition worsens.

One critical clinical outcome measure is whether or not the correct diagnoses, primary and differential, are being made in the teledermatology consults. One clinician had a unique use of diagnostic accuracy rates, combining them with other information to create "quarterback ratings" for the teledermatology readers that are used as quality "metrics to help us decide what a good reader is and how they utilize VHA resources."

Another suggested form of clinical outcome reporting was reviewing the charts of a random sample of teledermatology patients. This was suggested as a way to have quality review of the original teledermatology consults, to validate that the correct diagnosis was made, and to make sure the follow-up actually occurs. Instead of being a separate method, this could also be considered a way to accomplish evaluation of a few of the metrics mentioned above.

Two participants mentioned access to care was an important measure of success for teledermatology programs but did not give specific examples of how it should be measured.

In addition to the accuracy of the diagnosis, two participants were interested in knowing the total rates of each type of diagnosis in the teledermatology program. One interest was specifically about rates of skin cancer detection and if that is changing because of teledermatology. The other was the overall range of diagnoses to prepare and train the dermatologist reading the images.

Two participants mentioned one measure of access to care could be the change in the rate of dermatology appointments paid for by VHA, called fee-basis appointments. This metric shows that VHA is able to offer dermatology care within the hospital system to more participants than it was before the teledermatology program.

One hospital administrator and one dermatology care provider were interested in the impact of the teledermatology program on the residents training in the dermatology department. They were interested in their satisfaction and experiences with the technology as part of their education.

One dermatologist mentioned that he wanted to know if teledermatology changed the effective utilization of preventative medicine. This physician was interested in whether or not this program was educating providers to catch potential melanomas earlier and use topical chemotherapies to reverse sun damage when it was seen with teledermatology.

One participant was interested in the image quality as it particularly relates to how many patients needed to come back for more pictures or go straight to the dermatologist because the image quality was so bad.

Finally, one interviewee was interested in the demographics of the patients that are being treated with the teledermatology program specifically in reference to their rural or urban origination.

3.4 Discussion

3.4.1 Current state of teledermatology

There is significant variability in the way teledermatology programs operate in VHA. This includes the models of care delivery and other operational features such as training and educational programs. These discrepancies between the programs can each affect the outcomes that are measured for the teledermatology programs. This necessitates that further analysis of teledermatology at VHA should be separated out into these different programs. Analysis at the program level allows comparison of the various program structures for the metrics analyzed in the thesis. This comparison can help in the planning or improving of teledermatology programs by understanding the benefits of each structure.

Within the programs analyzed, only a few used clinical video telehealth, mainly as a supplement to the store and forward teledermatology program. The clinical video telehealth appointments are also similar to in-person appointments as compared to store and forward telehealth. Store and forward teledermatology will be the main focus of future analysis of teledermatology in this thesis because this method of care is the most utilized type of telehealth in dermatology and also because it significantly changes the care process.

One feature of the teledermatology programs that affects future analysis is the presence of regional readers. In most cases, the definition of a teledermatology "program" will be one hospital and all of the outpatient clinics that the hospital serves. But, in the programs with regional readers, the teledermatology "program" will include all of the hospitals that are served by a teledermatology program and all of their clinics. They will all be grouped into one large population for analysis. There still may be small differences between how the program operates and affects the populations of the different hospitals, but all of the biggest factors can be evaluated at the program level.

The difference in severity and type of conditions between the teledermatology population and the population sent straight to in-person care from a dermatologist must also be taken

into account when evaluating metrics. This difference creates a bias, and care must be taken when comparing specific outcomes between the two populations.

The most critical unexpected theme that emerged from the current state analysis is the fear people have about patients being lost in the teledermatology system. Subjects think it is possible that a patient will not have a potential melanoma biopsied or that the correct way to apply a medication will never be explained leading to poor adherence and effectiveness. Whether or not this fear is justified, its presence will likely affect the implementation and growth of teledermatology in VHA. For that reason, this concern will be addressed in the recommended metrics for teledermatology.

3.4.2 Recommendations for metrics for teledermatology

When discussing the current metrics used in teledermatology programs, there was little consistency between the various program and a sense that measurement is used differently across both locations and time in programs. Some measures are being used effectively to improve processes such as image quality feeding back into imager training, some measures are being used purely for reporting purposes such as workload, and some are used as one time studies to understand how a program is working but are too time intensive to be checked all the time. Two factors may be at play in complexity and completeness of measurements for a teledermatology program, first the maturity of the program and second the resources available. Current metrics may shift with national standards, change in resources, and the maturation of the teledermatology programs at each location.

Two measures were used with some frequency, the volume of teledermatology and the image quality. The image quality metric was exemplary in its ability to drive behavior and improve the teledermatology programs. Other measures were inconsistently used, though patient satisfaction surveys are being approved for national use and will likely be important for all programs in the future. This inconsistency leaves room for a standardized set of metrics that cover a wide range of important aspects of teledermatology.

Any nationally standardized metrics should cover the needs of all stakeholders, include all of the important categories of evaluation, and make sure that the goals of teledermatology are being met. The interviewees' answers about the benefits of teledermatology, current metrics, and ideal metrics were combined and sorted into the telehealth categories from the literature and IHI performance measures. To visualize how the responses fit into the categories and how well the current state matches the ideal metrics, Table 3-13 was created in which every metric and idea is related to the categories in the same row. The space was left blank if there was no category or metric for a column that fit with others in the row. The number of people who responded is noted in parentheses for each idea to emphasize the importance given to each segment. When looking at the chart it is also important to note that some measures are on the chart twice because they are addressing multiple categories. Additionally, this chart does not distinguish between regularly reported metrics and those with only one-time studies or planned actions not yet carried out within the "current metrics" column. This can create an overly optimistic view of what is being done in teledermatology measurement.

For example, reduced travel distance for Veterans and the associated reduction in face-to-face visits with dermatologist is a highly-ranked ideal metric for teledermatology. This metric is related to the potential teledermatology benefit of reducing the cost of the travel, for both the patient and for the hospital, which in turn can be categorized into the "cost" category of telehealth evaluation and the "efficiency" category of IHI healthcare system measurement, as seen in the left-most columns. This ideal metric is also related to the goal of reducing the travel distance for Veterans to get care. In this context the ideal metric is measuring the "access" and "patient centeredness" of the teledermatology program. In both cases, the metrics that have been measured within VHA, which can be seen in the rightmost column, are reduction in travel cost through estimates created one time by one program and the rate of post-teledermatology face-to-face visits with dermatologist investigated by six programs in one time studies.

A few things were excluded from the diagram created: (1) the types and rates of diagnoses because it did not fit clearly into any of the evaluation criteria, (2) the qualitative national

review as a current metric because though it covers many different aspects of evaluation it was not a behavior driver for the individual programs due to low frequency of evaluation, and (3) the effective utilization of preventative medicine as an ideal metric because this too was not specific to teledermatology and did not have clear metrics associated with it.

Study results were used to create a set of recommended metrics that cover the goals of the teledermatology program and the categories from the telehealth literature and from the IHI healthcare system measurement. These categories have been highlighted in the ideal metrics column of Table 3-13. Green indicates VHA is already making progress on a metric, orange is a metric for which data is available within VHA and will be addressed with the work in this thesis, and red should be added to the goals of VHA's future work.

Table 3-13. Relationship between telehealth evaluation categories, ideal metrics, and current metrics

Telehealth Categories	IHI Categories	Benefits in VHA (Number of Respondents)	Ideal Metrics in VHA (Number of Respondents)	Current Metrics in VHA (Number of Respondents)
Cost	Efficiency	Cost to hospital (11)	Reduced fee basis (2)	
			Cost (11)	Equipment cost incurred (1)
		Cost of travel (13)	Reduced face-to-face & travel (9)	Travel cost avoided (1)
		Cost to patient (2)		Face-to-face visits (6)
			Cost (11)	Travel cost avoided (1)
Clinical Outcomes	Timeliness	Earlier treatment- timely diagnosis & treatment (13)	Time to consult response (2)	Timeliness of consult response (5)
			Time to appointment (4)	Time to appointment (1)
			Time to definitive treatment (4)	
	Safety		Method for tracking patient follow up completion (5)	Internal follow up tracking (1)
				Orphans & consults pending (5)
			Adverse events reporting (3)	
			Chart review (3)	Chart review (1)
			Image quality & reimage rate (2)	Image quality (9)
			Correct diagnosis made (3)	Diagnostic accuracy (1)
				Photos are deleted (4)
	Effectiveness	Earlier treatment- reduced wait time in clinic (8)	Reduced wait times in clinics (6)	
		Serve areas with difficult physician recruitment (2)		
		New clinical perspective (3)		
Satisfaction	Patient Centeredness	Physician education & satisfaction (3)	Provider satisfaction (4)	
			Resident satisfaction & training (2)	Resident satisfaction (1)
		Patient satisfaction (5)	Patient satisfaction (9)	Patient satisfaction (6)
Access		Travel distance (13)	Reduced face-to-face & travel (9)	Travel cost avoided (1)
				Face-to-face visits (6)
				Rate of biopsies (2)
	Equa-lity	Earlier treatment- more likely to seek care (2)	Time to diagnosis- earlier treatment (2)	
			Patient demographics (1)	
				Workload/Volume (15)

RECOMMENDATION COLOR KEY:

VHA already addressing | Attempt as my research | Recommend VHA address

VHA is already measuring image quality, making information available on time to consult response, and launching a patient satisfaction survey. The organization should continue these efforts and make these metrics available for improvement in each of the programs. Measures are strongly inter-related.

VHA could improve teledermatology reporting by tracking the provider satisfaction, standardizing a method of patient tracking through the teledermatology system, measuring safety through chart review or adverse event reporting, and tracking costs particularly for reduced fee appointments to outside dermatologist. All of these measurements require new data collection or IT infrastructure within VHA but should be long-term goals to be included in the teledermatology program.

Three additional metrics that VHA is primed to take action on because of available data within the system are: time to treatment and time to appointment, reduced travel for Veterans because of reduced utilization of dermatology resources, and wait time changes within clinics, which are measured in VHA but not in relation to the teledermatology program. These three teledermatology metrics will be the content of the next chapters.

3.4.3 Limitations

Sampling bias of interviews and cases will be the biggest methodological limitation of the qualitative work, including both the convenience sampling of locations and personnel within the locations. This bias is unavoidable with the limited resources for this project. Efforts to mitigate the bias include filling the specific geographic and program size strata and supporting the results with other types of data. Finally, while relatively mature, some telehealth programs started before 2012 are still growing and full system efficiencies may not yet have been realized by the time of this analysis.

Because of the lengthy and burdensome approval process required to discuss teledermatology with a random sample of patients, no patient interviews were included in

this study. The patient is one of the most important stakeholders in this program and not having access to their thoughts is a significant limitation. To compensate for the missing data, stakeholders who had contact with patients were asked about any patient comments or opinions shared with them. Additionally, the conclusions take into account the existing and extensive literature on patient satisfaction data for teledermatology. For example, faster time to interaction with a dermatologist increases patient satisfaction[74] and willingness to pay,[73] so timeliness of consult was considered an important consideration for patients.

3.4.4 Future work

Further work in this area should expand to include data collection on the patients' perspectives. Their understanding of the benefits of teledermatology would be beneficial to understanding what should be measured about the system.

Additionally, this work brings up further questions about the implementation of teledermatology programs that can be answered with qualitative investigation.

- What types of metric reporting in VHA have the most impact on behavior and why? With some participants not being aware of teledermatology metrics and high-level officials not wanting to be aware, it is important to understand the most effective way to implement any new metrics added to the teledermatology program.
- Why is follow-up care not being given directly in teledermatology programs? Store and forward teledermatology has been cited as a possible way to follow-up on some conditions, but it is not currently being used in this way. Finding the barriers for this use could further improve access to dermatology within VHA.
- What is the most effective training program for local non-physician dermatology care providers utilized in teledermatology? There are a wide variety of tasks for which these care providers are being used and these could be compared among systems.

The next three chapters of this thesis will evaluate access to care metrics for teledermatology programs within VHA. The first to be evaluated is the time to treatment.

4 Time to Treatment for Skin Cancer Patients, Comparing Teledermatology and Consults

4.1 Introduction

In previous sections of this thesis, qualitative investigation of the Veterans Health Administration (VHA) stakeholders' viewpoints found that improved access was one of the key benefits of teledermatology programs. Twenty out of the 22 people mentioned the benefit "improved access to care" with one important component of access described as earlier treatment. Yet time to treatment is not actively measured within any teledermatology programs examined, except perhaps as a component of chart review. Time to treatment was selected as a measure of the success of telehealth to be examined in this thesis because of its importance, feasibility of execution, and current lack of information within the VHA programs. The analyses were performed on the sub-population of patients with skin cancer as their treatment is clinically time sensitive, potentially lifesaving, and has a definitive first treatment point: excision or destruction of the malignant lesion. The importance of skin malignancies was emphasized by stakeholders' many stories of melanomas treated quickly or the mentioned fears of melanoma diagnoses being missed. The examination of time to treatment in the VHA teledermatology patients compared to patients entering the system through traditional in-person consults is the subject of the following chapter.

There are a few instances of time to treatment for skin cancer using teledermatology being assessed in the literature. In 2005 Moreno-Ramirez and colleagues measured time to the first in-person visit with a dermatologist for teledermatology consults determined to be urgent.[93] The visits were all completed within two weeks as required by the clinic's skin cancer mandate. The same group did another study in 2007 that compared the time to surgery starting from the time of the diagnosis of non-melanoma skin cancer (NMSC) and referral to a NMSC surgery clinic.[106] Here the mean time to surgery was 26 days for

teledermatology and 61 days for traditional consults with the reduction in time for teledermatology patients due to the ability to plan the surgery without extra appointments.[106] Hsiao and Oh (2008) investigated the mean time to treatment for skin cancer patients referred to a dermatology surgery clinic as a result of teledermatology or traditional consult referrals in VHA.[79] They found teledermatology patients had faster time to initial consult (4 days to 48 days, $p<0.001$), faster time to biopsy (38 days to 57 days, $p=0.034$), and faster time to treatment (104 days to 125 days, $p=0.006$).[79] However their analysis suggest the differences in the time to treatment between the two groups are due to the subset of teledermatology patients that did not have to see a dermatologist because of an obvious tumor scheduled straight for surgery or PCP performing a biopsy instead of a dermatologist.[79] This work expands previous efforts by: 1) examining a larger data set across many VHA programs that includes skin cancer treatments done by any physician within the network, 2) analyzing both melanoma and non-melanoma skin cancers separately, and 3) creating data for each program to facilitate comparisons and development of best practices.

In this study the following hypotheses are examined:
Teledermatology changes access to care among different populations by decreasing the time to definitive treatment, specifically among skin cancer patients and that this decrease in time to treatment is due to a decrease in the time to biopsy or initial dermatology appointment.

These hypotheses will be assessed for melanoma patients and NMSC patients separately as the time to treatment has different clinical significance for the two groups. Time to treatment for teledermatology will be compared with in-person consults, which in this work refers to the traditional treatment model where patients are referred by their primary care physician for an in-person appointment with a dermatologist.

4.2 Methods

4.2.1 Data Sources

Information on patients who have been treated for skin cancer within VHA was retrieved from the VHA's Corporate Data Warehouse (CDW). The CDW is a national repository for information from clinical and administrative systems within VHA. Most fields are generated from the use of the Veterans Health Information Systems and Technology Architecture (VistA) system to schedule and document care in patients' medical records. The information is stored in a relational database. The CDW was accessed through a research portal that uses a generated patient identifier *PatientVID* instead of social security numbers. This patient identifier is different from the one used in the clinical setting for the protection of patients' private health information. Tables and fields from the CDW used in the time to treatment of skin cancer analysis are listed in Table 4-1.

Table 4-1. Description of CDW database tables

CDW Table	Information Contained in Table
Outpatient Visits	For each visit in VHA an entry is created with the date, time, location, primary and secondary diagnoses (using ICD9), procedure codes (using CPT), clinical provider(s) involved, department of care provided (by primary stop code: 304=dermatology, 323=primary care in-person), and if it occurs a marker for a specialty type of care within the department (by secondary stop code: 694=patient imaging for teledermatology, 695=provider analysis of teledermatology in same hospital system, 696=provider analysis of teledermatology in different hospital system).
Consult	For each time a physician request a consult (new access to specialty care for a patient) an entry is made with the date and time of the request, the location of the request, the requesting provider, and the department of care requested.
Patient (Demographics)	Patient files contain gender, race, address, marital status, and VA eligibility code information.
Dimensions	The dimensions table is used to translate coded fields in the tables above, such as the ICD9 diagnosis code and description. This second level of coding is used to protect patient health information.

4.2.2 Defining and Identifying Patient Cohorts

4.2.2.1 Inclusion into skin cancer patient cohorts

The population used for analysis of time to treatment of skin cancer is VHA patients with diagnosed skin cancers treated in VHA hospitals. This national analysis includes more than the patients associated with the 19 teledermatology programs identified in the introduction. Therefore, there are patients in new teledermatology programs and patients in the consult group who have no access to teledermatology. VHA patients treated for skin cancers at non-VHA hospitals through VHA-paid care or outside insurance were not included because not enough information could be obtained about this group.

There were two inclusion criteria for patients in the VHA skin cancer population: 1) the patient had a diagnosis of a skin cancer in the medical record and 2) the patient had an event of treatment of a malignant skin lesion. Eide and colleagues validate this method of identifying NMSC patients with diagnosis and procedure codes through a chart review of hundreds of patients and found a positive predictive value of 94.9-96.7%.[107]

The diagnosis of skin cancer was identified by the International Classification of Diseases, 9th Revision (ICD-9) diagnosis codes for melanoma or NMSC (Table 4-2) listed as a diagnosis of an outpatient visit or in a stored problem list recorded by a physician. These two diagnosis groups were analyzed separately because the risks of delayed treatment for melanoma are more serious than NMSC.

Table 4-2. Codes used for skin cancer diagnosis

Diagnosis	Corresponding ICD-9 Codes
Melanoma	172.00-172.99
Non-melanoma skin cancer	173.0-173.9

The treatment of malignant skin lesion was identified through the presence of the Current Procedural Terminology (CPT) codes for destruction of a malignant lesion (NMSC only), excision of a malignant skin lesion, or chemosurgery of a malignant lesion also commonly referred to as MOHS (NMSC only) (Table 4-3).

Table 4-3. CPT codes used for skin cancer treatment

Category of Treatment	Corresponding CPT Codes	Diagnosis Group for Inclusion
Excision of malignant skin lesion	11600-11606 11620-11626 11640-11646	Melanoma & Non-melanoma skin cancers
Destruction of malignant skin lesion	17260-17266 17270-17276 17280-17286	Non-melanoma skin cancers
Chemosurgery (MOHS)	17311-17315 17304-17310 (2nd pre 2007)	Non-melanoma skin cancers

If both the CPT and ICD9 codes are present in a patient record this patient was included in the initial cohort. It was not a requirement that the CPT and ICD9 codes were recorded at the same outpatient visit because in many cases the physician may not have a detailed diagnosis until after the pathologic analysis of an excised lesion. For these cases, the CPT code is directly associated with a more generic skin lesion diagnosis code.

Two more exclusion criteria were used to increase the likelihood that the treatment event corresponds to the diagnosis. First, patients with both melanoma and NMSC diagnoses were excluded from the analysis. Because the diagnosis and treatment do not always occur at the same time, it was not possible to consistently identify which treatment event was related to a specific diagnosis with the information available. Second, patients with more than five treatment events were excluded. The range of treatment events per person from 2005-2013 was from 1 to 41 for NMSC and 1 to 7 for melanoma. With so many treatment events it is difficult to decipher what events are related to malignancy and these populations were excluded. Only 5% of the NMSC and 1% of the melanoma patients were excluded for this reason.

4.2.2.2 Inclusion into treatment groups

After the skin cancer patient cohorts were created, they were divided into the teledermatology and traditional consult groups. Consults to dermatology were identified by the *ToRequestServiceName* field in the Consult table of the CDW, the name of the

department to which the consult request was made. To identify dermatology requests the terms "DERM" and "304" were used in the search field, but to exclude specialty dermatology departments like surgery and pathology and to exclude requests generated for teledermatology results with strings "PATH", "MOHS", "SURGER", "TELE", "FORWARD", "READER", "IMAG", and "PHOTO" were excluded. This exclusion list was generated by reading all results of the *ToRequestServiceName* and verifying that all requests to see a dermatologist were included and specialty dermatology and teledermatology were excluded. In the consult request there was a free text field for the reason for the consult, but this field is not required to generate the consult and was not used consistently enough to further refine the consult requests to those that mention potential malignancies.

The teledermatology clinical process generates two separate consults, one for the image to be taken and one for the dermatologist to review the image. Across different facilities there is no consistent naming strategy of these two consult requests. Additionally, some facilities changed their referral structure during the period of analysis. Dates of imaging teledermatology visits were used instead of consults to create a more consistent measure of the start of the teledermatology process. Specifically, teledermatology visits are those in the Outpatient table of the CDW with a primary stop code "304" for dermatology and a secondary stop code "694" to indicate imaging for store and forward teledermatology. Often the image is taken the same day as the request is put in the by referring physician, but occasionally there is a delay of a few days. This inconsistency creates a small bias towards the teledermatology group in the time to treatment analysis but was considered acceptable because it was the best option for identifying the patients. The diagnosis code for the outpatient teledermatology visit was not considered for further refinement of the teledermatology group because the skin cancer diagnosis was not yet known.

Using these criteria for the two groups excludes skin cancer patients who are already in treatment in the dermatology department and do not need a consult like a new patient would need. This excludes from the analysis skin cancers found on follow up skin exams and some incidental discoveries of skin cancer while treating other skin conditions.

Two exclusion criteria were put in place to increase the likelihood that the consult or teledermatology event identified was related to the treatment of skin cancer for that patient. The first criterion is exclusion of any patients where the consult or teledermatology appointment occurred more than one year before the treatment event or occurred after the treatment event. The one year time frame for treatment chosen for this analysis was validated by a subject matter expert and is consistent with a similar analysis done at a smaller scale.[79] The second criterion is exclusion of any patient with more than three dermatology visits between the teledermatology event and the excision. More than three dermatology visits would be inconsistent with the clinical process for treating a skin cancer identified in the initial consultation.

4.2.2.3 Summary

The inclusion and exclusion criteria for each analysis group are summarized in Table 4-4.

Table 4-4. Summary table of inclusion/exclusion criteria

Criterion Group	Description
Melanoma Patient Cohort	ICD-9 for melanoma (172.00-172.99) in visit or problem list AND CPT for excision of malignant lesion (11600-11606,11620-11626,11640-11646)
NMSC Patient Cohort	ICD-9 for NMSC (173.0-173.9) in visit or problem list AND CPT for excision of malignant lesion (11600-11606,11620-11626,11640-11646), destruction of malignant lesion (11600-11606, 11620-11626, 11640-11646), or MOHS (17311-17315, 17304-17310)
Consult Patient Cohort	In NMSC or Melanoma Patient Cohort AND "ToRequestServiceName" field of consult request with "DERM" or "304" but not "PATH", "MOHS", "SURGER", "TELE", "FORWARD", "READER", "IMAG", and "PHOTO"
Teledermatology Patient Cohort	In NMSC or Melanoma Patient Cohort AND Outpatient visit with PrimaryStopCode="304" and SecondaryStopCode="694"
Exclusion Criteria	1) In both Melanoma and NMSC Cohorts 2) More than 5 treatment events for skin cancer 3) More than 1 year between consult or teledermatology and treatment event 4) More than 3 dermatology visits between consult or teledermatology event and treatment event

4.2.3 Calculating Treatment Times

The primary analysis focused on time to treatment for each skin cancer diagnosis group, defined as the difference in days between the date of the consult request or teledermatology imaging visit (t=0) and the date of the treatment event. In the course of care it was possible that the patient had an in-person dermatology visit and/or had a biopsy. These two events did not always occur but were noted and added to the analysis when they did. In-person dermatology visits were defined as outpatient visit with a primary stop code of "304", indicating a dermatology department, but excluding those with secondary stop codes for teledermatology visits (694, 695, and 696). The definition for biopsy events was a procedure code (CPT code) for a biopsy (details of the biopsy CPT codes can be found in Appendix C). The CPT code list was created by generating list of all CPT codes recorded in dermatology visits and selecting all the codes that described biopsies.

For all treatment events that occurred in calendar year 2013, the time to treatment was calculated and aggregated into diagnosis groups, allowing comparison between teledermatology and consult categories. The step was repeated for the time to biopsy and time to first dermatology appointment when a biopsy and dermatology appointment occurred as part of the care process. Analysis for time to treatment for each diagnosis was also done on the two sub-groups: patients who had a biopsy and patients who did not have a biopsy.

For the NMSC cohort the population consistently had more than 10 patients in both the teledermatology and consult group for teledermatology program per year, a large enough sample to do analysis of time to treatment for each program started before 2011. The melanoma cohort was not large enough for this program level analysis. The NMSC analysis was expanded to include aggregation of treatment events in each program every year from 2006-2013, though some had less than 10 patients in the teledermatology groups in earlier years.

4.2.4 Demographics

For each patient in the analysis the date of birth, gender, race, county, marriage status, and VA eligibility code were extracted from the CDW. The VHA eligibility code is a structure used to note the amount of services and reason for services available to the Veteran due to a service connected injury or economic status of the Veteran. If there were two conflicting entries for any of the demographic information, the most recent non-null value was selected. The dates of birth were used to calculate the patients' ages at time of skin cancer treatment event. The county was matched with the Rural-Urban Continuum Codes (RUCC) from Economic Research Service.[108] More details about the codes can be seen in Table 4-5.

Table 4-5. Description of 2013 Rural-Urban Continuum Codes (REF)

Metro Category	RUCC	Description
Metro Counties	1	Counties in metro areas of 1 million population or more
	2	Counties in metro areas of 250,000 to 1 million population
	3	Counties in metro areas of fewer than 250,000 population
Non-metro Counties	4	Urban population of 20,000 or more, adjacent to a metro area
	5	Urban population of 20,000 or more, not adjacent to a metro area
	6	Urban population of 2,500 to 19,999, adjacent to a metro area
	7	Urban population of 2,500 to 19,999, not adjacent to a metro area
	8	Completely rural or less than 2,500 urban population, adjacent to a metro area
	9	Completely rural or less than 2,500 urban population, not adjacent to a metro area

For each diagnosis category, demographic information was compared between the teledermatology and consult groups to understand the equivalency of the populations.

4.2.5 Statistical Analysis

Time to treatment and time to clinical event curves are graphically displayed in the Kaplan-Meier Curve using the treatment or clinical event as the final time point. Kaplan-Meier curves for teledermatology and traditional consult were compared using the log-rank test with an α=0.01 significance level.

Demographic categorical data was analyzed using Fisher's exact test for count data when the calculation was possible. If the numbers were too large for Fisher's test calculations to be completed, the Chi-squared test was used. For RUCC analysis some codes were combined to ensure that the count in each category was sufficient for the use of the Chi-squared test. The mean and median age data were compared using the Student's t-test and Wilcox-Mann test, respectively.

Queries to generate patient cohort from the CDW were completed in MySQL Server Management Studio 2012. Further refinement of the cohort and statistical analysis were performed in R-Studio using R version 3.1.0.

4.3 Results

4.3.1 Melanoma National Analysis

There were 1,615 VHA patients who had a malignant skin excision in 2013 and fit the inclusion and exclusion criteria for the melanoma patient group. Of those, 868 (53.7%) and 165 (10.2%) fit the criteria for the consult and teledermatology cohorts, respectively. In the consult group 558 patients had a biopsy as part of the care process and 750 had a visit with a dermatologist. In the teledermatology cohort 86 patients had a biopsy and 129 had a visit with a dermatologist (Figure 4-1).

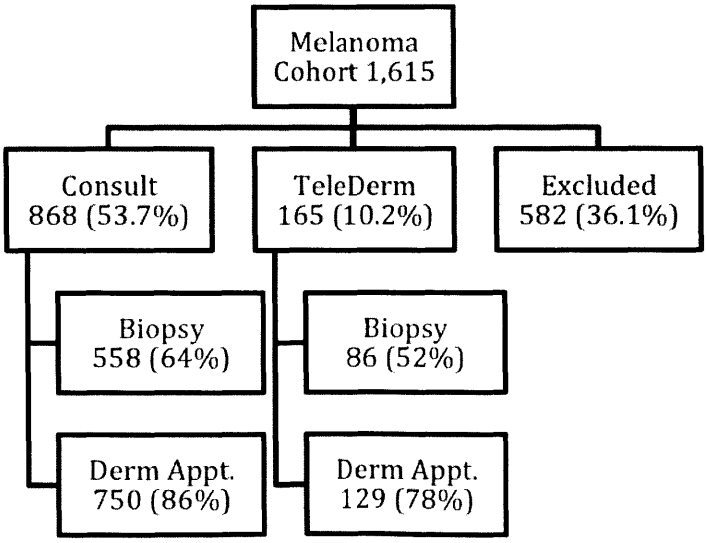


Figure 4-1. Melanoma cohort break down

Comparison of demographic information (Table 4-6) does not show significant differences between the two groups in the age, gender, VA eligibility code, race, or marital status. However, there was a difference ($p<0.001$) in the RUCC distribution. Teledermatology patients have a higher concentration in smaller metro areas and a lower concentration in large metro areas (RUCC 1) compared to traditional consult patients.

Table 4-6. Demographic summary of melanoma patients

Melanoma Skin Cancer Patient Demographic Summary					
Category	**Description**	**TeleDerm (n=165)**	**Consult (n=868)**	**p-Value**	**Type of Statistical Analysis**
Age	Mean Age at Treatment (Years)	65.7	64.5	0.2056	Student t-test
	Median Age at Treatment (Years)	66	65	0.18	Wilcox-Mann
Gender	% Male	97%	96%	0.7439	Fisher's Exact Test for Count Data
VA Eligibility Code	% VA Code 1	27.9%	26.0%	0.4248	Fisher's Exact Test for Count Data
	% VA Code 2	0.6%	1.5%		
	% VA Code 3	20.6%	23.3%		
	% VA Code 4	1.8%	2.2%		
	% VA Code 5	48.5%	47.0%		
	% VA Code 6	0.6%	0.0%		
Race	% American Indian or Alaska Native	0.0%	0.5%	0.1437	Fisher's Exact Test for Count Data
	% Asian	0.6%	0.0%		
	% Black or African American	0.0%	0.3%		
	% Unknown	6.0%	9.9%		
	% Native Hawaiian or other Pacific Islander	0.0%	0.8%		
	% White	93.4%	88.5%		
Marital Status	% Divorced	26.1%	25.3%	0.2551	Fisher's Exact Test for Count Data
	% Married	55.8%	56.7%		
	% Single	6.7%	9.6%		
	% Separated	3.6%	1.4%		
	% Unknown	1.2%	0.6%		
	% Widow/Widower	6.7%	6.5%		
Urban/ Rural Code	% RUCC 1 Metro Area: Population > 1 Mil	30.9%	49.1%	**1.27E-04**	Chi-Squared Test
	% RUCC 2 Metro Area: 1 Mil < Population < 250,000	26.1%	21.8%		
	% RUCC 3 Metro Area: Population < 250,000	14.6%	8.4%		
	% RUCC 4,6 Urban Population adjacent to Metro Area	18.2%	15.1%		
	% RUCC 5,7 Urban Population not adjacent to Metro Area	5.5%	3.5%		
	% RUCC 8,9 Rural Population	1.8%	2.1%		

The difference in days between the teledermatology appointment or consult request until the treatment event ranged from 0 to 364 for consult events and 2 to 364 for teledermatology events. For both the consult and teledermatology cohorts there is a positive skew in the aggregate data (Figure 4-2).

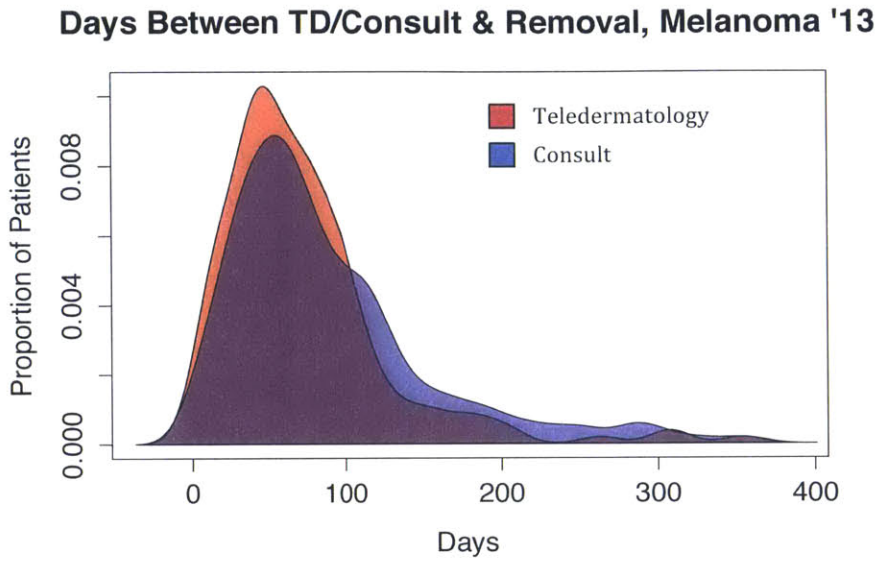


Figure 4-2. Time to treatment density curves for melanoma patients.

Median time to treatment is 70 days for traditional consults and 62 days for teledermatology. When comparing the Kaplan-Meier survival curve, where the treatment event is considered the endpoint (Figure 4-3), the teledermatology cohort has significantly faster time to treatment than the consult cohort (χ^2=9.5, p=0.002). The difference is most pronounced between the 80-150 days to treatment.

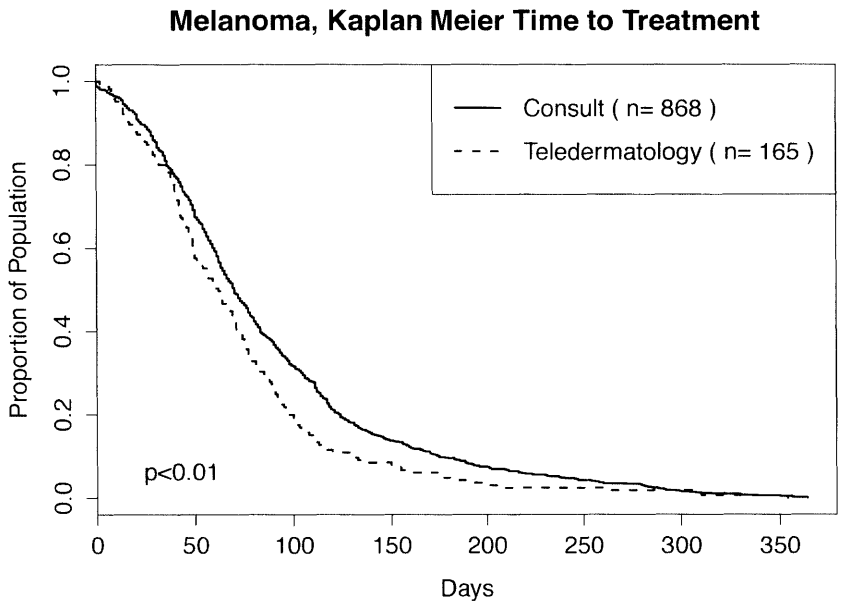


Figure 4-3. Melanoma time to treatment Kaplan-Meier curves

For those who had a biopsy (64% of consult cohort and 52% of teledermatology cohort), the distribution of the time to the biopsy is positively skewed with a median of 37 days for traditional consult patients and 29 days for teledermatology patients. In Figure 4-4 it is seen that similarly to the overall time to treatment for melanoma patients, the teledermatology group reaches the endpoint of biopsy faster than the consult group (χ^2=9.6, p=0.0019). The largest difference between the two curves occurs in the 40-80 day range.

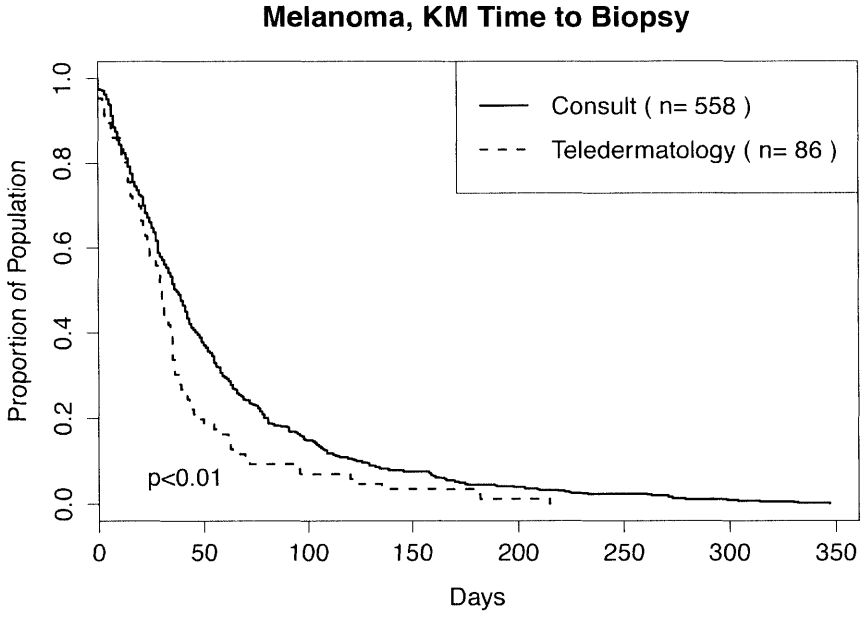


Figure 4-4. Melanoma time to biopsy Kaplan-Meier curves

For the time to the first dermatology appointment, which occurs in 86% of the consult patients and 78% of the teledermatology patients, there is not as much difference between the two cohorts. The median time to appointment is 31 days for the consult group and 29 days for the teledermatology group. This results in no statistically significant difference between the Kaplan-Meier curves of the time to dermatologist appointment (χ^2=5.8, p=0.016) (see Figure 4-5).

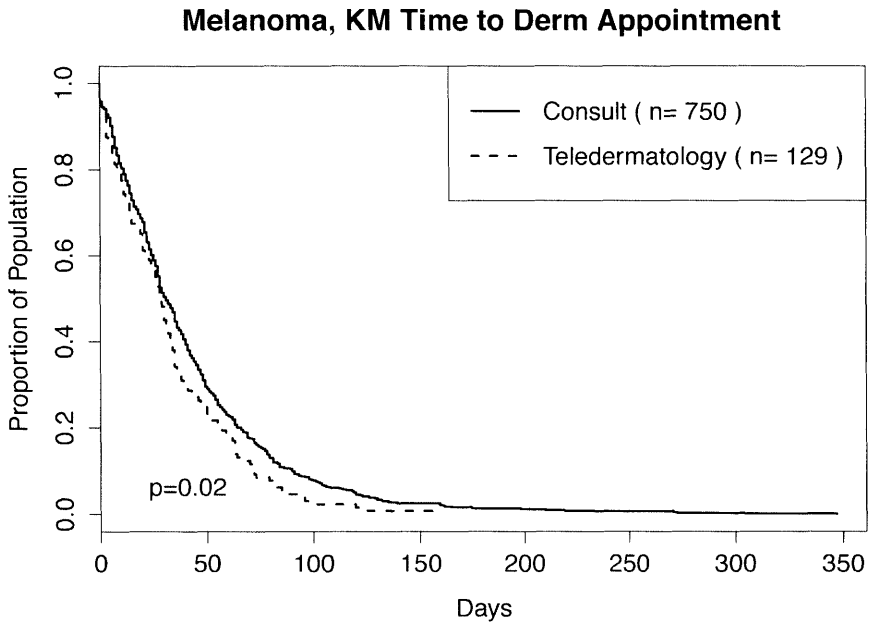


Figure 4-5. Melanoma time to dermatology appointment Kaplan-Meier curves

Because the time to biopsy was faster for teledermatology, the two cohorts were separated into those who had a biopsy and those who did not. The median time to treatment for those with biopsy is 76 days for consults and 64 days for teledermatology. The median time to treatment was faster for those without biopsy; 60.5 days and 54 days for consult and teledermatology groups, respectively. The Kaplan-Meier representation of time to treatment for these two sub-groups is shown in Figure 4-6. The time to treatment is faster for teledermatology for the cohort with biopsy (χ^2=8.6, p=0.003), but not for those without a biopsy (χ^2=0.5, p=0.46).

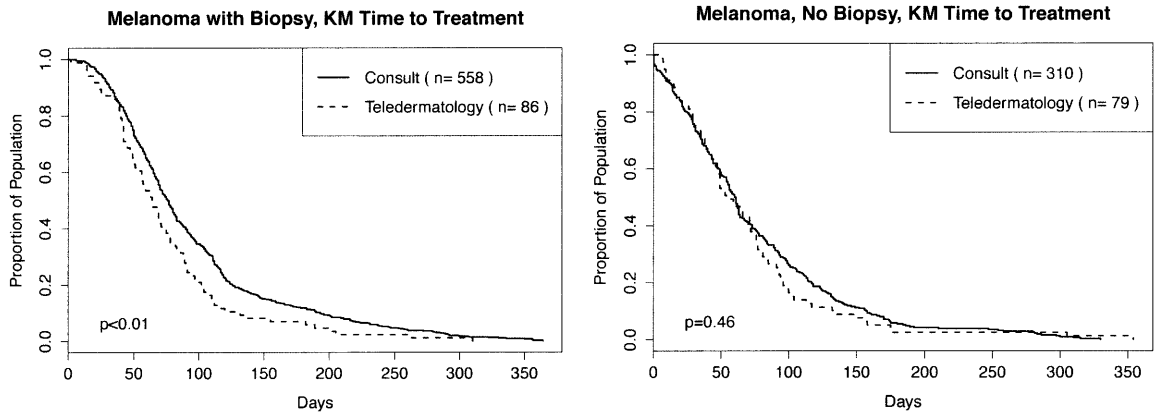


Figure 4-6. Melanoma time to treatment for biopsy and no biopsy subgroups, Kaplan-Meier curves

4.3.2 Non-Melanoma Skin Cancer National Analysis

There were 36,974 VHA patients who had a malignant skin excision, destruction, or chemosurgery treatment in 2013 and fit the inclusion and exclusion criteria for the NMSC patient group. Of those, 17,208 (47%) and 2,301 (6%) fit the criteria for the consult and teledermatology cohorts, respectively. Within the consult group 10,035 patients had biopsies and 13,068 had appointments with a dermatologist. Within the teledermatology group 1,224 patients had biopsies and 1,610 had appointments with a dermatologist. (Figure 4-7)

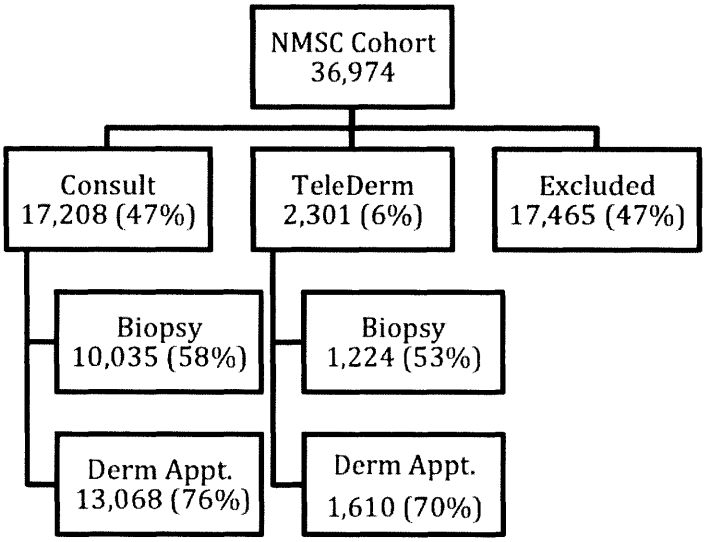


Figure 4-7. NMSC cohort break down

Teledermatology and traditional consult patients have similar gender, VA eligibility code, race, and marital status compositions (Table 4-7). Teledermatology patients are slightly younger, but the statistical significance of this difference ($p<0.001$ for mean and median comparisons) is due to the large size of the populations, and the actual differences are only about one year of age. Similar to melanoma patient populations, the teledermatology population is more concentrated in small metro areas ($p<0.001$).

Table 4-7. Demographic summary of NMSC patients

Non Melanoma Skin Cancer Patient Demographic Summary					
Category	**Description**	**TeleDerm (n=2,301)**	**Consult (n=17,208)**	**p-Value**	**Type of Statistical Analysis**
Age	Mean Age at ED (Years)	70.9	69.9	**1.86E-05**	Student t-test
	Median Age at ED (Years)	68	69	**1.03E-04**	Wilcox-Mann
Gender	% Male	98.0%	97.8%	0.4925	Chi-Squared Test
VA Eligibility Code	% VA Code 1	24.8%	25.0%	0.94	Chi-Squared Test
	% VA Code 2	2.6%	2.4%		
	% VA Code 3	18.9%	19.1%		
	% VA Code 4	2.3%	2.4%		
	% VA Code 5	51.4%	51.0%		
	% VA Code 6	0.0%	0.01%		
	% VA Code 7	0.0%	0.06%		
Race	% American Indian or Alaska Native	0.50%	0.30%	0.69	Fisher's Exact Test for Count Data
	% Asian	0.00%	0.05%		
	% Black or African American	3.80%	0.40%		
	% Unknown	11.80%	11.70%		
	% Native Hawaiian or other Pacific Islander	0.50%	0.50%		
	% White	86.80%	87.00%		
Marital Status	% Divorced	24.40%	24.20%	0.022	Chi-Squared Test
	% Married	58.30%	56.30%		
	% Single	5.60%	7.20%		
	% Separated	1.60%	1.90%		
	% Unknown	0.09%	0.30%		
	% Widow/Widower	10.00%	10.20%		
Urban/ Rural Code	% RUCC 1 Metro Area: Population > 1 Mil	30.8%	43.8%	**2.20E-16**	Chi-Squared Test
	% RUCC 2 Metro Area: 1 Mil < Population < 250,000	27.8%	24.3%		
	% RUCC 3 Metro Area: Population < 250,000	17.7%	9.0%		
	% RUCC 4,6 Urban Population adjacent to Metro Area	14.8%	15.1%		
	% RUCC 5,7 Urban Population not adjacent to Metro Area	6.1%	5.2%		
	% RUCC 8,9 Rural Population	2.8%	2.6%		

As expected by the difference in the clinical risk of the two malignancy types, time in days between the consult or teledermatology imaging and the treatment event is longer for NMSC than melanoma patients. Time to treatment ranged from 0 to 365 and 0 to 364 days for consults and teledermatology, respectively. The median time to treatment is 88 days for consults and 79 days for teledermatology. Similar to melanoma cases, the data is positively skewed (Figure 4-8).

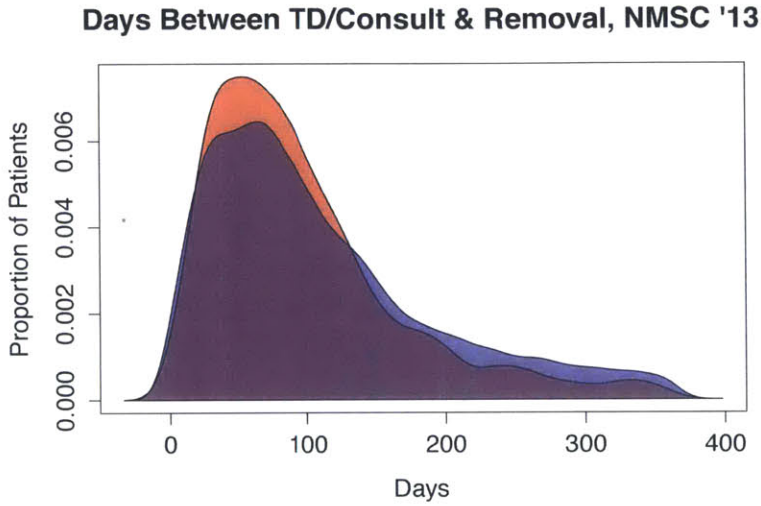


Figure 4-8. NMSC time to treatment density curves

Log rank comparison of the Kaplan-Meier curves (Figure 4-9) for the consult and teledermatology cohorts is significant (χ^2=60, p<0.001), though the magnitude of the difference between the cohorts is less than with melanoma and occurs later.

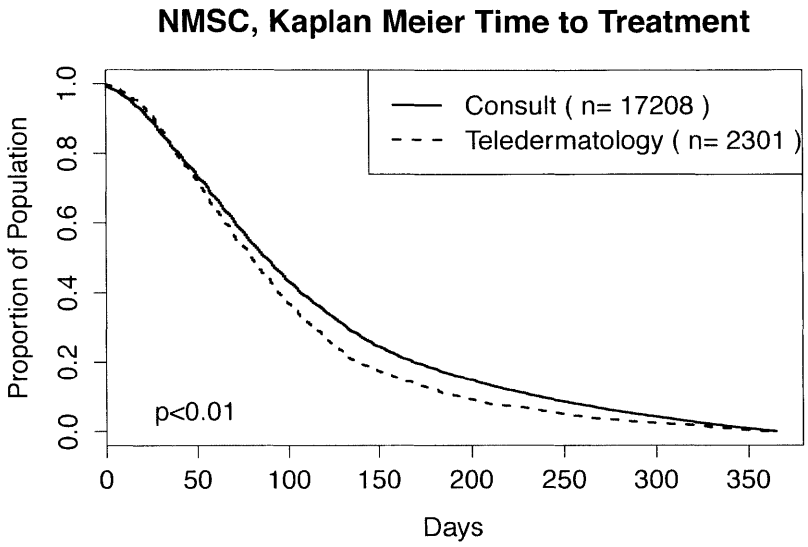


Figure 4-9. NMSC time to treatment Kaplan-Meier curves

Biopsies occur in 58% of the consult group and 53% of the teledermatology group for NMSC. The median time to biopsy is 39 days and 36.5 days for consult and teledermatology groups, respectively. The difference in the Kaplan-Meier curves (Figure 4-10) is less than with the melanoma group, but it is significant (χ^2=21.0, p<0.001) because of the large size of the population.

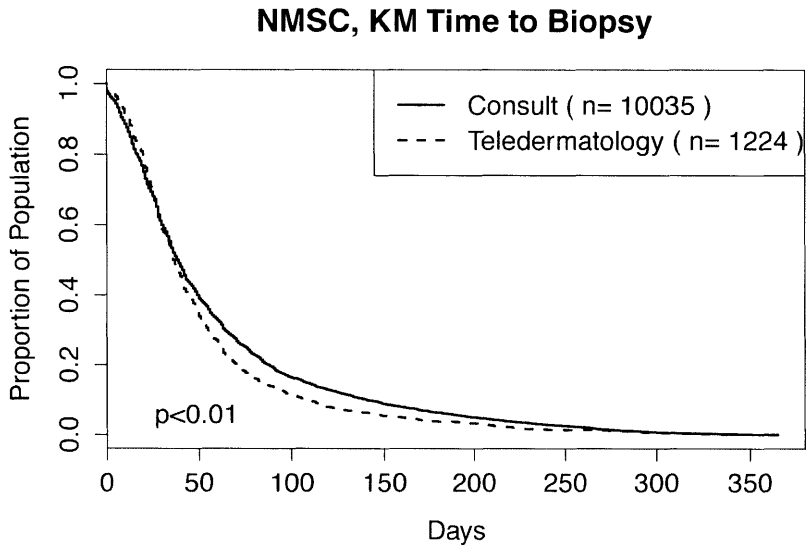


Figure 4-10. NMSC time to biopsy Kaplan-Meier curves

Dermatology appointments occur in 76% of the consult group and 70% of the teledermatology group. The median time to appointment is 33 days for both groups. There is no significant difference in the Kaplan-Meier curves for the two groups (χ^2=0.8, p=0.376).

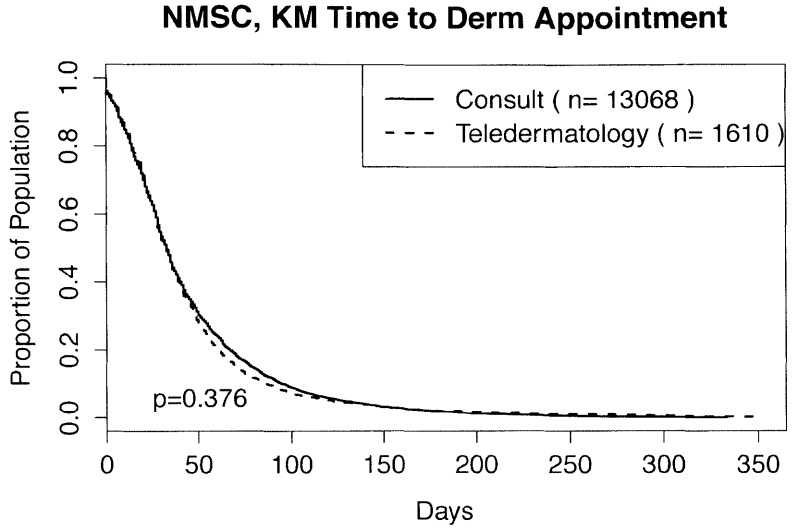


Figure 4-11. NMSC time to dermatology appointment Kaplan-Meier curves

Unlike in melanoma patient populations, both the biopsy (χ^2=21.2, p<0.001) and non-biopsy (χ^2=29.9 p<0.001) subgroups of NMSC have significant differences between the two cohorts. However, for patients with biopsies this statistical significance may be due to the larger cohort as the difference between the medians of the groups is smaller. The median time to treatment for patients with biopsies is 98 days and 92 days and for patients without biopsies 70 days to 59 days, for consults and teledermatology respectively in each group.

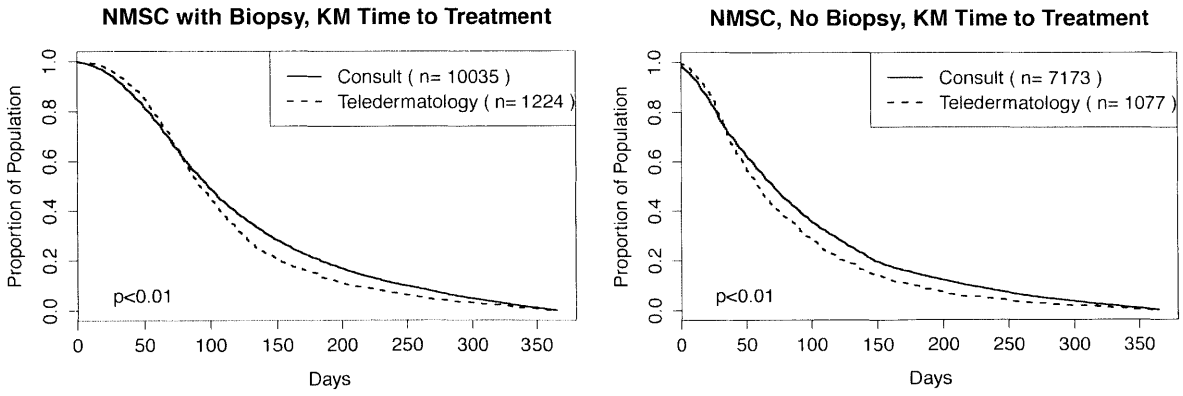


Figure 4-12. NMSC time to treatment for biopsy and no biopsy sub-groups, Kaplan-Meier curves

4.3.3 Non-Melanoma Skin Cancer Program Level Analysis

The NMSC population was large enough to evaluate the difference between traditional consult and teledermatology populations at the level of each program. The median time to treatment for each cohort in all teledermatology programs started before 2011 is reported in Table 4-8.

Table 4-8. Median time to treatment for NMSC by program, 2013

	Consult		Teledermatology	
Program	Median Time to Treatment (days)	Sample size, *n*	Median Time to Treatment (days)	Sample size, *n*
A	55	135	109	17
B	71	251	77	29
C	82	136	133	9
D	97	128	79.5	38
E	70	563	30.5	166
F	115	226	98.5	28
G	118	208	104	65
H	98	65	107.5	38
I	68.5	228	34	43
J	107	375	106.5	124
K	117	179	118	43
L	102	76	99	67
M	117	180	118	43
N	85	168	84	32
O	96	200	85	19
P	157	22	160.5	46
Q	55.5	112	42	173
R	51	7	140	21
S	85	139	102	69

This analysis was extended to all years from 2006-2013. The time to treatment for each cohort is represented on a bar graph with annotations for the number of patients in each category in Appendix D. Below the comparison of teledermatology and consults in each figure is another bar graph of time to treatment with both populations combined for that program over time. An example is given in Figure 4-13.

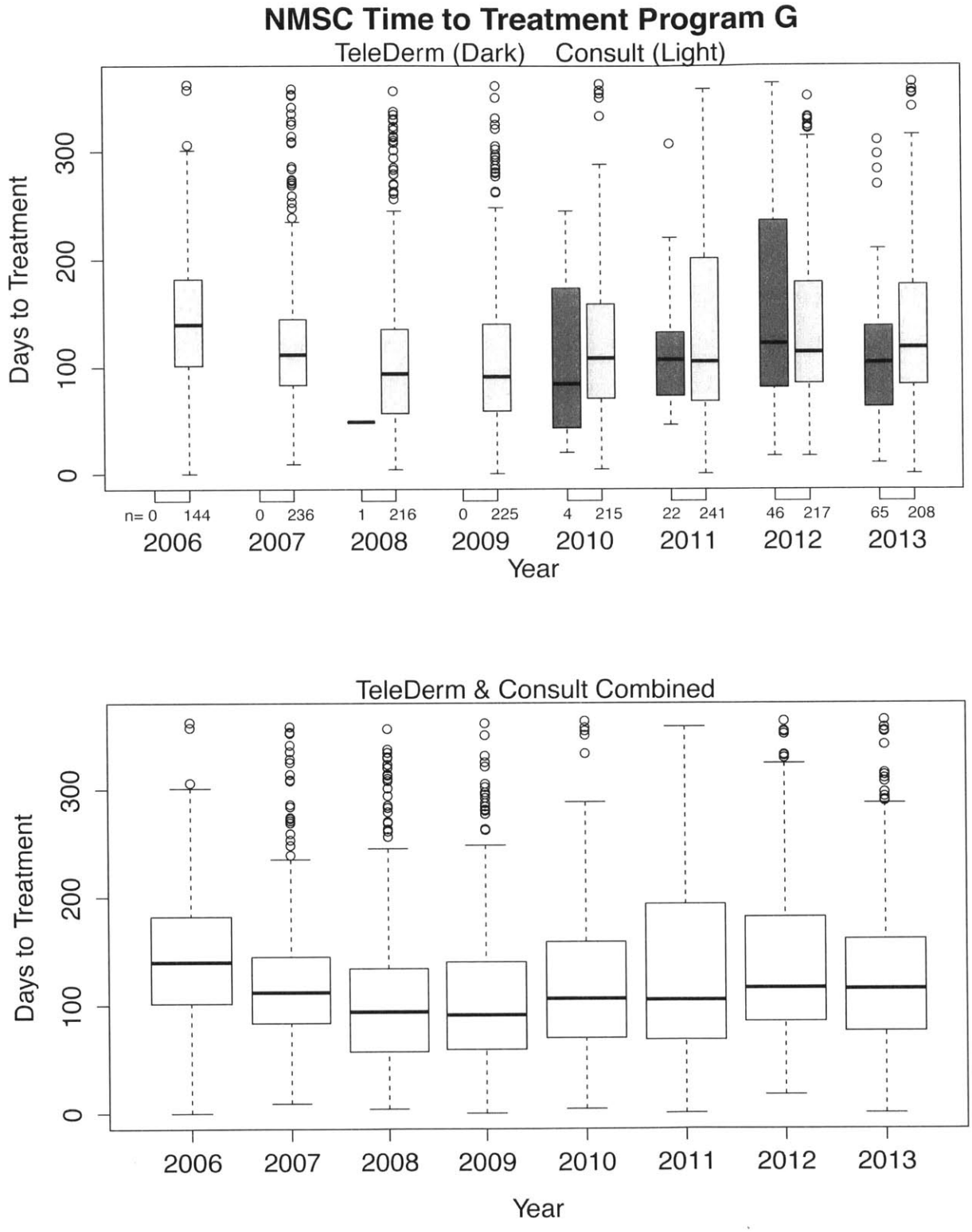


Figure 4-13. NMSC time to treatment for program G from 2006-2013

Each program was labeled as "Teledermatology Faster", "Traditional Consult Faster", and "Teledermatology and Consult Similar", and "Not Able to Make Determination" based on the following criteria. One mode of treatment was considered faster if 1) the difference in the medians was greater than 10 days in 2013, 2) the faster mode of treatment was consistent for the year before, and 3) visual inspection of other years confirmed the rating. For programs with less than 10 people in either category, no determination was made. All remaining programs were categorized as having similar treatment times between the two groups. Notes about some programs were added based on visual inspection (Table 4-9). Only one program (Program A) had clearly evident faster times to treatment for the traditional consult group. Four programs (Programs D, E, F, I, O and Q) had faster time to treatment for the teledermatology group.

Table 4-9. Analysis of NMSC time to treatment bar graphs comparing teledermatology and consults for each program (graphs located in Appendix D)

Program	Categorization	Notes
A	Consult Faster	Small proportion of teledermatology patients
B	Teledermatology and Consult Similar	
C	Not Able to Make Determination	Teledermatology is faster in every year but 2013, which also coincides with the significant decrease in the number of teledermatology patients
D	Teledermatology Faster	
E	Teledermatology Faster	
F	Teledermatology Faster	
G	Teledermatology and Consult Similar	
H	Teledermatology and Consult Similar	
I	Teledermatology Faster	
J	Teledermatology and Consult Similar	
K	Teledermatology and Consult Similar	
L	Teledermatology and Consult Similar	
M	Teledermatology and Consult Similar	
N	Teledermatology and Consult Similar	
O	Teledermatology Faster	
P	Teledermatology and Consult Similar	
Q	Teledermatology Faster	
R	Not Able to Make Determination	
S	Teledermatology and Consult Similar	

Visual inspection of the graphs in Appendix D does not support the theory that implementation of teledermatology decreases time to treatment for skin cancer overall, even in places where teledermatology is faster than traditional consults.

4.4 Discussion

4.4.1 Conclusions from time to treatment national analysis

This retrospective analysis examined whether VHA teledermatology programs have changed access to dermatology care by changing the time to treatment for skin cancer populations. For patients included in the study, entry into the system of care for skin cancer through teledermatology is associated with faster time to treatment over the traditional in-person dermatology consult for both melanoma and NMSC patients (see summary data, Table 4-10). Since teledermatology patients are also associated with a faster time to biopsy, it is possible that faster biopsies are one of the reasons teledermatology has faster time to treatment. This is also supported by the fact that melanoma skin cancers in which biopsies are part of the treatment process have different time to treatments between the two comparison groups, but melanomas without biopsies do not have a significant difference. For NMSC this difference in outcome is not evident between the biopsy and non-biopsy group, teledermatology patients are still treated faster when there is no biopsy. This may be because NMSC in some cases may be treated by the same less specialized providers who performed biopsies, a clinical resource in greater supply in teledermatology programs. It is also possible that teledermatology gives the dermatologist the opportunity to send a patient straight to a surgeon or plan longer appointments for excisions and reduce the need to come back for a second dermatology appointment when less specialized providers cannot perform the procedure.

Table 4-10. Summary of national data on time to skin cancer treatment event for melanoma and NMSC

Summary of Melanoma Data					
	Consult		Teledermatology		Log Rank Comparison
Time to Event (Days)	n	Median	n	Median	*p*
Time to Treatment	868	70	165	62	0.002
Time to Treatment With Biopsy	558	76	86	64	0.003
Time to Treatment No Biopsy	310	60.5	79	54	0.46
Time to Biopsy	558	37	86	30	0.002
Time to Dermatology Visit	750	31	129	29	0.016

Summary of Non Melanoma Skin Cancer Data					
	Consult		Teledermatology		Log Rank Comparison
Median Time to Event (Days)	n	Median	n	Median	*p*
Time to Treatment	17,208	88	2,301	79	<0.001
Time to Treatment With Biopsy	10,035	98	1,224	92	<0.001
Time to Treatment No Biopsy	7,173	70	1,077	59	<0.001
Time to Biopsy	10,035	39	1,224	36.5	<0.001
Time to Dermatology Visit	13,068	33	1,610	33	0.376

Surprisingly, there is no difference between the time to first in-person dermatology appointment between the two treatment groups in either diagnosis category. Faster dermatology appointments are not the reason for faster time to treatment in the teledermatology patient group. A difference was expected because images give more information to physicians to triage who needs to be seen in the clinic immediately, particularly melanoma patients. In most VHA facilities, if a patient cannot be given an appointment in 30 days then VHA will pay for outside care to be given. The median time to an in-person appointment being close to 30 days in all cases may be an indication that dermatology departments may not be able to offer earlier appointments with a dermatologist when necessary.

When considering the sub-group analysis it is important to note that there are differences in the proportion of patients who received biopsies and dermatologist appointments as part of the care process for each diagnosis category (64% consult, 52% teledermatology for

melanoma; 58% consult, 53% teledermatology for NMSC). It is possible that traditional consults had a higher rate of biopsies because getting the sample is simpler when the patient is already at the dermatologist's office, lowering the threshold of the decision to biopsy. The difference in who gets a biopsy could bias the biopsy subgroup analysis by separating out the less clear and potentially less serious cases for which biopsies are preformed and having more of them in the consult cohort of this subgroup. Unfortunately there was no way of accounting for these potential differences in the sub-group analysis with the information available in the CDW.

There was also a difference in the proportion of patients who have a dermatologist appointment in the teledermatology and consult groups for both diagnosis cohorts (86% for consult, 78% teledermatology for melanoma; 76% consult, 70% teledermatology for NMSC). This may indicate the teledermatology program is able to triage some patients straight to treatment with a surgeon or other non-dermatologist better than the traditional consult method. Hsiao and Oh (2008) also speculated that the reduced need for dermatologist appointments with teledermatology patients is one of the reasons for faster treatment in that cohort.[79]

While teledermatology patients were similar in age, gender, race, VA eligibility code, and marital status, there was a significant difference in the RUCC distribution of the populations for both melanoma and NMSC. This difference is unsurprising as many of the early teledermatology programs were started to increase access to care for rural Veterans or to establish dermatology services for smaller urban areas where recruiting a dermatologist was harder. Work by Landow and colleagues (2013) at VHA found that the rural northeast made up 15% of the teledermatology encounters for fiscal year 2013.[109] While anticipated, this rurality difference may cause a bias in the two compared groups due to the unequal distribution of healthcare resources without teledermatology.[8,11]

4.4.2 Conclusions from program analysis of time to treatment for NMSC

When time to treatment for NMSC is broken down to the individual programs, the significance of teledermatology in providing faster time to treatment is less clear. Median time to treatment is only faster for teledermatology in 10 of the 19 programs started before 2011. When the analysis of time to treatment for skin cancer patients is extended to include the years 2006-2013 there is only a clear pattern of faster time to treatment for teledermatology patients in 6 of the 19 programs, with 10 showing moderate equivalence between the two groups. There may be a difference between the national analysis and the program level analysis because in the national analysis consult group there are patients who do not have access to teledermatology programs.

There is an opportunity to study the programs that have faster time to treatment for skin cancer for best practices. Anecdotal evidence from discussions with a few programs show that the availability of local biopsy, training of all care providers about skin cancer, and resources of the program may have some impact on time to treatment.

Additionally, program A had a clear pattern of faster time to treatment for consult patients over teledermatology. Availability of this knowledge within VHA for performance improvement may allow investigations into any barriers for teledermatology patients for getting treatment in turn leading to improvements in future years.

Finally, tracking the time to treatment for skin cancer patients over time for each program gave no indication of overall decrease in treatment time for skin cancer purely because of teledermatology programs, even when teledermatology programs are large and associated with faster time to treatment than traditional consults.

4.4.3 Limitations

One serious factor could not be accounted for in this analysis, the clinical urgency of the condition. No information was available on the size or the stage of the skin cancers excised through the databases used in this study. There is potential that the teledermatology and

traditional consult patients had different levels of severity of disease. Physicians interviewed for earlier work on the thesis commented that more serious conditions get sent straight to the dermatologist because they know an operation or procedure must be done. Hsiao and Oh (2013) found that the traditional consults were more likely to have "urgent" priority rating on the referral and were more likely to have malignant neoplasm as the most likely diagnosis.[79] However, they found that the preoperative tumor sizes were larger with teledermatology. Additionally, the teledermatology population is more rural and may be more likely to have different levels of sun exposure, a skin malignancy risk factor, and perhaps may be less likely to seek treatment because of overall access issues.

This work is based on retrospective analysis on routinely collected administrative data. The study can only show the correlation between teledermatology and faster time to treatment for skin cancer patients, not direct causation. The study is limited by the type of information collected and also the quality of the information entered into the health record. There is the potential that some of the skin cancers in the analysis are not actually malignant lesions and also the potential that some skin cancer removals are not related to the initial consult or teledermatology event with which they are linked.

During the time of analysis new teledermatology programs started and others continue to grow. It is possible that the new and growing programs included in the national analysis have not yet established care pathways for skin cancer in teledermatology or reached efficiencies of scale of other programs. Additionally, a bias is created by the fact that teledermatology becomes proportionally more likely as time increases in the study.

4.4.4 Future work

When using time to treatment for skin cancer as a metric of teledermatology programs, it is important to consider that skin cancer is only one category of disease seen in teledermatology and is one where a dermatologist or specialist needs to be seen. This means the advantages of teledermatology might not be most pronounced in this time to

treatment analysis. Future work on time to treatment as a measure of success for teledermatology should include measurement of treatment of more conditions.

When looking specifically at skin cancer, work in this area can be improved by the availability of skin cancer depth information. If time to treatment information is made regularly available for VHA programs, further studies can assess what characteristics are associated with faster time to treatment within teledermatology and whether providing the information alone creates improvements.

The next thesis chapter continues investigation of access to care metrics for VHA programs with the examination of post-teledermatology utilization of care and travel distance for teledermatology care episodes.

5 Post-Teledermatology Utilization of Care and Travel Distance

5.1 Introduction

In addition to time to treatment for skin cancer, another important measure of access for VHA teledermatology stakeholders is the travel distance required for Veterans to get dermatology services. VHA is also interested in travel distance because they reimburse travel expenses for Veterans under some conditions. A metric of travel distance saved would reflect both improved access to care and economic success of the program. Teledermatology images are taken at the local physician's clinic, so if care can be handled with just the teledermatology visit, considerable driving distance could be saved. An integral part of the reduction of travel distance for each teledermatology program is how often in-person care is needed and how much of the in-person care can be given locally. For this reason, this investigation starts with quantifying the utilization of care post-teledermatology visit for all teledermatology programs and concludes with three case studies that calculate full travel distances.

Utilization of dermatology resources after a teledermatology encounter has been an important metric in teledermatology literature. In a review of 27 papers reporting utilization of care post-teledermatology, the range of people requiring dermatologists care in-person was 12-92%.[84] Most studies investigating travel distance avoided are assessing travel costs as part of an economic analysis of an entire program and do not have detailed information about travel and travel avoided.[110-112]

The hypothesis of this travel distance evaluation is that teledermatology will increase access to care by decreasing the average travel distance for an episode of dermatology care. The reduction in travel distance will be more evident in programs that offer more dermatology services locally, through the PCP or a non-physician surrogate dermatology provider.

5.2 Methods

5.2.1 Data sources

Data regarding teledermatology and follow up appointments with dermatologist and primary care providers were extracted from the VHA's Corporate Data Warehouse (CDW). When available, location information for each patient was also extracted from the CDW. The following CDW tables were integral into the analysis of post-teledermatology utilization of care and travel distance (Table 5-1).

Table 5-1. Description of CDW tables and fields used in analysis

CDW Table	Information Contained in Table
Outpatient Visits	For each visit in VHA an entry is created with the date, time, location, primary and secondary diagnoses (using ICD9), clinical provider(s) involved, department of care provided (by primary stop code: 304=dermatology, 323=primary care in-person, 324 & 338=primary care over phone), and if it occurs the a marker for a specialty type of care within the department (by secondary stop code: 694=patient imaging visit, 695=provider analysis of image in same hospital system, 696=provider analysis of image in different hospital system).
Patient (Demographics)	Patient files contain GIS location information based on patients' address when available.
Fee	For each visit in which VHA pays for outside providers to treat Veterans an entry with the invoice date, type of provider, diagnosis, and amount spent is recorded. This type of documentation is used inconsistently throughout VHA.
Dimensions	The dimensions table is used to translate coded fields in the tables above, such as the location code and description. This second level of coding is used to protect patient health information.

In addition to the CDW Fee table, data about non-VHA appointments were added from the Fee Basis Claims System (FBCS). This new administrative database collects national data on the VHA payment for outside providers to treat Veterans. Unlike the CDW Fee table, this data collection is standardized and used in all VHA facilities. The FBCS was started in 2012 and records approval for Veterans to receive fee basis care, the category of care approved, the estimate of costs, and the actual amount spent. A scrambled social security number created by the VHA research team linked data in the CDW to the FBCS.

5.2.2 Definition of care utilization categories

Post-teledermatology utilization of care was investigated in the following categories: 1) dermatology appointment with a dermatologist within VHA, 2) dermatology appointment with non-physician specialized dermatology provider within VHA, 3) dermatology appointment outside of VHA, 4) primary care provider (PCP) appointment, and 5) PCP telephone communication.

The care was considered related to a teledermatology appointment if it occurred within the six months (180 days) following the teledermatology store and forward encounter. There are two different dates associated with a teledermatology encounter: when the picture of the patient is taken and when a dermatologist analyzes the image. The latter date was chosen as the starting point for investigating post-teledermatology care because care recommendations are not given until the physician examines the image. These provider teledermatology visits were identified in the outpatient table by the primary stop code "304" for dermatology and secondary stop codes "695" and "696" for analysis of store and forward images.

Dermatology appointments were defined as visits with the primary stop code "304." The qualification level of the provider was added to dermatology visits with the *ProviderType* field of the visit. If the *ProviderType* contained the word "physician" the visit was labeled a dermatologist, otherwise it was categorized as a non-physician dermatology specialized clinician. Often these providers were nurse practitioners trained in dermatology as part of the teledermatology program.

Information on visits to an outside dermatologist is contained in both the CDW Fee table and the FBCS. The CDW Fee table has information on the providers' specialty type; however, this field was often empty. Fee visits were noted for each teledermatology patient and categorized as by a dermatology provider or unlabeled provider (determined by the *FeeSpecialtyCodeName* field). For CDW Fee events, the date associated with the event is the date of the vendor invoice. The FBCS data contained a required field

CategoryOfCare. FBCS fee events were included if they were in the following categories: "Dermatology" or "Dermatology Tests, Procedures, Studies." The date associated with the FBCS data is the start date of the approved time period for the fee appointment. It is important to note that the dates associated with both of these fee appointment sources are not the actual dates patients see an outside dermatologist and are less exact than appointments within VHA. Additionally, fee appointments are only paid for by VHA under certain service connected injury and economic status conditions; some Veterans may be getting outside appointments paid for by different sources that cannot be tracked with the data available.

Encounters with the PCP were defined by the primary stop code of outpatient visits: "323" for primary care visit in the office and "324" and "338" for phone calls. The visit was considered related to a dermatology concern if the primary diagnosis for the appointment was in the list of dermatology diagnoses in Appendix E.

When the data for all the appointments were combined, further attempts were made to have the information represent one instance of dermatology care, similar to a referral to an in-person dermatology consult. Any appointments occurring after a patient visited with a VHA dermatologist were removed. However, because the outside VHA dermatology fee appointment date data was inconsistent and of poor quality, no appointments were removed after the outside dermatologist appointments. Additionally, any patients with a visit to a VHA dermatologist had all fee appointments removed as it is unlikely that the patient saw a VHA dermatologist and also an outside dermatologist paid for by VHA.

5.2.3 Analysis of utilization of care post-teledermatology visit

Post-visit utilization of care was analyzed for teledermatology visits that occurred in 2013 for the 19 programs started before 2011. For each teledermatology visit the occurrence of dermatology visits, PCP visits and fee visits by the patient were identified separately. The primary analysis examined only the presence or absence of a visit in the category in the six months following image analysis. For each of the three categories above the percentage of

patients who had a visit are reported. Dermatology analysis reports appointments with dermatologist and non-dermatologist providers. Fee appointments analysis reports all data from FBCS and dermatology provider label data from CDW together and then separately reports any possible unlabeled fee visits from the CDW. PCP analysis reports in person and phone calls visits with the provider.

To better understand the total use of care, the average number of appointments in each category was calculated for people who utilized non-physician dermatology providers and their PCP for skin concerns.

The visits for each patient were combined and then ranked in the following order: 1) dermatology physician visit, 2) dermatology non-physician care provider visit, 3) outside dermatologist fee visit, 4) PCP office visit, and 5) PCP phone visit. For the combined analysis unlabeled and labeled fee visits were grouped together. It is unlikely that all unlabeled fee visits were related to dermatology, but the analysis included all of them to represent the worst-case scenario. The highest ranked appointment was selected for each patient after the teledermatology visit and the percentage of teledermatology visits resulting in utilization of each category was calculated for each program. Outside dermatologist fee visits are ranked after VHA non-physician dermatology care providers because the fee basis data is less reliable; however, these two are reported in the opposite order because the outside dermatologist is a higher level provider.

All data was pulled from the CDW and the FBCS with MySQL Server Manager 2012; post processing was done in R Studio running R 3.1.0 and Microsoft Excel.

5.2.4 Travel distance analysis

Geographic information system (GIS) coordinates from the patients' demographic files were used to calculate actual road travel routes related to all of the different appointments. This analysis was completed for three different teledermatology programs: one with high utilization of local surrogate dermatology care providers (Program E), one with high

utilization of dermatologist (Program L), and one with high utilization of PCPs (Program N). These specific programs were also selected because of their low use of outside dermatologist in the patient population, for which data is less accurate.

The first step in the analysis was to document the type of GIS information available in each patient population. The GIS information taken was that entered into the system most recently before the teledermatology appointment. This information was labeled with what the coordinates for the patient represented: an address, a street, a city, or a postal code.

GIS information for each teledermatology patient in the three programs and the locations of all VHA facilities was uploaded in to ArcGIS ArcMap 10 software on VHA servers. The network analyst tool was used to calculate the travel distance and travel time to the three closest VHA medical centers (VAMCs) and to the five closest facilities including all medical clinics in the VHA. The travel time and distance impedances were set to zero to represent best-case scenarios. The non-traversable street network elements were included in the analysis because some VHA facilities are located on private and service roads and cause the software to exclude the facilities from the results without this option. The addresses for the patients were only considered accurate and included in the analysis if all treatment locations for the patient were within the eight locations identified by the closest facility analysis.

The travel times and distances were merged with the data on post-teledermatology care utilization to document the travel time and travel distance to each instance of care utilization at a VHA facility. Phone visits were excluded because there was no travel involved for the patient. For non-VHA fee visits to outside dermatologists, no travel distance calculation was possible because the location was unknown. Instead, it was assumed that a dermatologist would be available at the same distance as the closest medical center. The travel for each visit a patient made after a teledermatology visit was summed to create an aggregate travel distance in miles and travel time in minutes. This travel distance was then compared to the distance a patient would have to travel to a dermatologist, which was assumed to be the distance to the closest VHA medical center.

The travel distance saved was considered the travel to the closest medical center minus the aggregate travel distance for post-teledermatology utilization of care. When a patient had to travel more than the distance to the closest medical center, for example, once to a local clinic and once to the medical center, this resulted in a negative travel distance saved. Travel distance saved across the teledermatology visits for each program was analyzed and represented with charts and summary statistics.

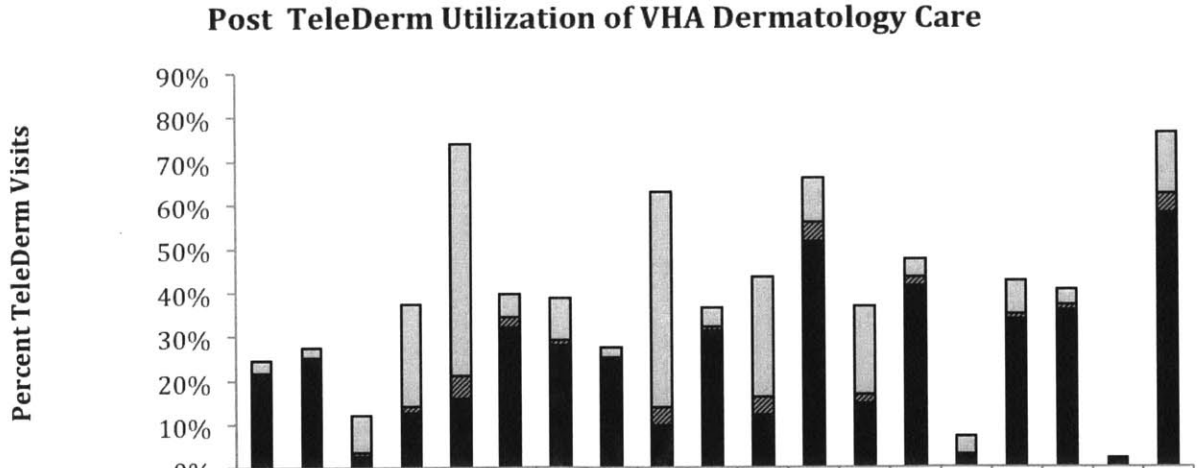
One critical assumption was made for this analysis: the teledermatology imaging visit does not create additional travel for the patient. This assumption was made because most programs have imagers at the same locations as the PCP and pictures can be taken immediately after the PCP recommends it. The patient would already have to come to the PCP to get the dermatology referral or teledermatology referral. If the picture were taken at the same time and location as that visit there would be no additional travel created by the teledermatology imaging visit.

5.3 Results

5.3.1 Post-teledermatology utilization of care

First, three categories of post-teledermatology care are presented separately: dermatology care in VHA, dermatology care outside VHA, and PCP care.

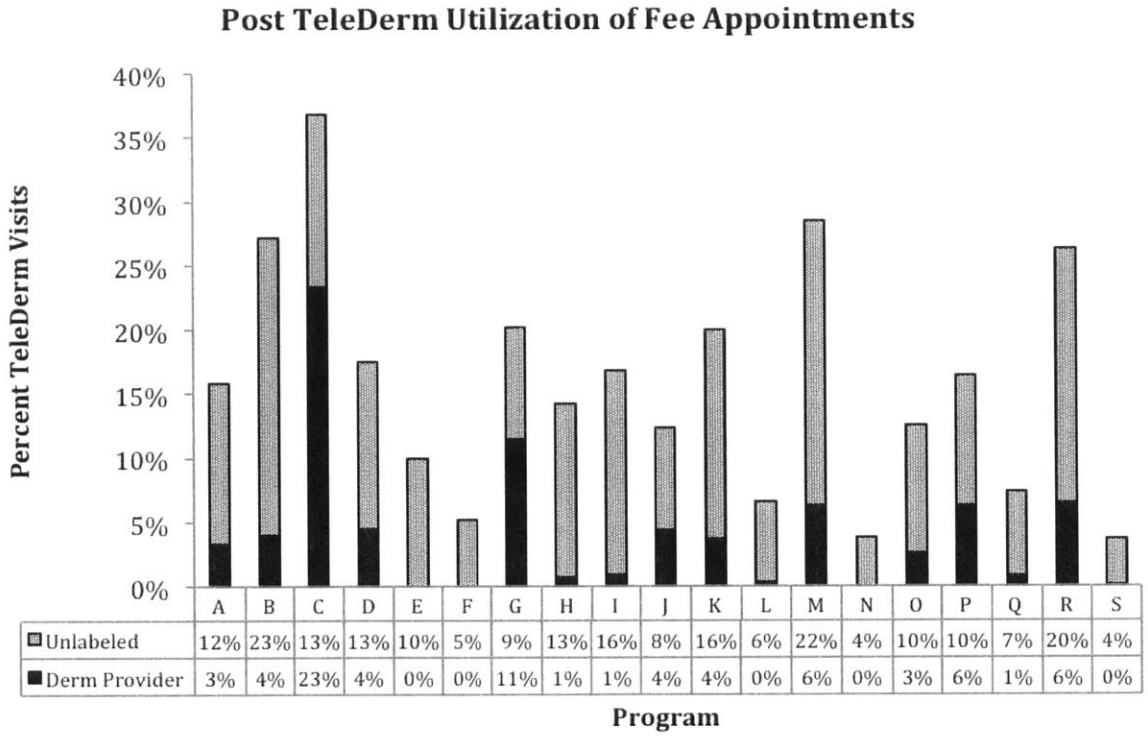
Post-teledermatology utilization of VHA dermatology care in 2013 is reported for all programs started before 2011 (Figure 5-1). Total use of VHA dermatologist care after teledermatology ranged from 2% to 62%. Programs R, O, and C appear to have the lowest rates of dermatologist and overall dermatology services utilization. However, program R does not have a local dermatologist for in person appointments, and program C, in addition to being a program in decline, has a high rate of fee basis appointments. Program O should be investigated further for the reason of low dermatology service utilization. The next five programs that are able to keep a low utilization of dermatologist resources all have high utilization of non-physician dermatology providers. There are a small number of patients who visit a non-physician dermatology provider and who visit a dermatologist.



	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S
Non-Physician	3%	2%	8%	23%	53%	5%	9%	2%	49%	4%	27%	10%	20%	4%	4%	7%	3%	0%	14%
Both	1%	1%	1%	1%	5%	2%	1%	0%	4%	1%	4%	4%	2%	2%	1%	1%	1%	0%	4%
Dermatologist Only	21%	25%	3%	13%	16%	32%	28%	25%	10%	31%	12%	52%	15%	41%	2%	34%	36%	2%	58%

Figure 5-1. Post-teledermatology utilization of VHA dermatology care, physician and non-physician

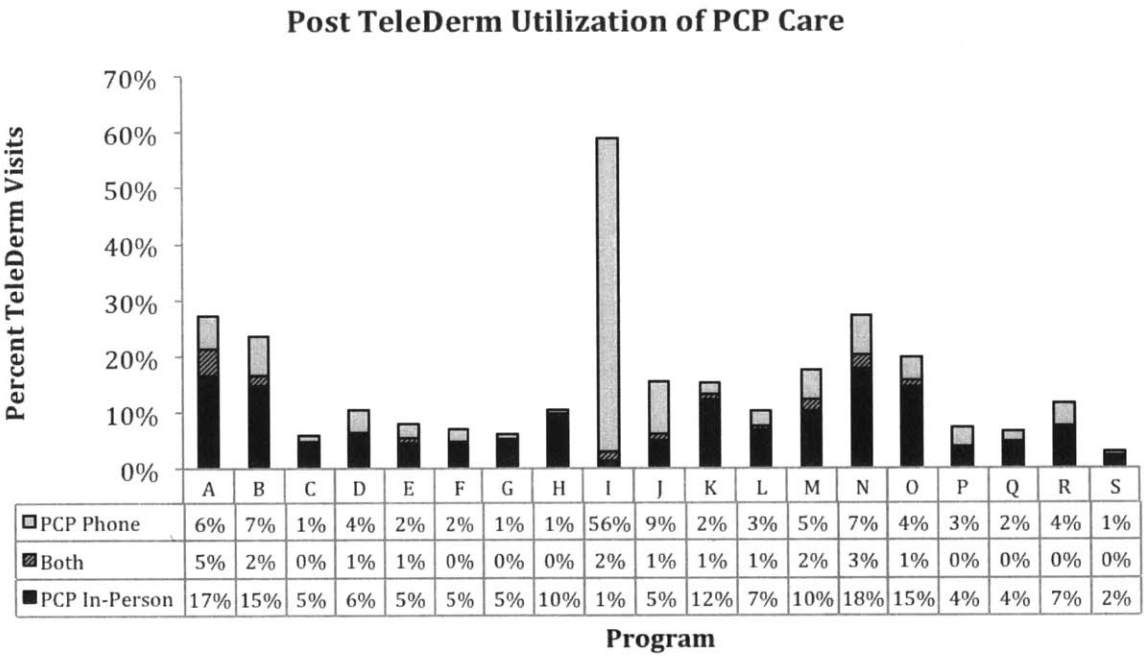
Dermatology care provided outside VHA is not recorded with as much accuracy as dermatology care within VHA. In addition, it is only recorded for patients who are eligible to have the VHA pay for their care. The data reported in Table 5-2 includes two sources for documentation of visits to dermatologists outside of VHA (FBSC and CDW Fee tables) and indicates whether the fee data is labeled as a dermatology provider or unlabeled data. Since such a large quantity of the data is unlabeled the overall quality of the fee data is poor. Both program G and program C have higher levels of labeled fee basis appointments after a patient has had a teledermatology appointment.



	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S
Unlabeled	12%	23%	13%	13%	10%	5%	9%	13%	16%	8%	16%	6%	22%	4%	10%	10%	7%	20%	4%
Derm Provider	3%	4%	23%	4%	0%	0%	11%	1%	1%	4%	4%	0%	6%	0%	3%	6%	1%	6%	0%

Figure 5-2. Post teledermatology utilization of outside VHA fee visits, labeled and unlabeled

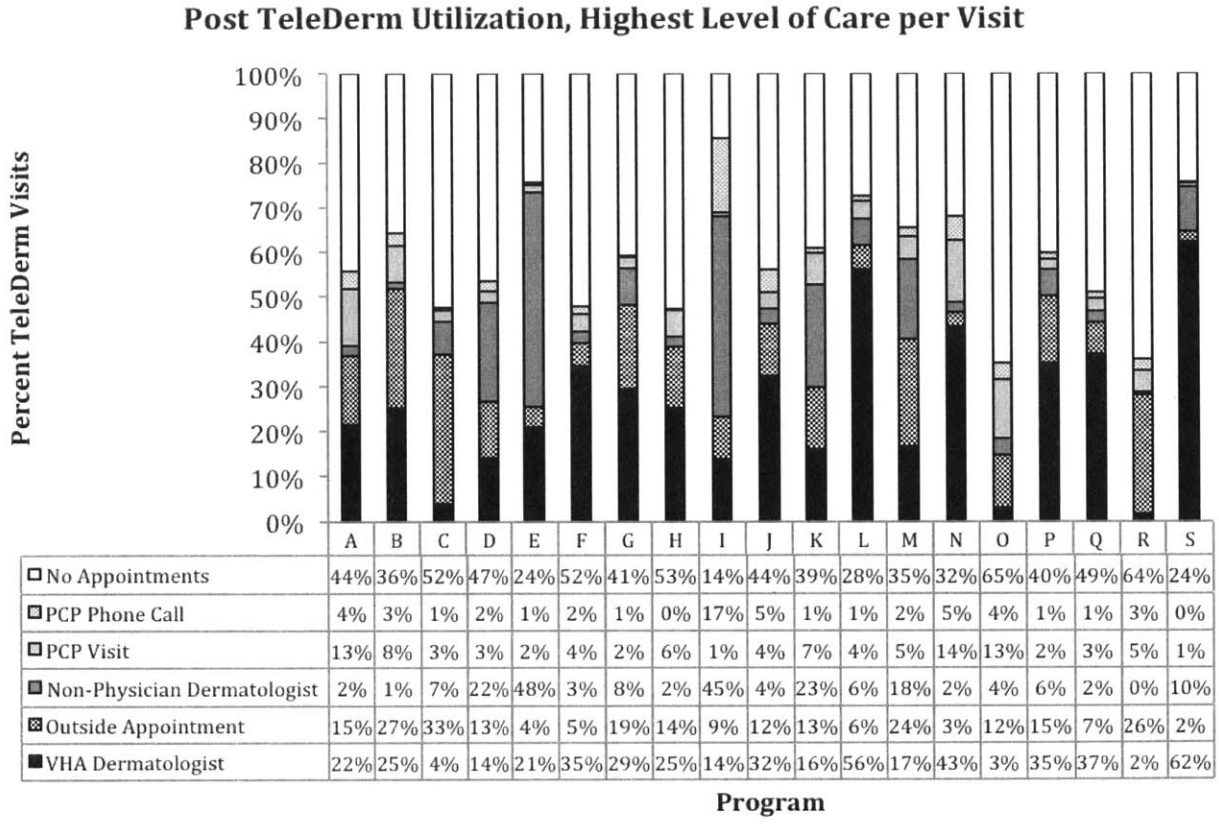
Teledermatology programs have shifted some workload of the post-teledermatology dermatology care to the PCP. This care can be in the form of an in-person office visit or a phone call. Figure 5-3 shows rates of in-person visits, phone calls, and the overlap between the two groups. The range of in-person PCP follow-ups is from 2-22%. Program I has a low rate of PCP follow up in-person but far exceeds any other program in the proportion of patients who receive follow up phone calls.



	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S
PCP Phone	6%	7%	1%	4%	2%	2%	1%	1%	56%	9%	2%	3%	5%	7%	4%	3%	2%	4%	1%
Both	5%	2%	0%	1%	1%	0%	0%	0%	2%	1%	1%	1%	2%	3%	1%	0%	0%	0%	0%
PCP In-Person	17%	15%	5%	6%	5%	5%	5%	10%	1%	5%	12%	7%	10%	18%	15%	4%	4%	7%	2%

Figure 5-3. Post-teledermatology utilization of primary care office and phone visits

Figure 5-4 reports the highest-level provider seen for each patient after a teledermatology visit. A striking feature of Figure 5-4 is the high variability in the number of patients who need no care at all after teledermatology. In the programs investigated this result ranged from 14-64%. It is possible that this represents the number of patients treated with teledermatology alone. Though, because the fee data is of low quality, in programs with high rates of fee appointments the number of patients with no appointments after teledermatology is likely to be less accurate.



	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S
No Appointments	44%	36%	52%	47%	24%	52%	41%	53%	14%	44%	39%	28%	35%	32%	65%	40%	49%	64%	24%
PCP Phone Call	4%	3%	1%	2%	1%	2%	1%	0%	17%	5%	1%	1%	2%	5%	4%	1%	1%	3%	0%
PCP Visit	13%	8%	3%	3%	2%	4%	2%	6%	1%	4%	7%	4%	5%	14%	13%	2%	3%	5%	1%
Non-Physician Dermatologist	2%	1%	7%	22%	48%	3%	8%	2%	45%	4%	23%	6%	18%	2%	4%	6%	2%	0%	10%
Outside Appointment	15%	27%	33%	13%	4%	5%	19%	14%	9%	12%	13%	6%	24%	3%	12%	15%	7%	26%	2%
VHA Dermatologist	22%	25%	4%	14%	21%	35%	29%	25%	14%	32%	16%	56%	17%	43%	3%	35%	37%	2%	62%

Figure 5-4. Post-teledermatology utilization of care, highest level provider seen per patient

To better understand the total use of care after each teledermatology visit, the number of times a person visits a clinician within VHA was explored. Table 5-2 lists the average number of appointments for the group of people who utilized that particular type of care. For example, 22% of teledermatology patients in Program A visited the PCP in-person after

the teledermatology consult. This group of patients had an average of 1.28 appointments with the PCP before seeing a dermatologist or within 6 months.

Table 5-2. Average number of visits for patients utilizing care post-teledermatology

Program	Derm Non-Physician	PCP Office Visit	PCP Phone
A	1.23	1.28	1.15
B	1.09	1.22	1.14
C	1.42	1.00	1.40
D	1.54	1.31	1.08
E	1.27	1.18	1.19
F	1.19	1.17	1.05
G	1.23	1.18	1.11
H	1.10	1.21	1.00
I	1.34	1.19	1.16
J	1.24	1.14	1.12
K	1.49	1.32	1.16
L	1.13	1.16	1.05
M	1.53	1.39	1.25
N	1.15	1.25	1.10
O	1.22	1.42	1.03
P	1.10	1.09	1.11
Q	1.14	1.17	1.07
R	1.00	1.19	1.08
S	1.17	1.05	1.09
Total (All Programs)	**1.37**	**1.28**	**1.16**

5.3.2 Travel distance per teledermatology encounter

There was significant variability in the rate of visits to clinicians after a teledermatology encounter, which could translate into differences in the amount of travel saved for patients in each program. Three programs were chosen to analyze these potential differences: Program E representing significant activity by local non-physician dermatology providers, Program L representing significant activity by dermatologists, and Program N representing higher levels of primary care provider activity. Both Program E and Program L are large programs with over 1,500 teledermatology visits in 2013, but Program N is smaller and had only 320 visits.

For the three programs analyzed, the patient populations did not have all have GIS address available (Table 5-3). For programs E, L, and N there were 91%, 86%, and 83% of the patients with address level GIS data, respectively. The street location and postal code data are less accurate for calculating driving distances but was still included in the analysis.

Table 5-3. Type of GIS information available for patients in Programs E, L, and N

GIS Information Type	Percent TeleDerm Patients In Program		
	E (*n*= 1,692)	L (*n*= 1,573)	N (*n*=320)
Address	91%	86%	83%
Street Name	2%	2%	0%
Postal Code	7%	11%	16%
No Information	0.1%	0.3%	0.3%

In addition to patients who have less specific GIS locations, there were also patients with incorrect address information in the system. This could happen if a Veteran has recently moved, is staying at a summer home, is homeless, or if the information is not recorded correctly into the system. Incorrect addresses were identified as those for which the facilities of treatment were not in the 5 closest facilities or in the 3 closest medical centers. Table 5-4 addresses the total number of patients in each program that were excluded because of inaccurate information and also what type of appointments these patients had after teledermatology. Program L had a higher rate of incorrect GIS information compared to Programs E and N. The types of appointments missed appear consistent with the types of appointments seen in each group. For example in Program E, most patients with post-teledermatology care visit a non-physician dermatology provider and this group is also the largest in the missing data. Therefore, exclusion of this inaccurate information is not likely to be creating a bias.

Table 5-4. Number of patients in Programs E, L and N with incorrect GIS information

Program	Number (% of Program Total) of Patients with Incorrect GIS Information	Number of Patients with Visits to:			
		Dermatologist	Non-Physician Dermatology Clinician	PCP	Fee
E	131 (7.7%)	31	96	13	4
L	227 (14.4%)	173	25	32	17
N	20 (6.3%)	10	1	9	0

Using the information for patients with valid addresses, the distance to the closest facility and the closest VAMC was calculated (Table 5-5). Patients in Program E are further from the closest medical center but closer to a local clinic than patients in the other two programs.

From personal experience during the qualitative investigation of teledermatology, these distances seem accurate. There were times I had to drive hours, each way, from the main hospital to interview stakeholders at the closest facility using teledermatology.

Table 5-5. Travel to closest medical center and medical facility

Summary of Round Trip Travel To Closest VAMC						
	Program E		Program L		Program N	
	Distance (mi)	Time (min)	Distance (mi)	Time (min)	Distance (mi)	Time (min)
Mean	223.54	266.89	118.66	154.36	110.89	140.64
Median	239.01	281.15	98.68	137.77	105.90	129.41

Summary of Round Trip Travel To Closest Facility						
	Program E		Program L		Program N	
	Distance (mi)	Time (min)	Distance (mi)	Time (min)	Distance (mi)	Time (min)
Mean	20.92	34.04	30.54	46.1	29.14	45.16
Median	20.92	29.16	30.54	36.72	29.14	34.9

For patients with accurate GIS information the total driving distance and travel time for the episode of dermatology care was calculated. This includes all appointments with VHA non-physician dermatology providers and PCP before any VHA dermatology appointment that occurs or over the six months following the teledermatology visit if no dermatologist appointment is needed. Fee visits were also included in the analysis, and the unknown distance to the fee visit was estimated as the distance to the closest VHA medical center. The sum of all the travel for teledermatology was compared to the distance to the closest VHA medical center, the assumed distance that the patient would have had to travel to see the dermatologist in person, to calculate the travel time and distance saved. Negative travel saved represents a patient who had to travel more for teledermatology than if they had gone straight to a dermatologist for treatment.

The aggregation of travel distance saved and travel time saved for patients in Program E, a program that offers local non-physician dermatology specialists for post-teledermatology care, are represented in histograms in Figure 5-5. In Program E many patients saved travel time and travel distance, but there was a long tail of patients that had more travel because of teledermatology. In some cases these patients represent people who have to travel many times to the "local" facility that is far from their home. However, these data points should be investigated in further studies with chart review to verify their accuracy. There is a spike in the histogram around zero representing the many patients who had only one trip to a dermatologist or fee appointment and did not save or add additional travel by using teledermatology.

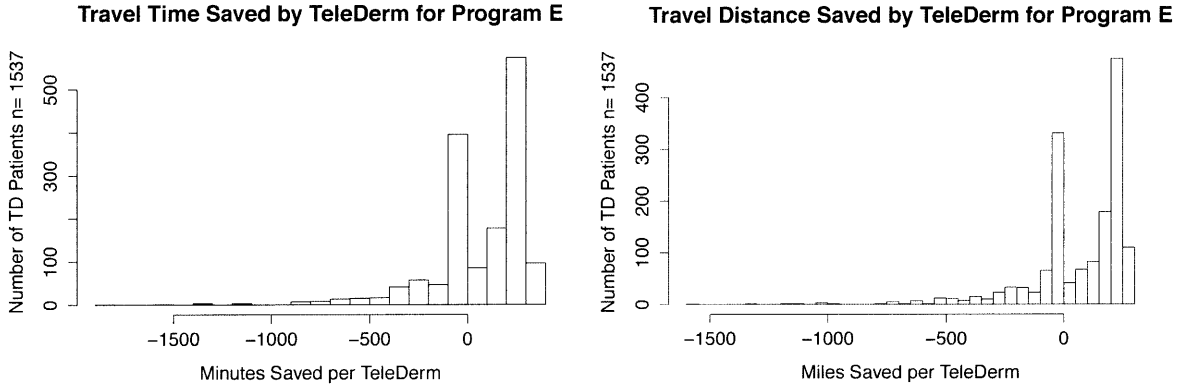


Figure 5-5. Travel time and distance saved with teledermatology in Program E, histograms

In Program L, a program that relied heavily on dermatologist for post-teledermatology care, there is a less extreme negative tail to the distribution (Figure 5-6). There were also a large number of patients with zero travel savings after using teledermatology.

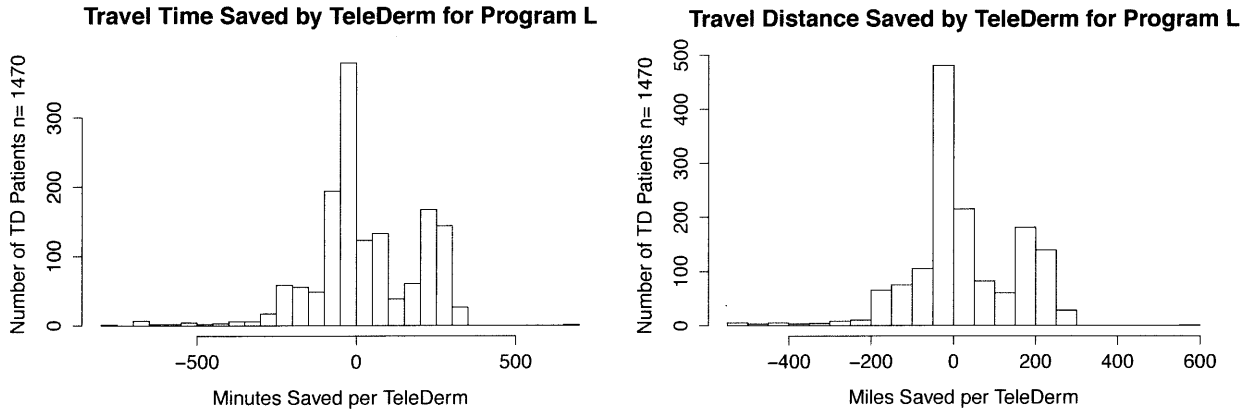


Figure 5-6. Travel time and distance saved with teledermatology in Program L, histograms

Program N, which is smaller and relies more on local PCPs than the other programs, has a different type of distribution with fewer of the patients concentrated around zero travel saved (Figure 5-7).

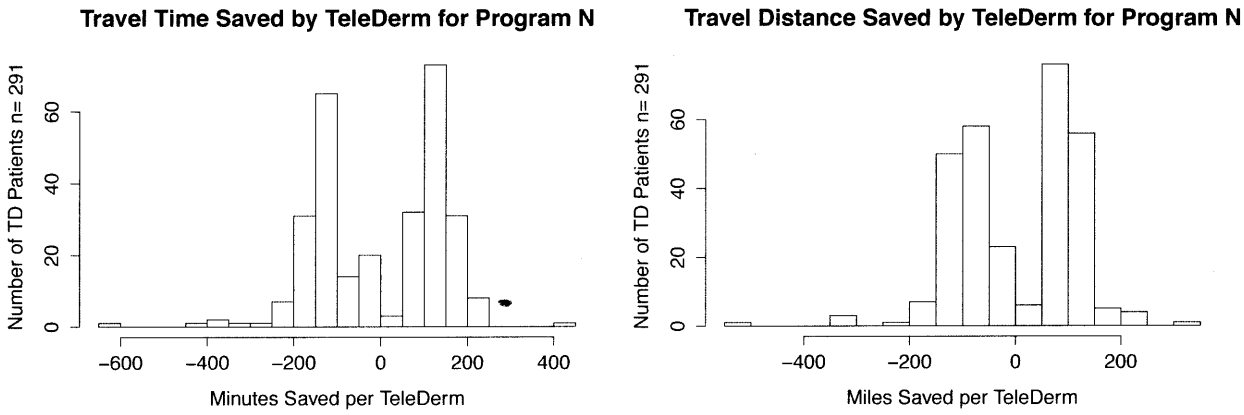


Figure 5-7. Travel time and distance saved with teledermatology in Program N, histograms

None of the travel savings data is normally-distributed; each shows a bi-modal distribution. For each of these programs the travel saved data is summarized by the means and medians in Table 5-6.

Table 5-6. Mean and median travel distance and travel time saves for Programs E, L and N

Summary of Travel Saved						
	Program E (*n*= 1,537)		**Program L (*n*= 1,470)**		**Program N (*n*= 291)**	
	Distance (mi)	Time (min)	Distance (mi)	Time (min)	Distance (mi)	Time (min)
Mean	72.66	78.00	32.08	28.82	3.65	2.77
Median	147.40	160.89	0.00	0.00	31.12	42.41

5.4 Discussion

5.4.1 Post-teledermatology utilization of care conclusions

The most striking result from the post-teledermatology utilization of care data is the extreme variability between the different programs in all aspects of care utilization. The causes for the differences are likely the varying structure, available financial and staff support, and goals of teledermatology programs. If the goal is strictly for triage, then having 62% of the patients see a dermatologist is not surprising. The program can still be accomplishing its objective by affecting time to treatment with appropriate scheduling of urgent patients. But if the goal is to reduce the utilization of the scarce resource in the system, the dermatologist, or to save travel for Veterans, then this program has the highest utilization of the dermatology and is not successful compared to other programs. These differences in the programs must be taken into account when comparing programs and analyzing the post-teledermatology utilization of care data.

Looking specifically at programs with low levels of outside dermatologist fee appointments because the programs more reliably capture the need to see a dermatologist, lower levels of dermatologist usage are associated with higher utilization of the non-physician dermatology provider. Examples of this phenomenon are Programs D, E, I, K, and M. Overall, there are not many patients who end up seeing both the lower level dermatology providers and the dermatologist. This could indicate that programs are able to successfully triage patients to the correct level of provider to handle the skin issue. Successful triage allows the dermatologist to practice at the "top of their license," doing tasks that only they can do and not spending their limited and more expensive time on issues that a nurse practitioner can handle. Programs with high levels of PCP use for post-teledermatology

care may also have this benefit, though overall the maximum utilization of PCP care (22%) is less than the percentages handled by non-physician dermatology providers in programs D, E, I, K, and M. This difference in workload could be because of lack of training for PCPs or could also be due to the lack of dedicated time to handle issues. Program N, which has a high level of PCP care and low level of outside dermatology care, still requires 43% of the patients to see a dermatologist, a higher percentage than any of the programs with specialty dermatology providers. But because the other programs with higher PCP utilization (programs A, B, and O) rely heavily on outside dermatologists, it is difficult to determine if the need for more dermatology care is true for all programs with high PCP utilization or if the overlap between patients who see the PCP and then see the dermatologist anyways is high.

Besides programs A, B, N, and O, the low level of PCP involvement is a surprising result. Part of the purpose of teledermatology programs is to push some of the workload away from dermatologists to PCPs. The low level of PCP workload may be designed into these programs or may result from pushback from PCPs in taking on the extra work.

5.4.2 Travel distance conclusions

The occurrence of different patterns of post-teledermatology utilization of care allows for the comparison of travel distance among the different program structures. Three programs were selected for comparison: one with high non-physician dermatology provider utilization (E), one with high dermatologist utilization (L), and one with high PCP utilization. In these three programs there are a few differences other than program structure to note: 1) Program N is smaller than E and L, 2) Program E has higher average travel distance to the closest VAMC, and 3) Program L has higher levels of inaccurate address information.

For the patients analyzed, Program E, L, and N have saved a total of 111,687, 42,365, and 1,062 miles of patient travel with teledermatology, respectively. Program E has the highest mean travel distance and travel time saved. This advantage holds even when the ratio of

mean travel distance saved to mean distance to a medical center is used as a metric instead of overall travel saved (0.33:1, 0.24:1, and 0.03:1 for programs E, N, and L respectively). While Program L also saves travel distance, the median distance saved is 0, meaning fewer than half of the patients are saving travel. The median distance saved for Program E is 147 mi, indicating a larger proportion of patients are saving travel distance with Program E in addition to saving overall more miles. All of the data supports the structure of Program E, with high levels of post-teledermatology care provided by local non-physician dermatology clinicians, as the most effective at reducing patient travel. This new evidence can be used to support the addition of local non-physician dermatology providers to teledermatology programs when the goal is to reduce travel distance for Veterans.

Each of the distributions of travel distance saved in the three programs has peaks in two different places. The peaks represent three different "modes" of patient travel behavior and care utilization. Mode 1, the peak at 0 in Programs E and L, represents patients who travel the same distance as they would have if they had not used teledermatology. These are the patients who utilize only the VHA dermatologist or outside fee dermatologist care. Mode 2, the peak at around 200 miles saved in all three programs, represents patients who did not have to travel to a medical center and had no follow up care or, in the case of Programs E and N, only local follow up care. Mode 3, the peak at around -200 miles seen in Program N, represents patients who had to travel more than the comparison distance of the closest medical center. Given that this peak is only evident in Program N and that there is no peak at zero, it is possible that there is no dermatologist at the closest medical center for most patients and the comparison distance is incorrect in this case. Some of this data could represent patients who need to travel to the dermatologist and also to other local providers, though only 7% of patients see a PCP and a dermatologist in Program N.

5.4.3 Limitations

This analysis is a retrospective analysis of administrative data collected for purposes other than this research. For that reason a few simplifying assumptions were made that if incorrect may change the results of this analysis. First, it was assumed that the

dermatologist is located at the closest medical center. This may not be true for all programs, as evident in Program N data, where it appears patients had to travel further than the closest dermatologist for care. Additionally, it is possible that in some cases the dermatologist regularly travels to local clinics to hold appointments; this would create an overestimate of the travel times to which teledermatology is compared. The second assumption was that the teledermatology appointment does not require extra travel. This is generally true but in some programs the photograph is taken by a surrogate provider for which a separate appointment is needed. In other cases, the patient cannot stay for a photo or a photographer is only available a few days a week and a patient needs to return to the local clinic later in the week for the teledermatology imaging. These cases would require a separate type of analysis that includes this extra travel. Third, it was assumed that all of the appointments for skin concerns before a dermatologist or within six months are related to the issue identified for teledermatology. It is possible that this assumption is creating an overestimate of travel for teledermatology patients seen by their PCP or a non-physician dermatologist. It was not possible to verify this assumption because diagnoses recorded for teledermatology can be vague. For example, one teledermatology program uses the same diagnosis for all teledermatology imaging appointments. The fourth assumption is that non-dermatologist trained for lower level dermatology care for teledermatology programs are nurse practitioners. If a physician PCP holds a dermatology clinic he or she would still be labeled as a physician and would appear the same way a dermatologist would. In the qualitative work performed. only nurse practitioners were encountered in this role, but it is possible that some are physicians causing an overestimate of the utilization of dermatologists. Finally, it was assumed that the administrative data collected are accurate. The information analyzed was cleaned as much as possible, but it still conceivable that some data used were entered incorrectly or for different purposes by some programs' staff.

This work, particularly the utilization of outside dermatologist care, is limited by the quality of the data collected within VHA. The poor quality of the data that are collected and the small fraction for which the recording of information is required decreases the accuracy of the results for programs highly dependent on outside care.

The analysis in this chapter is only one aspect of access to care, and the goals and other measures of access must be taken into account when evaluating teledermatology programs. Even in time measurements themselves, there is more complexity. For example, the patients' time analyzed is only the travel time saved for a patient and it does not take into account any time spent in waiting rooms and with a provider.

The retrospective nature of this analysis dictates that causation cannot be implied when saying Program E has the greatest travel saved because of its program structure. It is possible there are confounding variables such as the financial support for the teledermatology program that cannot be included in the analysis but still influence the correlation between the two variables investigated.

5.4.4 Future Work

With adequate resources this work could be expanded to include travel distance saved analysis for other programs to validate the results created from the three case studies. Further work could also include the new health factors collected within the VHA teledermatology templates to increase validity of outside dermatologist data by comparing newly available data to the number of patients who are recommended to visit the dermatologist.

Program E has a few outliers who have large amounts of extra travel for teledermatology. These patients can be examined with chart review or other analysis to identify if travel is being included that should not be or, if this is not the case, to understand how to avoid putting patients in this situation in the future.

This study can also be expanded by identifying the patients for whom VHA pays travel reimbursements and using them to calculate the travel cost saved through the teledermatology programs.

The next thesis chapter expands the measures of access to care by examining how implementation of teledermatology affects wait times for all in-person dermatology appointments.

6 Wait Time for Dermatology in VHA

6.1 Introduction

In Chapter 3, VHA stakeholders identified one of the important changes in access that teledermatology can effect as reduced wait times for in-person appointments for all patients being seen in the dermatology clinics. The stakeholders believed that by using teledermatology some patients could be treated virtually and would not have to take a spot in the clinic, thus reducing the queue for patients to be treated in person. This thesis chapter will analyze changes in wait time after the implementation of teledermatology programs.

Wait times for dermatology appointments and wait times for consultation requests have been studied by directly comparing the wait time for conventional treatment pathways to those of patients using teledermatology.[71,74,80,82,83,100] This study is different from those already in the literature because it looks at the impact of teledermatology on wait time for the clinic as a whole, not just for the patients using teledermatology.

The analysis in this chapter will test the following hypothesis:
Implementation of teledermatology technologies reduces the wait time for all in-person dermatology appointments by removing patients from the queue that do not need to be seen in person.

6.2 Methods

6.2.1 Data sources

Wait time information regarding dermatology appointments in VHA was extracted from the CDW. In addition to data for wait times, the following covariates were also used in analysis: number of appointments offered by dermatology, the number of patients who see a PCP for primary skin concern, and the number of consults requested for each

dermatology clinic. All data was structured as a monthly total or mean of values within a month. Table 6-1 is a summary of the data tables from which information was extracted for analysis in this chapter. The Appointment table and the Outpatient table contain some overlapping information. However, the Appointment table includes more administrative data and includes information on all appointments scheduled whereas the Outpatient contains more clinical details and only includes completed visits.

Table 6-1. CDW data source for wait time analysis

CDW Table	Description of information used in wait time analysis
Appointment Table	For each visit in VHA that has occurred or that is scheduled to occur VHA tracks the whether the appointment actually occurs, the time the appointment is scheduled, the date and time of the appointment, the location of the appointment, the department of care for the appointment (by primary stop code: 304=dermatology, 323=PCP), and if it occurs the marker for a specialty type of care within the department (by secondary stop code: 694=patient imaging for teledermatology, 695=provider analysis of teledermatology in same hospital system, 696=provider analysis of teledermatology in different hospital system).
Outpatient Visits	For each visit in VHA an entry is created with the date, time, location, primary and secondary diagnoses (using ICD9), procedure codes (using CPT), clinical provider(s) involved, department of care provided (primary stop code), and if it occurs the marker for a specialty type of care within the department (secondary stop code).
Consult Table	For each time a physician requests a consult (new access to specialty care for a patient) the date and time of the request, the location of the request, the requesting provider, and the department of care requested are recorded.
Dimensions	The dimensions table is used to translate coded fields in the tables above, such as the ICD9 diagnosis code and description. This second level of coding is used to protect patient health information.

6.2.2 Data definitions

6.2.2.1 Wait time for dermatology

The data point used to represent wait time is the difference in days between when an appointment is created in the computer system and when an appointment occurs. Specifically, the wait time for dermatology appointments was extracted from the Appointment CDW table by calculating the difference in days between *AppointmentMadeDateTime* and *AppointmentDateTime* for all appointments with a

PrimaryStopCode of "304" (dermatology) from the Appointment table. All of the wait times were aggregated by the date of the dermatology appointment and the teledermatology program to calculate a monthly average wait time per program. This analysis does not include any appointments that were canceled or any appointments where the patient does not show up. If an appointment is canceled and then rescheduled, the wait time will only account for time from the rescheduling, not from the original request for an appointment.

This method of wait time measurement does have some flaws. It is common to schedule an appointment with dermatology weeks to months in the future. Therefore, with this data, the wait time will never reach zero. This work was done under the assumptions that the number of appointments scheduled into the future remains constant and that availability of reduced wait times for acute patients accounts for enough of the schedule to affect the mean wait time.

VHA has other methods of measuring wait time to take into account the difference between the desired appointment date and the actual appointment date, but these were not included because there have recently been discoveries of falsification of these particular data.[113]

Any wait time calculated that was less than zero was considered an error and not included in the analysis.

6.2.2.2 Wait time for teledermatology

Since a teledermatology appointment is not a traditional office visit, the same wait time data structure does not work. The wait time for teledermatology should represent the time when a consult is initiated by requesting a picture until the time the image is analyzed by a dermatologist. This involves the addition of two separate steps: the wait time until the picture is taken and then the wait time for the dermatologist to look at the image.

The wait time until the picture is taken can be calculated the same way as the wait time for an in-person appointment, adding the requirement that the *SecondaryStopCode* is "694" to isolate the patient imaging appointment. Often, the wait time is zero or very low because the image can be taken immediately after the PCP writes the consult. As with the in-person dermatology appointments, any negative wait time data were not included in the results. In teledermatology there were higher rates of negative wait times, perhaps because the image was taken before the PCP finishes a consult to teledermatology. During one site visit, an imaging technician exclaimed that sometimes she has to wait a day or more to finish a consult if the PCP is behind on record keeping.

Analysis of the same wait time data for provider analysis of teledermatology images revealed issues. Negative wait times occur in 10.6% and 46.6% of teledermatology provider analysis visits with the secondary stop codes 695 and 696, respectively, and only 0.0058% of appointments without a secondary stop code. Because the dermatologist performed the image analysis at a time of his or her choosing, the administrator's creation of the appointment might not occur until after the physician has looked at the image. These data were not sufficient to determine the wait time between when the patient imaging appointment occurs and when the dermatologist has responded. Instead, visit data from the CDW Outpatient Table were used to calculate the difference in days between the imaging visit and the teledermatology reading visit. For each teledermatology imaging visit (*PrimaryStopCode*= "304" and *SecondaryStopCode*= "694") the unique patient identifier *PatientVID* was used to match the visit to all following provider teledermatology visits (*PrimaryStopCode*= "304" and *SecondaryStopCode*= "695" or "696"). The system automatically creates a provider visit on the same day as the patient visit, so the second closest date following the imaging visit was used as the physician imaging analysis visit. Image analysis wait times over 90 days were assumed to be errors and excluded from the analysis. Such errors could occur if a consult is rejected for poor image quality or the two-consult process is not set up correctly in the computer record system.

The wait time appointment data and the visit date difference data were accessed by separate CDW mechanisms for which patient identifiers were scrambled. Therefore,

specific teledermatology image wait time and time to image analysis could not be computed at the patient level. Instead, the wait time for the imaging visit from the appointment data and the wait time for the physician analysis from the visit data were separately averaged by month and added together for the average total wait time for teledermatology. If the number of patients in each calculation is different, the patient count from the outpatient visit data was used.

6.2.2.3 Number of dermatology appointments in-person

The supply of in-person dermatology appointments was considered a covariate for the wait time for an in-person appointment and was included in the analysis. The number of in-person dermatology appointments was created by counting the number of visits per month for each program with the *PrimaryStopCode* "304" for dermatology, but excluding teledermatology appointment with the *SecondaryStopCode* "694", "695", and "696".

6.2.2.4 Number of visits to a PCP for a skin concern

The baseline population was also taken into consideration through the number of patients seen by the PCPs for a skin concern within the teledermatology program. Population growth and demographic changes that impact the skin morbidity burden should all be accounted for in the number of visits to PCPs. The data were extracted from the Outpatient Table of the CDW. The PCP visits were identified as those with the *PrimaryStopCode* "323". The PCP visits where then linked to the *Vdiagnosis* table for the *ICD9SID* (Identifier for ICD-9 diagnosis codes) of the visit with *PrimarySecondary* of "P" to indicate the primary reason for the visit. The *ICD9SID* was then converted to the actual ICD-9 code and diagnosis name through the dimension tables. Any appointment with an ICD-9 code on the list of dermatology ICD-9s (listed in Appendix E) was included in the final count. Using the *VisitDateTime* for the outpatient visit the data were summarized by the number occurring within each teledermatology program per month.

6.2.2.5 Number of consults requested

In addition to the number of patients with skin concerns in the population, the rate at which these patients were being referred to dermatology also affects the wait time. If more of the dermatology concerns are being referred the queue will increase and vice versa. The number of consults requested was used in the analysis of this chapter. The data were extracted from the CDW Consults tables. Consults to dermatology were identified by the *ToRequestServiceName* field in the Consult table of the CDW, the name of the department to which the consult request was made. To identify dermatology requests the terms "DERM" and "304" were used in the search field, but to eliminate specialty dermatology departments like surgery and pathology results with strings "PATH", "MOHS", and "SURGER" were excluded. This exclusion list was generated by reading all results of the *ToRequestServiceName* and verifying that all requests to see a dermatologist were included while specialty dermatology requests were excluded.

Teledermatology could increase the number of referrals because the process generates two consults to dermatology, one for the image and one for the analysis. There could also be a third consult to see a dermatologist in person if the patient requires certain treatments. Because there could be multiple consults that do not actually represent an increase in the number of patients seen by dermatology, the consults were listed per month and then the number of unique patients on that list was used as the result instead of the number of consults themselves.

All data extractions from the CDW were done using Microsoft SQL Server Manager 2012. Some further processing was done in R Studio with R version 3.1.0.

6.2.3 Analysis of dermatology wait times

The monthly average wait time for seeing a dermatologist in person and for teledermatology were combined into one data set to calculate an average wait time for all dermatology patients. This overall mean wait time was graphed along with the teledermatology and in-person dermatology wait times.

Analysis of the graphical data led to a hypothesis that teledermatology was increasing the wait time for in-person teledermatology appointments. This hypothesis was evaluated with auto-regressive, integrated, moving average model, the ARIMA(p,d,q) model. This model was chosen because the wait times for each month are not independent and there appeared to be a seasonal trend to the data. Since 2007 policy changes affected reporting of wait times, only programs started after 2008 were considered in the analysis, and only data after 2008 were used in all calculations. The (p,d,q) components of the overall ARIMA model and of the seasonal components of the model were calculated using the *auto.arima()* function from *forecast* package of R. The dependent variable is the average monthly in-person wait time. The independent variable is the number of teledermatology appointments per month. The number of dermatology appointments offered and number of PCP visits for skin concerns were used as the covariates to represent changes in supply and demand for dermatology that could also affect wait times. The confidence intervals of all coefficients in the model were calculated at α=0.05. The residuals of the wait time models were plotted to evaluate the normality homogeneous variance and zero-mean. The Box-Ljung statistic was calculated and the auto-regressive and partial auto-regressive functions graphed to evaluate the independence of the residuals and verify the appropriate (p,d,q) levels were chosen (Appendix F).

All analysis was done in R Studio using R version 3.1.0. Some graphing and post processing were done in Microsoft Excel 2011.

6.2.4 Analysis of change in number of consults after teledermatology

The ARIMA models took into account any changes in the population but not any possible changes in the specialist care seeking behavior. Teledermatology could increase the number of people who want a specialist opinion because it is easier and faster. Whether the number of dermatology consults increased due to teledermatology was evaluated with hierarchical regression for all of the teledermatology programs that were implemented in or after 2008. Two linear regression models were fit for the dependent variable of number of consults per month. The first had only number of patients per month with skin concerns

seen in primary care as an independent variable. The second had the number of patients per month seen by PCPs and the number of teledermatology image analysis visits per month. Both models were evaluated for patterns in the residuals (Appendix F). The two models were compared using ANOVA analysis to see if the second model, adding teledermatology, accounted for more of the variability in the number of consults.

All analysis was done in R Studio using R version 3.1.0.

6.3 Results

6.3.1 Wait time for in-person dermatology and teledermatology

The average monthly wait time for a dermatology appointment for all of the dermatology services in teledermatology from 2005-2013 is presented for each teledermatology program in Appendix G. A few examples will be shown here to discuss the trends observed.

Often, when teledermatology is first implemented, the wait time for teledermatology fluctuates significantly. Programs A, E, F, H and R all have larger variation at the beginning of teledermatology than in the later years. The graph for Program F is shown in Figure 6-1 as an example.

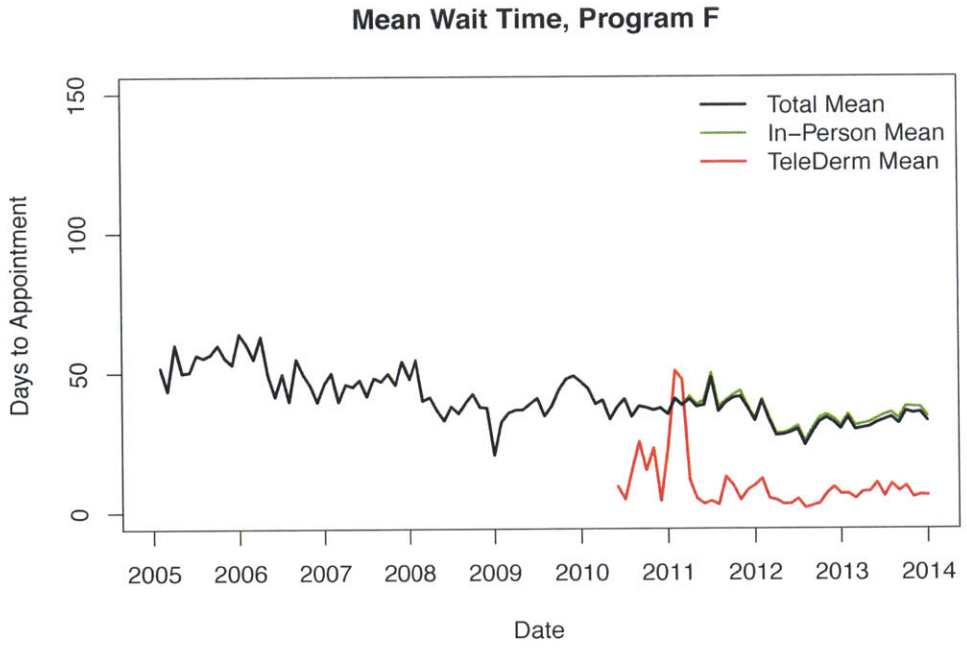


Figure 6-1. Mean wait time for dermatology service 2005-2013, Program F

Program C and D both show consistently high wait times for teledermatology. Program D is shown as an example in Figure 6-2. In both of these programs, for the period of high wait time, patients needed to make an appointment to have a surrogate care provider take an image of the skin concern. This resulted in higher wait times than the other programs that have technicians available almost immediately for teledermatology imaging. In Program C

the wait time decreases because the program ends. In Program D the wait time decreases because technician imagers are made more widely available. Program S also has instances of high wait times for teledermatology, but the time fluctuates and does not stay consistently high like Programs C and D. This program does not require an appointment with a surrogate provider for an image, so the reason for the higher wait times may be with the response time for the dermatologist or a shortage of imaging technicians to respond immediately to PCP requests.

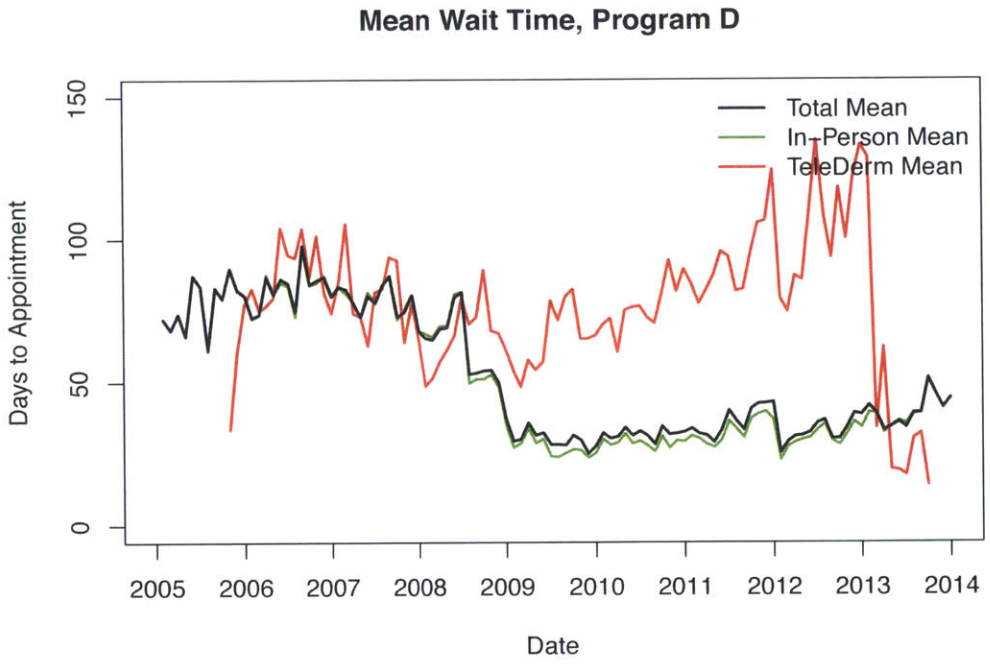


Figure 6-2. Mean wait time for dermatology service 2005-2013, Program D

In 2007 VHA implemented a requirement that Veterans have access to a specialist within 30 days. This requirement greatly decreased the variance across programs in wait times for dermatology services. For example in Program H, the average recorded wait times dropped from 150 days to around 30 days (Figure 6-3). These changes were likely due to a combination of changes in resources and methods for documenting appointments, both of which are not relevant to teledermatology. Therefore, further wait time analysis will focus only on data from 2008 to 2013.

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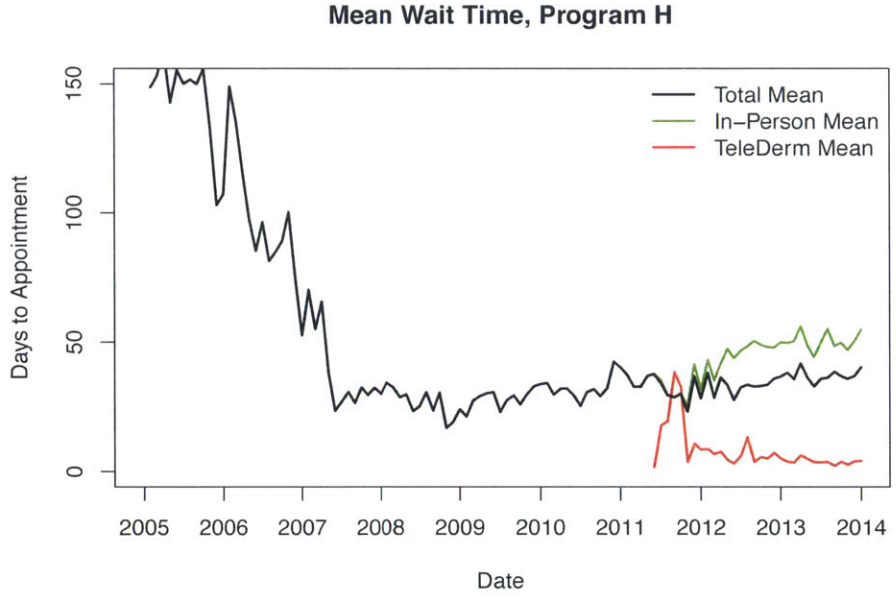


Figure 6-3. Mean wait time for dermatology service 2005-2013, Program H

Overall, the implementation of teledermatology does not have a clear association with a change in the wait time for dermatology services. The programs that should have the largest impact on wait times are those that have the largest percentage of the population utilizing teledermatology. For that reason Programs H and P should have the most evident trends (Figure 6-3 and Figure 6-4, respectively). Program P has complicating factors, since for a few months the facility did not have a dermatologist. But despite the issues, in both of these programs it appears that after the implementation of teledermatology the wait time that takes into account both in-person and virtual dermatology care remains within the

previous range of values, but the wait time to see a dermatologist in person rises after the implementation of teledermatology.

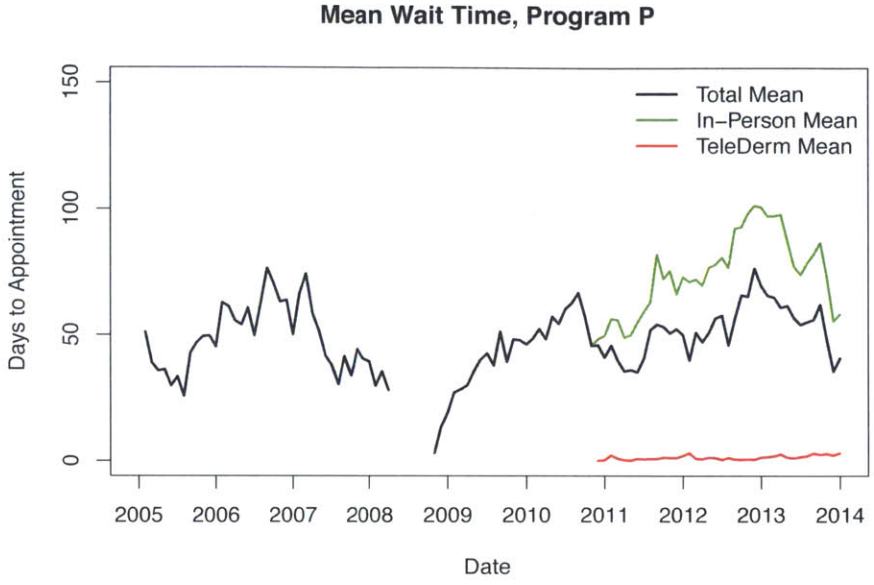


Figure 6-4. Mean wait time for dermatology services from 2005-2013, Program P

6.3.2 In-person wait time changes after implementation of teledermatology

ARIMA models for the wait time data were used to test for the statistical significance of the change in wait time for in-person appointments. The p,d,q parameters for each of the programs generated by the *auto.arima* fitting are listed in Appendix F. Only data after 2008 was used in the models. In the case of Program P, only data after 2009 was used to remove the outliers when there was no dermatologist available. The model fit coefficients to the covariates, to the independent variable, and to the auto-regressive and "shock" terms when present. The overall magnitude of the teledermatology coefficient represents the monthly effect on wait time once the equilibrium has been reached (Figure 6-5).

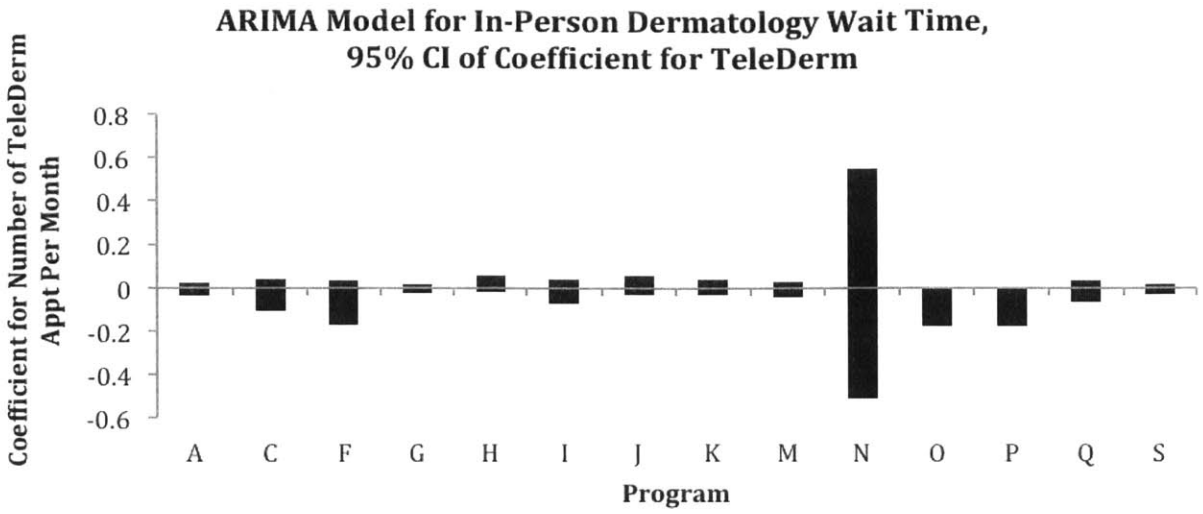


Figure 6-5. ARIMA model coefficient for teledermatology intervention (95% CI)

All of the 95% confidence intervals for the teledermatology coefficients cross 0. None of the teledermatology interventions have a statistically significant effect at the α=0.05 level. The rest of the details for the other coefficients for ARIMA model can be found in Appendix F.

6.3.3 Change in number of consults after implementation of teledermatology

Teledermatology may increase the number of patients treated in dermatology because patients feel seeking care is easier. To test this, a hierarchical linear regression was performed to decipher if a teledermatology variable is able to explain more variation in the number of consults to dermatology than just the changes in the population size. The number of consults to unique patients per month for each program can be seen in Appendix H. First, a linear regression was created with the number of consults to dermatology as the dependent variable and the number of PCP visits about skin concerns as the independent variable. A second linear regression was created with the number of teledermatology appointments per month added as an independent variable. The R^2 values of the two linear regressions were compared with ANOVA to test if teledermatology explains a significant amount of the variability in the number of consults per month. The ANOVA results are presented in Table 6-2.

Table 6-2. Hierarchical linear regression ANOVA results testing whether teledermatology is a statistically significant addition to the linear regression model

Program	A	C	F	G	H	I	J
***p*-value**	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Program	K	M	N	O	Q	S	
***p*-value**	<0.001	<0.001	<0.001	0.0092	<0.001	0.0704	

In all but one of the programs analyzed, the teledermatology variable explains a significant amount of the remaining variation. Program P was not evaluated because of there was no dermatologist in 2008. The information about the coefficients for the variables in the models can be found in Appendix H.

6.4 Discussion

In theory, wait time for the dermatology clinic would be affected by a teledermatology program if enough patients are filtered out of the queue to see a dermatologist. However, if there is a fixed amount of resources, particularly the time of a dermatologist, this will only come to fruition if 1) the program is large enough to filter out a noticeable number of patients and 2) the requirements of Equation 1 are met.

Equation 1. Requirement for teledermatology programs with fixed dermatologist resources to reduce wait time

$$t_{In\text{-}Person} > t_{TeleDerm} + t_{In\text{-}Person} * D$$

Where
$t_{In\text{-}Person}$ = The average time a dermatologist spends with a patient for an in-person visit
$t_{TeleDerm}$ = The average time a dermatologist spends on a teledermatology consult
D = The percentage of time a teledermatology consult results in an office visit to a dermatologist

The wait time will not be reduced if a large fraction of the population has to see a dermatologist in-person after the teledermatology consult or if the time to perform teledermatology consults is high.

Some teledermatology programs add on a dermatologist or surrogate dermatology providers for the teledermatology program, so a reduction in wait times would only require that the dermatologist filter enough people out of the in-person.

6.4.1 Wait time for dermatology services

There was no indication that the monthly average wait time for the in-person dermatology clinic was affected by the implementation of teledermatology. In most cases the fraction of teledermatology patients is too small to have an impact, but the result holds true even when a large percentage of the population uses teledermatology services. If anything, in programs H and P there seemed to be a stable average monthly wait time for the population as a whole, but the wait times for in-person visits seemed to increase. This is the opposite effect of what was expected. There may be no decrease in wait times because more of the skin concerns in the underlying population are being treated by the dermatologist or because not enough people are being triaged out of the queue for in-person appointments.

Some teledermatology programs had higher fluctuations and higher wait times at the beginning of the teledermatology program. These longer wait times could be because the program is adjusting the resources needed to run the teledermatology program or the data entry changes and the quality of that data is low.

Teledermatology, in most cases, had a shorter wait time for patients to be evaluated by a dermatologist than in-person visits. This was not the case in Programs C and D, both of which required an appointment with a surrogate care provider to have an image taken. Like the dermatologist, this surrogate care provider became a scarce resource, and wait times increased for the imaging appointments. If the goal of a teledermatology program is to have faster time to evaluation by a specialist, then the surrogate care model will not be successful unless technicians who can take the skin image are available immediately and locally.

6.4.2 Statistical analysis of in-person wait time changes due to teledermatology

Evaluation of the graphs of monthly average wait time for programs H and P led to the new hypothesis that implementation of teledermatology was increasing the wait time for in-person appointments. This phenomenon, opposite of the expected outcome, could be for multiple reasons. First, this measure is the time from when an appointment is made to when it occurs and the presence of teledermatology may have allowed more of the less serious patients to be triaged to a longer wait time than traditional consults, shifting the mean wait time. Second, the early evaluation by the dermatologist may alter the location of the "state of dysfunctional equilibrium." The consistent wait time for an appointment represents the point at which enough patients renege, drop out of the queue, and forego treatment or find alternatives to maintain an equilibrium between the patients entering the queue and staying and the number of appointments available.[114] Teledermatology creates two separate queues. For those that need to be seen in person, some patients have already been evaluated by an expert through teledermatology and may be willing to wait longer to see the dermatologist. The presence of the teledermatology queue may create more people to feed into the in-person queue because more patients may seek dermatology treatment if they know that they do not have to wait and will get immediate feedback on the skin problem.

Using ARIMA models, the number of teledermatology appointments per month did not have a statistically significant impact on the mean monthly wait time for in-person dermatology appointments. The reason the apparent trends in the wait time for Program H and Program P are not significant may be that the graph does not take into account any change in the underlying population. Additionally, for Program P the analysis could only be done for 2009-2013, and the lack of a dermatologist in 2008 creates a temporal trend of increasing wait times to start with that may have impacted the final analysis.

6.4.3 Change in number of consults after teledermatology implementation

Though there is no evidence that the in-person wait times are changing because of teledermatology, it is still possible that the number of patients seeking dermatology care by

a specialist is increasing. Even accounting for changes to the population of the dermatology services, teledermatology is associated with an increased number of consultations. This indicates the increase in consults likely results from increased referrals for dermatology conditions from a same base population, or, at least, increased referrals to the VHA dermatologists. The result suggests a perceived change in access that encourages more providers to refer or more patients to request treatment.

6.4.4 Limitations

This study relied on retrospective evaluation of administrative data collected at many different programs in VHA. The quality of the data available limits the strength of the conclusions. There have been issues discovered with wait time data within VHA, and while this analysis avoids any reported issues, it is possible that there is some level of falsification or error.

VHA's policy to have patient seen within 30 days could be masking the effects of teledermatology. In many facilities if a new patient cannot be seen in the required time, VHA will pay for those patients to have outside care. Because the quality of the data on patients seen outside VHA is so poor, the effect of this policy could not be explored. Teledermatology may be "reducing the wait time" by decreasing the need to send patients to outside dermatologists, and this would not be shown in this study.

Because the study is retrospective, there is also the possibility that other external forces are affecting the results. The study takes into account the policy change in 2007 that reduced wait times to around 30 days by only using data past 2008 for statistical analysis. There are also variables to account for changes in the underlying population and supply of dermatologists. Qualitative investigation of the teledermatology did not reveal any other policy changes or forces that should be included, but some local variables may still be affecting the results.

Finally, this analysis does not differentiate between dermatology appointments with a dermatologist and those with a non-physician surrogate provider. If a non-physician provider is part of a teledermatology program, his or her wait times are being lumped in with the dermatologist. The extra appointments are accounted for in the model, but the potential shorter wait times for the less specialized provider are not.

6.4.5 Future Work

If better fee data for outside dermatologist appointments became available in VHA, this work would be improved by including any changes in fee appointments in the data. Additionally, as teledermatology programs become larger, this analysis should be repeated to see if teledermatology remains insignificant for changing wait times.

This chapter ends the presentation of new data for the thesis. The following chapter will summarize the results and draw further conclusions from their synthesis.

7 Conclusions

The goal of the thesis was to investigate teledermatology programs within VHA by identifying the type of metrics most appropriate for evaluation and executing a few of those metrics nationally. VHA provides an ideal platform for studying teledermatology because of the combination of separate programs initiated independently, some national oversight, and a common medical record across different programs. The thesis research was conducted in two parts: first, the qualitative research on the national variation in program operations and creation of a set of recommended holistic metrics and, second, the evaluation of a selection of the metrics.

7.1 Summary of contributions

This work is the first rigorous, qualitative examination of variations between the teledermatology programs operating within VHA. It is also the first examination of the current metrics and stakeholders' preferred metrics for teledermatology. The system level teledermatology studies presented in Chapters 4-6 build upon the store and forward teledermatology literature, which has historically focused mainly on feasibility studies and small retrospective trials of diagnostic ability. Multiple modes of teledermatology operations were evaluated while analyzing the largest number of teledermatology patients to date. The time to treatment of skin cancer study was the first in VHA to look at patients treated by all physicians, not just dermatologists. The travel distance analysis was the first to look at travel distance as a primary outcome and to rely on more than self-reported travel data. The wait time evaluation was the first research effort to look at the potential impact on non-teledermatology patients. In combination, these metrics also allowed for the unprecedented comparison of various program structures within VHA.

7.2 Summary of qualitative results

Qualitative investigation into the current state of teledermatology and the evaluation metrics included 4 teledermatology programs site visits and 25 key stakeholder interviews. Key insights about the current state were: 1) there is large variation in how programs are run, particularly in how much follow-up care can be given locally; 2) the patients referred to teledermatology may be significantly different from those referred to in-person care; and 3) there is a fear within some programs that patients are being lost to follow-up. The first two results are key to setting up and interpreting the evaluation of the teledermatology programs. The existence of differences between programs allows for comparison of the program structures, but it also weakens the ability to make conclusions based on national level evaluations. The difference in severity and type of diseases between the dermatology and teledermatology populations creates a bias when directly comparing the two groups. The third result is vital feedback to the national office because any lack of trust in the care process should be addressed to achieve full implementation of the technology.

The evaluation of teledermatology programs' current metrics, goals of the stakeholders in using teledermatology, and opinions on the ideal metrics was conducted through interviews with key stakeholders. The stakeholders were most interested in measuring teledermatology's impact on access to care but were not regularly executing any metrics related to it. This was mirrored within the teledermatology literature, which did not directly and rigorously evaluate access to care measures. The qualitative analysis was used to create a set of recommended metrics for VHA teledermatology programs. The recommended metrics were classified in three categories: already executed within VHA, currently possible, and requires new data collection. First, many teledermatology programs were successfully using image quality as a process improvement metric. The national office is also close to launching tools to measure time to teledermatologists' response and patient satisfaction. These three measures are a great first step in evaluating and improving teledermatology programs. VHA currently has access to some aspects of time to treatment, post-teledermatology utilization of care, travel distance, and wait times

for in-person dermatology clinics. These metrics were explored as part of the quantitative evaluation in the second half of the thesis. Finally, it is recommended that VHA improve data collection on teledermatology costs, particularly the expenditure on outside dermatologist fee-basis appointments; provider satisfaction with teledermatology; and quality of care through chart review or adverse event reporting, so that they can be included as future metrics of teledermatology program success. The latter is of particular importance because it will help address the patient follow-up and trust issues within some of the teledermatology programs.

7.3 Summary of access metric evaluation

7.3.1 Time to treatment for skin cancer

Analysis of time to treatment was completed retrospectively for melanoma and non-melanoma skin cancer patients. Treatment was considered to be the excision, destruction or chemosurgery of a malignant lesion. For all VHA patients nationally, entry into the care process through teledermatology is associated with faster time to treatment than entry into the care process from a traditional in-person referral for both melanoma (teledermatology median: 62 days; in-person consult median: 70 days; p=0.002) and non-melanoma skin cancer (teledermatology median: 79 days; in-person consult median: 88 days; p<0.001). For melanoma, the patients who underwent a biopsy had a faster time to treatment with teledermatology, but for patients who did not, there was no difference for teledermatology. In melanoma and non-melanoma skin cancers, teledermatology was associated with a faster time to biopsy but not a faster time to an in-person appointment. When broken down at a program level, the advantages of teledermatology in reducing time to treatment for non-melanoma skin cancers were less clear. Only 10 of 19 programs had a median time to treatment faster for teledermatology for 2013, and when the analysis is expanded to the period 2005-2013, only 6 programs show a clear advantage for teledermatology. Any conclusions drawn from this analysis are weakened by the initial observation that the severity of the skin conditions likely differs between the groups compared. Only access to the diagnosis of skin cancer was available, and no further severity indices could be used to mitigate this potential bias. Additionally, the patients

using teledermatology are from smaller metro-areas than patients sent straight to in-person care.

7.3.2 Post-teledermatology utilization of care and travel distance

Retrospective analysis of administrative data was used to characterize the post-teledermatology care utilization for 19 teledermatology programs. Five different levels of care were identified and tracked for the six months following a teledermatology appointment: 1) dermatologist, 2) outside-VHA dermatologist, 3) non-physician dermatology provider, 4) primary care provider in-person, 5) primary care provider over the phone. The 19 programs had staggeringly different utilization of all five of the levels of care. The percent of patients utilizing a VHA dermatologist post-teledermatology ranged from 2%-62%. The lowest utilizations of dermatologists were observed in programs that had high outside fee-dermatologist appointments. Groups with low utilization of VHA and outside-VHA dermatologists were those that had high utilization of a non-physician dermatology provider. Overall, when utilized as a major part of the teledermatology program, the non-physician dermatology providers were more utilized (maximum utilization 58%) than PCPs (maximum utilization 23%) for local post-teledermatology care. This analysis was limited by the quality of the data available on the outside-VHA dermatologist fee appointments.

Three programs were used as case studies for the total travel distance saved by teledermatology care analysis. One program relied mainly on dermatologists for post-teledermatology care; one relied on PCPs; and the other relied on local non-physician surrogate care providers. Based on address information from VHA files, all round-trip travel to VHA care providers for a skin concern within six months after teledermatology or until a dermatologist appointment was calculated for each patient. The travel after teledermatology was compared to a trip to see a dermatologist in-person. The program with local non-physician surrogate care had the most travel saved per person, even when normalized by the average travel distance to a medical facility.

7.3.3 Teledermatology's impact on in-person wait times at dermatology clinics

The final measure of access to care evaluated in this thesis was change of in-person wait times created by the teledermatology program. In theory, teledermatology could decrease in-person wait times for patients not using the service by filtering out patients who do not need to see a dermatologist in-person. This study used different wait time sources than those recently criticized for falsification. Retrospective evaluation of monthly mean wait times from 2008-2013 for 14 teledermatology programs started between 2008-2011 did not show any impact of teledermatology on wait times. This result is likely a combination of the low utilization of teledermatology relative to the in-person services and other policy efforts to see patients within 30 days of a request. However, there was an increase in the number of consults to the dermatology service overall for equivalent wait times.

7.4 Importance of local dermatology care provider

Synthesizing all of these results, one important theme emerges: the importance of the local surrogate dermatology care provider. The existence of the surrogate care provider is not a new concept, but the utilization of such services in the dermatology departments has increased with the implementation of teledermatology. The presence of a local provider able to perform biopsies and small excisions is one of the possible reasons teledermatology is associated with faster time to treatment for skin cancers. The utilization of a non-physician dermatology care provider is also one of the factors associated with lower utilization of dermatologists for post-teledermatology care. The surrogate care provider is taking the workload away from both the dermatologist and the PCP. The workload shift allows the dermatologists to spend more time practicing at the top of their licenses. This presence of a local care provider also resulted in a decreased travel distance for Veterans to receive dermatology care, indicating increased access to care and potentially financial savings for VHA. Additionally, in some programs observed during the qualitative analysis of the current state, this surrogate care provider held a significant amount of the responsibility for verifying that follow-up was achieved for the patients who needed it. The local dermatology provider is key to reducing travel and the burden on dermatologists, and despite the expense, a teledermatology program may not be worth executing without it.

7.5 Generalizability of thesis results

This analysis was performed for VHA, a unique healthcare system with a predominantly male population that is sicker and of lower socioeconomic status than the general population.[16] Additionally, VHA does not have a traditional third party payment system; nor does VHA suffer from the same liability and state-based medical licensing barriers to telehealth as other US healthcare systems. Finally, VHA is an integrated care system using the same medical record between the PCP and specialty providers. Therefore, care must be taken when generalizing the results of the teledermatology studies to other systems. The results are most applicable to single payer, national health care organizations such as those in the United Kingdom and Canada. The particular metrics identified may be a good starting point for other hospital systems. However, some metrics such as travel distance for care may not be as important, and the mechanisms for post-teledermatology care may be very different.

In addition, these results may be applicable in part to other types of telehealth care. The types of metrics chosen for evaluation, such as the time to final treatment and the travel distance avoided, could be used for other types of telehealth within VHA. Also, understanding the amount of time a telehealth encounter will result in a patient needing to travel to a specialist for care is important in the design of any telehealth program. Like teledermatology, lower level providers may need to be trained to make a telehealth program more successful.

7.6 Future work

This work can be incrementally improved by a few additions to the current studies. First, information about malignancy size can be added to the time to treatment for skin cancer analysis to account for any bias created by teledermatology in practice. The time to treatment analysis can also be expanded to other dermatologic diseases, particularly those that do not need in-person follow-up. Secondly, travel distance calculations can be expanded to more programs to validate the comparison between the different program

structures. Finally, the addition of high quality outside appointment data would enhance the post teledermatology care, travel distance, and wait time analysis.

The next big step in teledermatology metric research would be to monitor the effect of implementation of a small set of these metrics over time. This could answer the questions of how these metrics would be used in programs and whether they are effective as performance improvement tools.

Finally, the importance of the local dermatology-trained surrogate provider could be quasi-experimentally tested within VHA. By adding providers in some locations and doing both qualitative studies and quantitative evaluations of metrics, the value of the surrogate care provider itself can be tested. This would reduce confounding factors of the conclusions of this research such as the increased funding available to programs that currently use surrogate providers.

7.7 Implications of current results

This work was completed with the support of the Veterans Engineering Resource Center. This group has the capabilities to operationalize this work by making the metrics created for this thesis, such as the characterization of the post-teledermatology care required, available in an easy to use tool for the teledermatology programs in VHA. This will allow teledermatology programs to use the information for performance improvement, creating better care for Veterans.

This work was completed to improve the current state of knowledge about teledermatology in VHA. The qualitative results can aid the national teledermatology leaders in the strategic planning regarding which data to collect and use to evaluate teledermatology. Similarly, individual programs can use the information to implement local metrics. The results of this work can also be used to make recommendations about the relative value of different program structures when implementing new programs or changing existing programs.

Appendix A Classification of teledermatology programs and details on program size

Using VHA's own reporting tools, the VSSC Telehealth Data Cube: *CVT SF Telehealth Cube,* initial data analysis was conducted to understand the variation in the size and patient population of VHA teledermatology programs. This data source is generated from data created when treating patients and is used internally to track telehealth workload. It matches the encounter recorded at the patient site to an encounter recorded at a provider site.

This data was used to identify all programs that had been running before FY 2012. For these programs the volume of patients seen in each program, which hospitals (provider sites) and clinics (patient sites) were associated with each program, and the rural categorizations of the patients seen by the teledermatology program were recorded. Over 20% of the teledermatology data in the cube was unmatched between patient and providers, indicating some errors in the data recording system. This was considered acceptable because data is only used to generate categorizations of the teledermatology programs.

Graphs of the patient volume were created to understand the makeup of the VA programs and create categorizations. The names of each exact program cannot be disclosed, but each bar represents one facility and their associated clinics in Figure A-1. Teledermatology patient volume for fiscal year 2012, Store and Forward (SF) and Clinical Video Telehealth (CVT), each bar is a program. The categorizations in Table A-1 were determined visual examination of the spread of program size and confirmed by national teledermatology leadership.

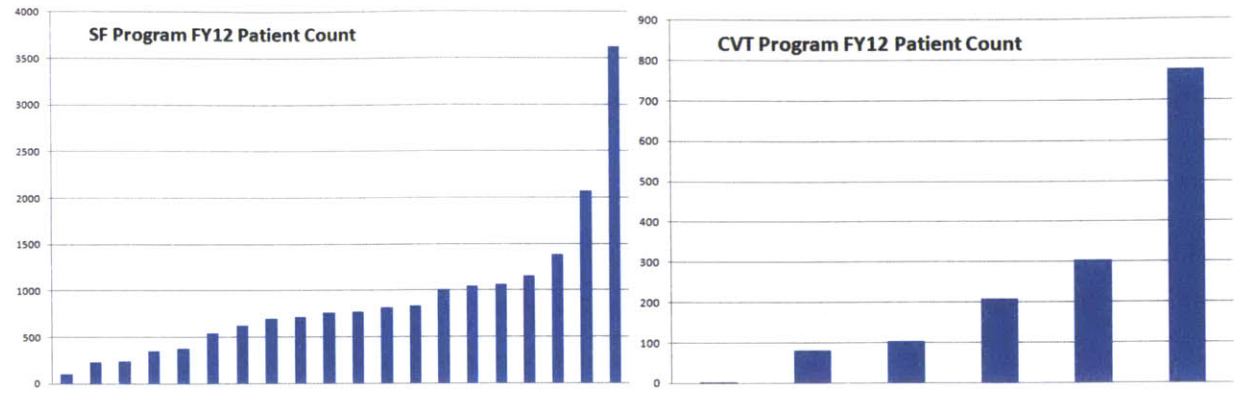


Figure A-1. Teledermatology patient volume for fiscal year 2012, Store and Forward (SF) and Clinical Video Telehealth (CVT), each bar is a program

Table A-1. Size categorizations of VHA teledermatology programs

Category	Store and Forward	Clinical Video
Small	Less than 500 patients/year	Less than 150 patients/year
Medium	500-1000 patients/year	150 to 400 patients/year
Large	More than 1000 patients/year	More than 400 patients/year

The same process was repeated looking at the rurality categorizations of patients treated in the teledermatology programs. Some patient data was not available. Each VA program started before FY2012 was mapped into a rurality and size categorization

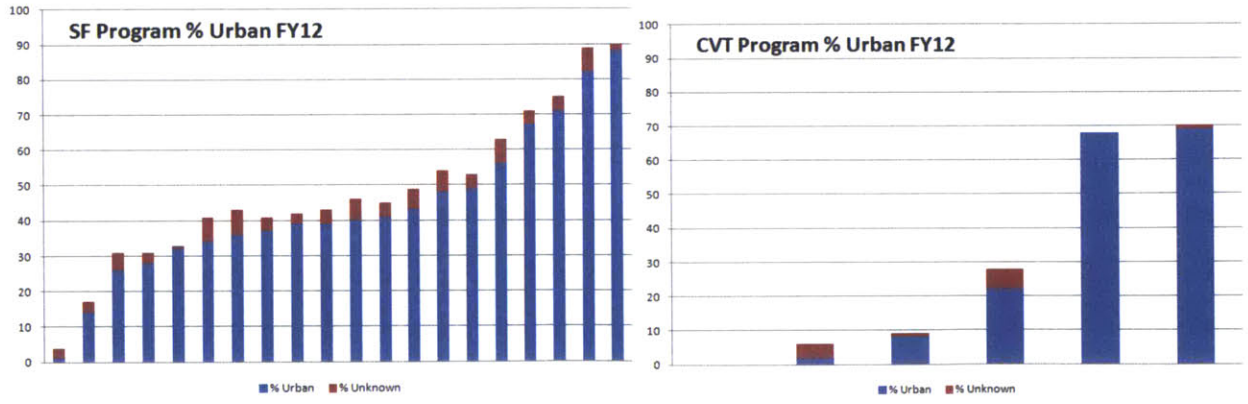


Figure A-2. Percent of teledermatology patients of 2013 per program who are urban, red is unknown

Table A-2. Rurality categorization of VHA teledermatology programs

Category	Store and Forward	Clinical Video
Urban	More than 66% urban patients	More than 66% urban patients
Mixed	33-66% urban patients	33-66% urban patients
Rural	Less than 33% urban patients	Less than 33% urban patients

Table A-3. Number of VHA SFT teledermatology programs in rurality and size categorizations

	Urban	Rural	Mixed	TOTAL
Small	1	2	1	**4**
Medium	1	4	3	**8**
Large	2	5	0	**7**
TOTAL	**4**	**11**	**4**	**19**

For reference, more information about the utilization of the store and forward teledermatology appointments was extracted from the CDW and reported in Table.

Table A-4. The number of teledermatology appointments per year for each teledermatology program

	Number of Provider Teledermatology Appointments per Year								
Program	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**
A	0	0	0	32	221	582	916	1258	1185
B	0	7	89	16	171	258	435	739	1042
C	0	0	0	0	0	0	403	1837	372
D	0	0	1002	1454	1294	1394	1289	1218	1387
E	0	260	772	945	1236	1171	1464	1523	1689
F	0	0	0	0	18	67	366	491	732
G	0	0	0	0	0	93	1232	1410	2380
H	0	0	0	0	0	0	168	1585	1419
I	0	0	0	0	450	903	795	1134	1339
J	0	0	0	0	0	0	67	1249	1783
K	0	0	106	685	643	866	959	942	1018
L	0	630	1505	1761	1881	1955	1905	1048	1755
M	0	0	0	0	1163	4332	6626	6917	7529
N	0	0	0	0	0	0	54	164	315
O	0	0	14	170	243	12	188	263	545
P	0	0	0	0	0	97	1873	2220	2276
Q	0	0	0	0	0	5	362	1722	3156
R	0	0	0	1	298	725	796	840	831
S	0	0	0	735	1575	671	735	929	939

Appendix B Teledermatology literature review metric details

A structure literature review was completed for the teledermatology metrics (See 2.3.6). The following is a detailed breakdown of the metrics found in the teledermatology literature, by category.

In the tables the following abbreviations are used:
TD= Teledermatology
F2F= Face-to-Face
PCP= Primary Care Provider

Table B-1. Description of structure measures from teledermatology literature

Structure Measures	# Papers
Quality	
3 metric, 36 papers	
Quality of image[72,81,88,90,91,95,98,102,104,115–140]	35
Quality of video[141]	1
Quality of reported history[81,88,98,102,104,126,130]	7
Equipment and Software	
3 metrics, 1 paper	
Assess multiple software systems' capabilities[142]	1
Opinion of software of new user[142]	1
Opinion of software of high volume user[142]	1

Table B-2. Description of process measures regarding post-teledermatology visits from literature

Process Measures A. Visits Needed: 45 papers	# Papers
Need F2F or Further Action	
11 metrics, 21 papers	
Percentage of F2F referrals needed from TD group[53,72,93,95,96,100–102,104,129,143,144]	12
Number of further investigation needed from TD group[53,102,129,130,138,145]	6
Could be sent straight for appropriately surgery[91]	1
Inappropriately booked for surgery based on TD alone[91]	1
Surgery cancelation rates for TD patients triaged straight to surge	1
Percentage triaged NOT to need F2F but F2F changes diagnosis[98]	1

Process Measures	
A. Visits Needed: 45 papers	**# Papers**
Percentage cases were TD is appropriate[141]	1
Number of referrals added (originally no intent to refer)[94]	1
Number of patients needing follow up[100]	1
Rate of visit to PCP for follow up versus telephone as reported by PCP[146]	1
Actual rates of follow up and dermatology visits[146]	1
Does Not Need F2F	
6 metrics, 16 papers	
Number triaged not to need F2F[54,81,85,91,98,100–102,105,116,131]	11
Whether F2F determines F2F not needed[92,103,111]	3
Unnecessary F2F referrals from TD (no treatment needed)[81]	1
False positive referrals (TD said needed but not histopathology)[127]	1
Could not be managed with TD alone[91]	1
Provider opinion of amount of appointments suitable for CVT[147]	1
Referrals Avoided	
4 metrics, 11 papers	
Number of referrals avoided[83,86,88,90,94,95,146,148,149]	9
Estimated GP reduction in referrals because of learning[112]	1
Reduction in dermatology workload because of TD[150]	1
Reduction in dermatology load with TD with time lost to perform TD[146]	1
Extended Further Action Needed	
6 metrics, 8 papers	
Re-attendance rates by geography and type of healthcare sought[112,151]	2
Mean rates of additional visits to health care providers[112,151]	2
Second communication needed[102,148]	2
Number of second opinions[86,152]	2
Number of visits to the hospital[106]	1
Mean number of follow up visits[100]	1
Triage	
5 metrics, 7 papers	
Percentage of TD referrals a diagnosis could be made[72,118,141,144]	4
Number of visits needed to diagnosis[74]	1
Percentage of appropriate patients labeled as urgent[82]	1
Reliability of urgency level of referral letter alone[98]	1
Compare rates of urgent patient of referral with and without photo[98]	1
Reason for Decision	

Process Measures A. Visits Needed: 45 papers	# Papers
2 metrics, 3 papers	
Reason for F2F referral[44,93]	2
Reason a consultation was preventable[103]	1

Table B-3. Description of process measures from teledermatology literature

Process Measures	# Papers
Time Impact	
9 metrics, 27 papers	
Clinician time impact (specialist)[81,93,102,104,115,133,138,139,141,153–156]	13
PCP time impact (person taking picture)[53,80,96,115,126,127,133,141,154,157,158]	11
Response time for TD[53,81,86,93,96,117,133,145,148,159]	10
Time break down of PCP activities[126,133]	2
Factors significant to PCP time spent on consult[126]	1
Time to follow up after appointment[80]	1
Time to closed consult[123]	1
Length of time patient spends at appointment or e-visit[153]	1
Amount of time procedure or test needed[144]	1
Appointment Info: Type of disease	
3 metrics, 70 papers	
Diagnostic categories & number of patients/lesions[40,41,53,72,74,78,81,86,88,91–94,96,98,100–105,115–117,122,123,127,129–131,133–135,139–141,143–145,147–149,155,156,160–184]	69
CPT codes as a measure of case complexity[65]	1
ICD9 codes as a measure of case types[65]	1
Appointment Info: Type of Action from Dermatologist	
4 metrics, 13 papers	
Type of recommendation and treatment from TD[145,155,175,183–185]	6
Percentage of appointments with recommended biopsy[146,181,186]	3
Purpose of the TD appointment (diagnosis, management)[144,145]	2
Number of excisions[131]	1
Frequency of tests being ordered[140]	1
Appointment Info: Source of referral	
5 metrics, 12 papers	
Who referrals are coming from[53,129,148,155,175,183]	6
Number of referrals per PCP[80,86,133]	3

Process Measures	# Papers
Whether TD was first contact with dermatologist[96,144]	2
Where first contact to dermatology is made[187]	1
How many services are billed for patients from TD v F2F[187]	1
Whether TD patients are first time or follow up[155]	1
Physician Learning	
2 metrics, 2 papers	
Physician self reported learning[86]	1
Percentage of TD with content that is considered educational[72]	1
Misc.	
Ability to make a diagnosis from the image[101,123,128,145–147,176]	7
Ability to make definitive single diagnosis[185]	1
Percentage of dermatology referrals that are TD[53,129]	2

Table B-4. Description of safety measures from teledermatology literature

Safety Measures	# Papers
13 metrics, 19 papers	
Reason for TD misdiagnosis[103,134,141,174,188]	5
Under diagnosis of malignant lesions with TD[40,41,118]	3
Number of malignant lesions missed from TD to F2F[85,87,100]	3
Severity of mismanagement based on histopathology[40,41]	2
Clinically relevant disagreement between TD and F2F[135,166]	2
Adequate management decisions[116]	1
Problems in handling adverse events[119]	1
Number Needed To Harm[100]	1
F2F follow up that no adverse events happen in 3 months[172]	1
Number of wrongly diagnosed tumors[185]	1
Number of malignant lesions missed from TD to histopathology[87]	1
Melanoma pick up rate; skin cancer pick up rate[81]	1
Number mismanaged with TD compared to F2F[128]	1

Table B-5. Description of diagnostic ability measures from teledermatology literature: primary diagnosis

Diagnostic Ability Measures: Primary Diagnosis	# Papers	w/ Kappa
Primary Diagnostic Concordance: TD compared to F2F		
6 metric, 49 papers		

Diagnostic Ability Measures: Primary Diagnosis	**# Papers**	**w/ Kappa**
Diagnostic concordance[72,76,87,88,91,98,100,102,104,105,115,117,122,124,125,128,130,132,135,137,139–141,145,156,158,160,162,163,165–167,169,171,177–180,182,183,185,186,189]	43	9
Intra-observer agreement[87,139,166,172,190]	5	1
Diagnosis agreed upon after F2F[116]	1	0
Under poor image quality and high image quality[130]	1	0
Number of TD making diagnosis same as F2F[169]	1	0
Only when both chose a single definitive diagnosis[185]	1	0
Primary Diagnosis Concordance: TD compared to TD **4 metrics, 15 papers**		
Diagnostic concordance[76,81,104,116,130,166,167,169,170,172]	10	6
In large group of dermatologists[116]	1	0
Between SF and CVT diagnosis[176]	1	0
Intra-observer agreement[81,173]	0	2
Primary Diagnosis Concordance: F2F compared to F2F **1 metric, 8 papers**		
Diagnostic concordance[78,87,100,156,165,178,189]	7	2
Primary Diagnosis Concordance: TD compared to Referrer **2 metrics, 6 papers**		
Diagnostic concordance with PCP[81,104,129,170]	3	1
Diagnostic concordance with ER doctor[117,178]	1	2
Primary Diagnosis Concordance: F2F compared to Referrer **2 metrics, 2 papers**		
Diagnostic concordance with PCP[172]	1	0
Diagnostic concordance with ER doctor[178]	0	1
Primary Diagnosis Accuracy: TD compared to histopathology **3 metrics, 22 papers**		
Diagnostic accuracy with histopathology[40,41,93,104,106,118,127,131,132,134,136,137,139,174,186,189,191–194]	13	10
Comparison of accuracy within macro, PLD, and CID and within specific types of neoplasms[195]	1	0
Correct second opinion consult[196]	1	0
Primary Diagnosis Accuracy: F2F compared to histopathology **3 measures, 12 papers**		

Diagnostic Ability Measures: Primary Diagnosis	# Papers	w/ Kappa
Diagnostic accuracy with histopathology[104,131,132,134,136,139,174,191,193,194]	6	6
Comparison of accuracy within macro, PLD, and CID within specific types of neoplasms[195]	1	0
Correct second opinion consult[196]	1	0
Primary Diagnosis Accuracy: Referrer compared to histopathology		
1 measure, 1 paper		
Diagnostic accuracy with histopathology[192]	1	0
Primary Diagnosis Sensitivity/Specificity: TD compared to F2F		
1 measure, 6 papers		
Sensitivity/Specificity of finding skin cancer[81,87,100,127,131,197]	6	0
Primary Diagnosis Sensitivity/Specificity: TD compared to histopathology		
2 measure, 5 papers		
Sensitivity/Specificity of finding skin cancer[81,87,127,131]	4	0
Sensitivity/Specificity of diagnosing leprosy[124]	1	0

Table B-6. Description of diagnostic ability measures from teledermatology literature: differential and categorical diagnosis

Diagnostic Ability Measures: Differential/Categorical Diagnosis		
Differential Diagnosis Concordance: TD compared to F2F	**# Papers**	**w/ Kappa**
4 measures, 20 papers		
Differential diagnosis concordance[91,122,145,156,165,177,178,182,186,189]	10	2
Categorical diagnosis concordance[76,87,102,128,141,145,160,185,190]	8	3
Intra-observer agreement on a scale from 1-5[98,198]	2	0
Inter-observer concordance on a scale of 1-6[98]	1	0
Differential Diagnosis Concordance: TD compared to TD		
2 measures, 4 papers		
Differential diagnosis concordance[172,178,189]	2	1
Differential diagnosis concordance between SF and CVT[176]	1	0
Differential Diagnosis Concordance: F2F compared to F2F		
1 measure, 3 papers		
Differential diagnosis concordance[156,178,189]	3	1
Differential Diagnosis Concordance: TD compared to Referrer		
1 measure, 1 paper		
Differential diagnosis concordance[129]	1	0

Differential Diagnosis Accuracy: TD compared to histopathology		
1 measure, 4 papers		
Differential diagnosis accuracy[40,41,178,189]	4	0
Differential Diagnosis Accuracy: F2F compared to histopathology		
1 measure, 2 papers		
Differential diagnosis accuracy[178,189]	2	0

Table B-7. Description of diagnostic ability measures from teledermatology literature: primary management

Diagnostic Ability Measures: Management	# Papers	w/ Kappa
Management Concordance: TD compared to F2F		
1 measure, 14 papers		
Management concordance[76,91,93,100,104,117,120,127,160,163,167,180,185,189]	10	7
Management Concordance: TD compared to TD		
4 measures, 7 papers		
Management concordance[81,120,127,189]	1	3
Management concordance between SF and CVT[167,176]	2	1
Intra-observer management concordance[81]	0	1
In large group of dermatologists[152]	1	0
Management Concordance: F2F compared to F2F		
1 measure, 2 papers		
Management concordance[127,189]	1	1
Management Accuracy: TD compared to histology		
1 measure, 3 papers		
Management accuracy[40,41,127]	2	1

Table B-8. Description of diagnostic ability measures from teledermatology literature: categorical or differential management

Diagnostic Ability Measures: Differential/Categorical Management		
Categorical Management Concordance: TD compared to F2F	**# Papers**	**w/ Kappa**
9 measures, 7 Papers		
Partial management concordance[178]	1	0
Concordance on whether to biopsy[178]	1	1
Management concordance to treat at different levels (surgical, local)[163]	1	1

Diagnostic Ability Measures: Differential/Categorical Management		
Management concordance within different levels (surgical, local)[163]	1	1
Agreement in request for diagnostic tests[88]	1	0
Agreement in need for follow up[88]	1	0
Agreement in treatment[88]	1	0
Concordance of planned surgery method[106]	0	1
Management concordance when both chose a single definitive diagnosis[185]	0	1
Categorical Management Concordance: TD compared to TD		
2 measures, 2 papers		
Partial management concordance	1	0
Concordance on whether to biopsy	1	0
Categorical Management Concordance: F2F compared to F2F		
2 measures, 2 papers		
Partial management concordance[189]	1	0
Concordance on whether to biopsy[178]	1	0

Table B-9. Description of diagnostic ability measures from teledermatology literature: triage decision

Diagnostic Ability Measures: Triage Decision		
Triage Concordance: TD compared to F2F	**# Papers**	**w/ Kappa**
4 measures, 3 papers		
Concordance on which lesions to evaluate further[199]	1	1
Concordance follow up needed for lesions[199]	1	1
Correctly triaged as agreed after F2F[116]	1	0
Level of urgency correctly marked[90]	1	0
Triage Concordance: TD compared to TD		
4 measures, 3 papers		
Concordance on which lesions to evaluate further[199]	1	1
Concordance follow up needed for lesions[199]	1	1
Triage concordance[116]	1	0
Triage concordance between letter + letter with picture[150]	0	1
Triage Sensitivity/Specificity: TD compared to F2F		
1 measure, 2 paper		
Correct benign/needing referral decision[173,198]	2	0
Triage Sensitivity/Specificity: TD compared to TD		
1 measure, 1 paper		

Inter-observer benign/needing referral decision[173]	1	0

Table B-10. Description of diagnostic ability measures from teledermatology literature: disease severity rating

Diagnostic Ability Measures: Disease Severity Rating	# Papers	w/ Kappa
Severity Rating Concordance: TD compared to F2F		
6 measures, 5 papers		
Disease severity rating[121,200]	0	2
Rating signs of melanoma[193]	1	0
Inter-observer concordance according to the Saida classification[197]	1	0
Inter-observer agreement for other Saida classification of dermatoscopic images[197]	1	0
Concordance of described signs of a lesion (rated from 1-100 in certainty) between video and F2F[161]	1	0
Described signs of a lesion (rate from 1-100) between high definition image and F2F[161]	1	0
Severity Rating Concordance: TD compared to TD		
1 measure, 3 papers		
Disease severity rating[121,157,200]	3	2
Severity Rating Correlation: TD compared to F2F		
1 measure, 4 papers		
Correlation of disease severity ratings[121,200–202]	4	0
Severity Rating Correlation: TD compared to histopathology		
1 measure, 1 paper		
Correlation of disease severity ratings[201]	1	0

Table B-11. Description of confidence in diagnosis measures from teledermatology literature

Confidence in diagnosis measures	# Papers
5 metrics, 23 papers	
Confidence in diagnosis[88,98,104,115,127,130,135,138–141,144,145,148,167,182,183,203,204]	19
Diagnostic difficulty as determined by an expert[132,134,137]	3
Confidence in diagnosis compared to biopsy rates, concordance, accuracy[203]	1
Concordance of diagnostic confidence level between TD and F2F[163]	1
Weighted Kappa for concordance of diagnostic confidence level between TD and F2F[163]	1

Table B-12. Description of clinical outcome measures from the teledermatology literature

Clinical Outcome Measures	# Papers
Long-Term Follow Up	
7 metrics, 6 papers	
Documented improvement on repeat visits[76,78,164]	3
Number of patients discharged clear of psoriasis[205]	1
Review of charts (only for patients not receiving face-to-face)[101]	1
Number of adverse events in charts after 3 months[172]	1
Total number of light treatments needed[205]	1
Proportion of patients with side effects[205]	1
Proportion of patients getting GP follow up to light treatments[205]	1
Standardized Clinical Assessment	
7 metrics, 6 papers	
Psoriasis Area Severity Index (PASI)[121,206]	2
Investigator Global Assessment (IGA)[206]	1
Total Number of Inflammatory Lesions[153]	1
Osnabruck Hand Eczema Severity Index (OHSI)[157]	1
Hand Eczema Severity Index (HECSI)[157]	1
Severity Scoring of AD (SCORAD)[207]	1
Saida Classification of dermatoscopic images[197]	1
Surveys	
8 metrics, 6 papers	
Dermatology Quality of Life Index (DLQI)[75,206,208,209]	5
Infants' Dermatitis Quality of Life Index (IDQOL)[210]	1
Impact of Chronic Skin Disease on Daily life[210]	1
Visual Analog Scale of Itching[210]	1
European Quality of Life Insturment-5 Dimensions (EQ-5D)[208]	1
Ware 12 Short Form Health Survey[211]	1
Schipper and Levitt Functional Living Scale[211]	1
Quality Adjusted Life Years (QALYs)[208]	1
Time to Treatment	
9 metrics, 16 papers	
Mean wait time[71,74,80–83,100,101,154]	9
Median wait time[100,155]	2
Time from referral to initial consult[79,93]	2
Time from referral to surgery[79,106]	2

Clinical Outcome Measures	# Papers
Time to first response (intention to treat)[65,188]	2
Time to first response (actual clinic visits)[188]	1
Time from referral to biopsy[79]	1
Time to endpoint for malignant lesions[90]	1
Number of clinic appointments before surgery[79]	1
Value of Expert	
4 metrics, 11 papers	
Whether patient attend appointments recommended by dermatologists[99,112,151,176,212]	5
Change in diagnosis after TD appointment[41,78,143,149,155]	5
Change in management after TD appointment[41,78,143,149]	4
Receive definitive care at first visit[83]	1
Patient Behavior	
2 metrics, 2 papers	
Patient compliance with TD program[119]	1
Self management behavior patterns[207]	1

Table B-13. Description of patient satisfaction measures from the teledermatology literature

Patient Satisfaction Categories and Question Topics
General Satisfaction
Overall satisfaction[53,54,71,72,74,75,80,85,93,100,103,133,138,141,146–148,153,155,161,180,182,185,188,192,213–215]
Would recommend to others[71,119,180,214]
Satisfaction on convenience[54,74,75,80,215]
Whether program is a good idea[119]
Would use e-service again[148,149,153,161,192]
Amount willing to pay for service[73,92,152]
Amount willing to pay for TD w/ and w/o reduced wait time[73]
TD should be readily available[129,180]
Visit-Specific Satisfaction Questionnaire (VSQ) for patients[54]
Patient satisfaction questionnaire III[213]
Compare TD/F2F
Prefer TD over F2F[54,71,72,75,80,130,141,147,192,211,213,215–217]
Is TD equivalent to F2F[217]
TD v. F2F with different wait times[213]
Was treated just as well as in person[153]
Patient feels something is missing with TD[213]
TD better able to meet dermatology needs[146]

Patient Satisfaction Categories and Question Topics
Preference between SF and CVT[130]
Barriers/Concerns
Embarrassment[75,141,155,182,185,215]
Privacy concerns[75,215]
Data transmission issues[119,153]
Problems taking pictures[119]
Barriers in seeking care[216]
Concerns with teledermatology process[216]
Which body locations are acceptable for teledermatology[216]
Wait Time
Satisfaction over wait time[54,74,80]
Wait time too long[71,75,215]
Actual wait time recorded[72]
Time spent on consultation[54,72,141,154,216,217]
Satisfaction on time spend[74,138,153,190]
Wait time in waiting room[72]
Time for recording data[119,153]
Clinical Outcomes
Thought condition improved[53,153]
Thought properly treated[71,75,141,214–216]
Thought received adequate follow up[71]
TD reduced worry/stress about skin condition[155,182,217]
Need to be seen in person after TD[147,218]
Practitioner skills[54,100,141,213,214]
Patient's thoughts on TDs ability to diagnose[147,161]
Ability of TD to treat problem[161,214]
Perception of diagnosis and treatment plan via TS[218]
Disease's impact on daily live[153,209]
Symptoms[211]
Travel/Access
Willingness to wait for TD results for convenience of reduced travel[216]
Distance traveled[54,71,154,155,182]
Convenience[100,213]
Access[53,100,213]
Savings of time/travel/money[129]
Would you go to distant clinic if TD not available?[214]
Availability of drugs prescribed by TD[53]
Communication
Satisfaction in interactions[54,100,103,141,147,209,213,214]
Could express concerns and questions[75,138,141,153,215]
Thoughts on the information and detail provided by TD[147,218]

Patient Satisfaction Categories and Question Topics
Communication[100,141,149,213]
Feeling of contact with the dermatologist[141]
Respect/ courtesy[138]
Trust/Confidence
How confident did you feel?[141]
Confidence in teledermatology before and after[129,218]
Do you trust video conferencing as a physician's aid?[149]
Comfort with new process[138,161,182,185,217]
Feeling at ease with TD[75,129,215]
Misc.
Willingness to use own mobile[119]
Usability[209]
Ease of use[120]
Reason for using service[93,152]
Purpose of technology[219]
Benefits of teledermatology[92]
Prior experience with health care[211]
Perception of teledermatology before and after[218]
Video/audio quality[182,217]
Patients' self reported advantages and disadvantages of CVT[141]
Patient's favorability of GP being present[141]
Level of service[53]

Table B-14. Description of provider satisfaction measures from the teledermatology literature

Provider Satisfaction Categories and Question Topics
Overall Satisfaction
Provider: Overall satisfaction[53,54,85,93,96,100,138,146,147,149,161,214,220]
Provider: Use TD in their practice[100,220]
Provider: TD makes it better for patient, practitioner[100,220,221]
Provider: TD met expectations[145,220]
Provider: Usefulness of TD program[133,214,221]
Practitioner satisfaction[80,115,121,153]
Nurse: Overall satisfaction[161]
Nurse: Recommend TD to other nurses?[96]
Clinical Effectiveness
Provider: Provided adequate care to patient[96,147,153,161,220]
Provider: Saw patient improvement[153]
Provider: TD consult helpfulness for PCP[222]
Provider: Quality of TD response[53,54,138,214]
Provider: Confidence in teledermatology diagnosis and management[54,100,138,220,221]

Provider Satisfaction Categories and Question Topics
Provider: TD makes it easier to triage patients[54]
Provider: Ability to perform history, exam over CVT[141,147]
Provider: Likely to use TD because it gives more diagnostic certainty[138]
Nurse: Improve management of patients[161]
Barriers/Concerns
Provider: Obstacles to TD appointment[145,221]
Provider: Patient's cooperation[147]
Provider: Barriers to use/ cases when TD isn't appropriate[141]
Compare to F2F
Provider: Preference between e-visit and in person[54,146,153,191]
Provider: TD convenience over F2F[138]
Nurse: Medical care equivalent to F2F?[96,152]
Nurse: Quality of health after TD compared to F2F?[96]
Time
Provider: Patients receive timely appointments with TD[54]
Provider: TD is an effective use of time[54]
Provider: Perceived time needed[54,93,133,141,146,148,153]
Provider: Was there enough time[141]
Provider: TD is less timely[138]
Pre-TD Study
Provider: Pre study: TD quality, efficiency, use if available[129,220]
Provider: Pre TD implementation, perceived knowledge (experience, talks, papers read)[221]
Provider: Pre implementation expectations of benefits and challenges[221]
Provider: Pre implementation concerns about 1) cost, 2) image of PCP, ethics, confidentiality, liability, relationship with patient[221]
Technical System
Provider: System technical performance[96,149,185,190]
Provider: IT readiness for TD[129,221]
Provider: Comfortable with equipment and procedures for consult[138]
Provider: Comfortable it info security of TD compared to F2F[138]
Nurse: Convenience of entering data[96,161]
Nurse: Prefer electronic records to paper ones[96]
Educational Aspects
Provider/Residents: Knowledge gained[53,54,133,146,148,149,185]
Provider: TD provides professional updating?[161]
Nurse: TD service represents a professional updating?[161]
Misc.
Provider: Good feeling of contact?[141]
Provider: Patient's confidence[141]
Provider: Ability to communicate info[141]
Provider: Did you answer all of patient's questions[141]

Provider Satisfaction Categories and Question Topics
Provider: What would you have done if there were no TD?[146]
Provider: Likely to use TD because it is convenience[138]
Provider: Satisfaction in terms of patient's response to consultation[185]
Provider: Organizational advantage?[161]
Provider: Assess collaboration of your dermatologic colleagues[161]
Provider: Accessibility to the service[161]
Experience of dermatologists[134,197]
Nurse: TD produce organizational advantage[161]

Table B-15. Description of the economic measures from the teledermatology literature

Economic Measurement Types	# Papers
Direct Cost[74,90,127,168,190,207,210]	7
Indirect Cost[168,190,207,210]	4
Societal[111,112,151,176,190,208,212,223–227]	13
Compare costs of TD to F2F on hospital system[83,85,99,112,149,168,180,212,223,225,227]	11
Health services use only[83,183]	2
Fixed Cost[99,110,112,151,176,224–227]	9
Variable Cost[99,110,112,151,176,224–227]	9
Break even point[110,151,223]	3
Uncertainty analysis[111]	1
Sensitivity analysis[112,151,168,176,224,225]	6

Appendix C CPT Codes for Biopsy

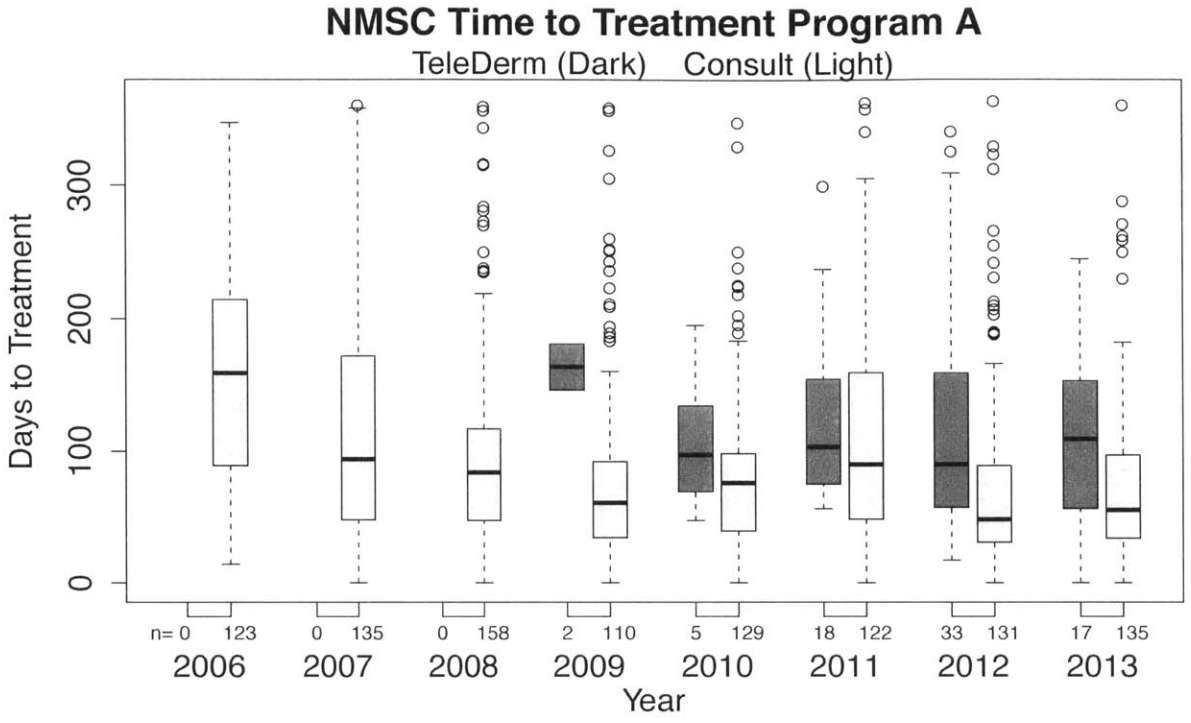
The CPT code list was created by generating list of all CPT codes recorded in dermatology visits and selecting all the codes that described biopsies. Descriptions and code names are taken from the CPT Dimension table in the CDW.

Table C-1. CPT codes for biopsy events

CPT Code	CPT Code Name	CPT Code Description
11100	BIOPSY SKIN LESION	BIOPSY OF SKIN, SUBCUTANEOUS TISSUE AND/OR MUCOUS MEMBRANE (INCLUDING SIMPLE CLOSURE), UNLESS OTHERWISE LISTED; SINGLE LESION
11101	BIOPSY SKIN ADD-ON	BIOPSY OF SKIN, SUBCUTANEOUS TISSUE AND/OR MUCOUS MEMBRANE (INCLUDING SIMPLE CLOSURE), UNLESS OTHERWISE LISTED (SEPARATE PROCEDURE); EACH SEPARATE/ADDITIONAL LESION (LIST SEPARATELY IN ADDITION TO CODE FOR PRIMARY PROCEDURE)
11755	BIOPSY NAIL UNIT	BIOPSY OF NAIL UNIT (EG, PLATE, BED, MATRIX, HYPONYCHIUM, PROXIMAL AND LATERAL NAIL FOLDS) (SEPARATE PROCEDURE)
21550	BIOPSY OF NECK/CHEST	BIOPSY, SOFT TISSUE OF NECK OR THORAX
21920	BIOPSY SOFT TISSUE OF BACK	BIOPSY, SOFT TISSUE OF BACK OR FLANK; SUPERFICIAL
21925	BIOPSY SOFT TISSUE OF BACK	BIOPSY, SOFT TISSUE OF BACK OR FLANK; DEEP
23065	BIOPSY SHOULDER TISSUES	BIOPSY, SOFT TISSUE OF SHOULDER AREA; SUPERFICIAL
23066	BIOPSY SHOULDER TISSUES	BIOPSY, SOFT TISSUE OF SHOULDER AREA; DEEP
24065	BIOPSY ARM/ELBOW SOFT TISSUE	BIOPSY, SOFT TISSUE OF UPPER ARM OR ELBOW AREA; SUPERFICIAL
24066	BIOPSY ARM/ELBOW SOFT TISSUE	BIOPSY, SOFT TISSUE OF UPPER ARM OR ELBOW AREA; DEEP (SUBFASCIAL OR INTRAMUSCULAR)
25065	BIOPSY FOREARM SOFT TISSUES	BIOPSY, SOFT TISSUE OF FOREARM AND/OR WRIST; SUPERFICIAL
25066	BIOPSY FOREARM SOFT TISSUES	BIOPSY, SOFT TISSUE OF FOREARM AND/OR WRIST; DEEP (SUBFASCIAL OR INTRAMUSCULAR)
27613	BIOPSY LOWER LEG SOFT TISSUE	BIOPSY, SOFT TISSUE OF LEG OR ANKLE AREA; SUPERFICIAL
27614	BIOPSY LOWER LEG SOFT TISSUE	BIOPSY, SOFT TISSUE OF LEG OR ANKLE AREA; DEEP (SUBFASCIAL OR INTRAMUSCULAR)

CPT Code	CPT Code Name	CPT Code Description
30100	INTRANASAL BIOPSY	BIOPSY, INTRANASAL
38500	BIOPSY/REMOVAL LYMPH NODES	BIOPSY OR EXCISION OF LYMPH NODE(S); OPEN, SUPERFICIAL
40490	BIOPSY OF LIP	BIOPSY OF LIP
40808	BIOPSY OF MOUTH LESION	BIOPSY, VESTIBULE OF MOUTH
41100	BIOPSY OF TONGUE	BIOPSY OF TONGUE; ANTERIOR TWO-THIRDS
41105	BIOPSY OF TONGUE	BIOPSY OF TONGUE; POSTERIOR ONE-THIRD
41108	BIOPSY OF FLOOR OF MOUTH	BIOPSY OF FLOOR OF MOUTH
42100	BIOPSY ROOF OF MOUTH	BIOPSY OF PALATE, UVULA
54100	BIOPSY OF PENIS	BIOPSY OF PENIS; (SEPARATE PROCEDURE)
67810	BIOPSY EYELID & LID MARGIN	INCISIONAL BIOPSY OF EYELID SKIN INCLUDING LID MARGIN
69100	BIOPSY OF EXTERNAL EAR	BIOPSY EXTERNAL EAR

Appendix D Time to treatment for NMSC for Programs A-S



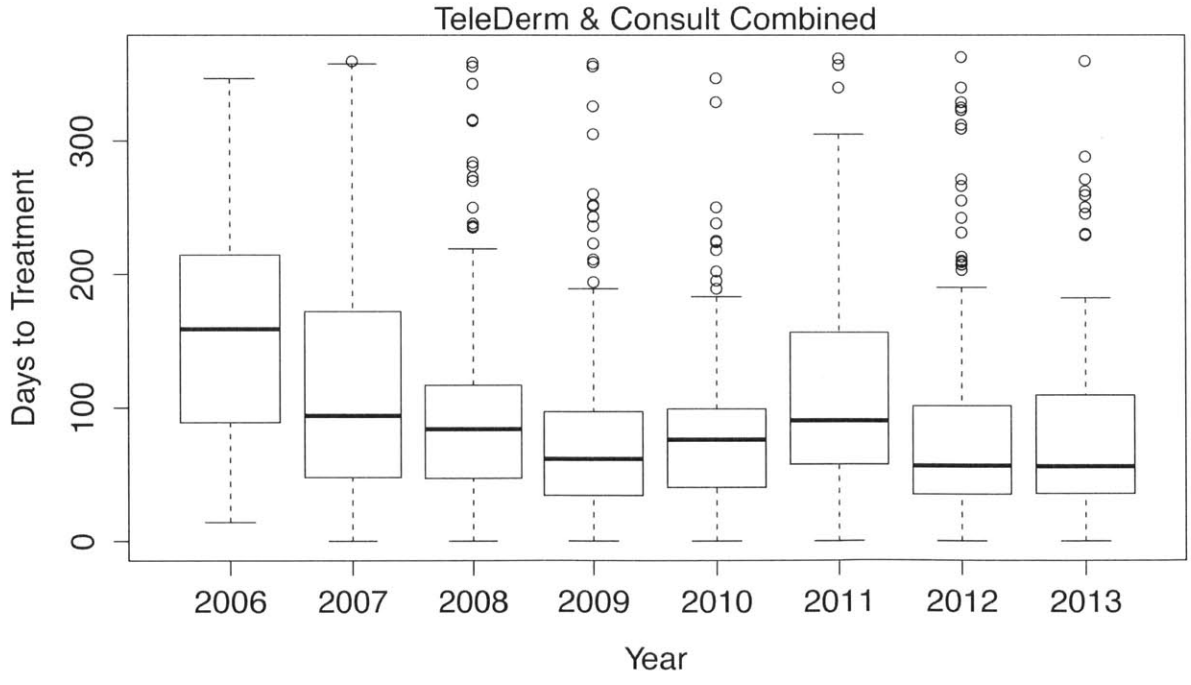


Figure D-1. NMSC time to treatment for Program A, 2006-2013

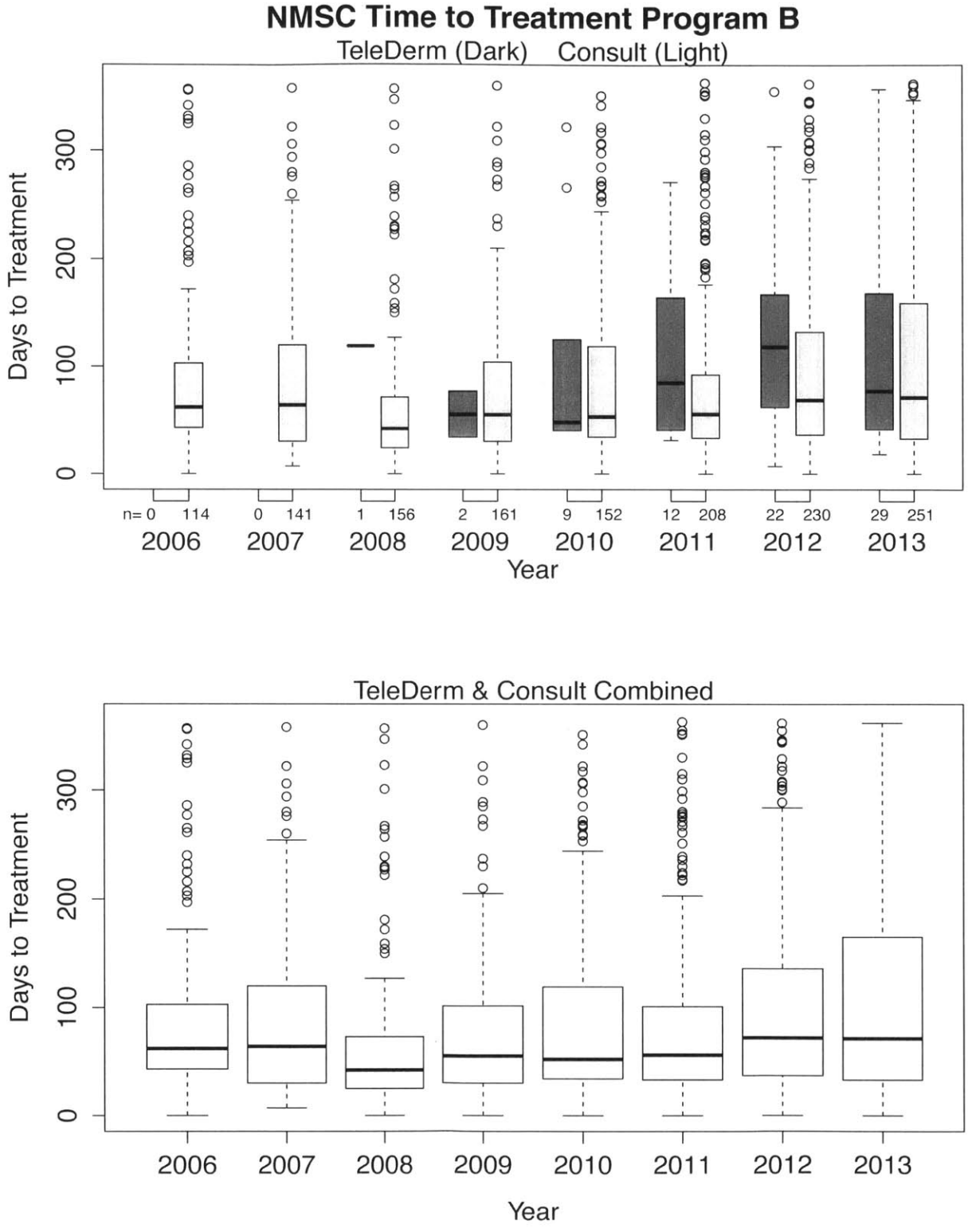


Figure D-2. NMSC time to treatment for Program B, 2006-2013

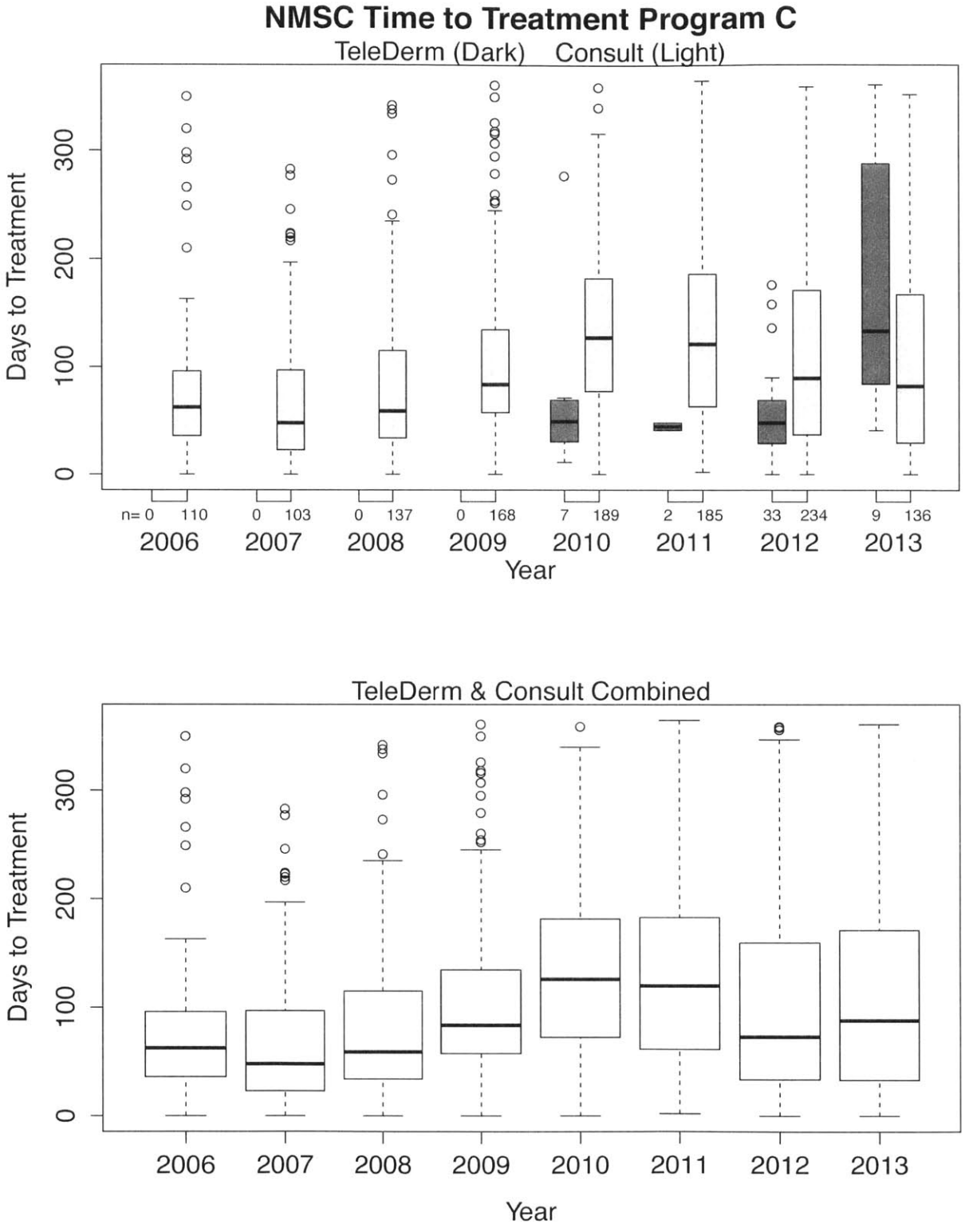


Figure D-3. NMSC time to treatment for Program C, 2006-2013

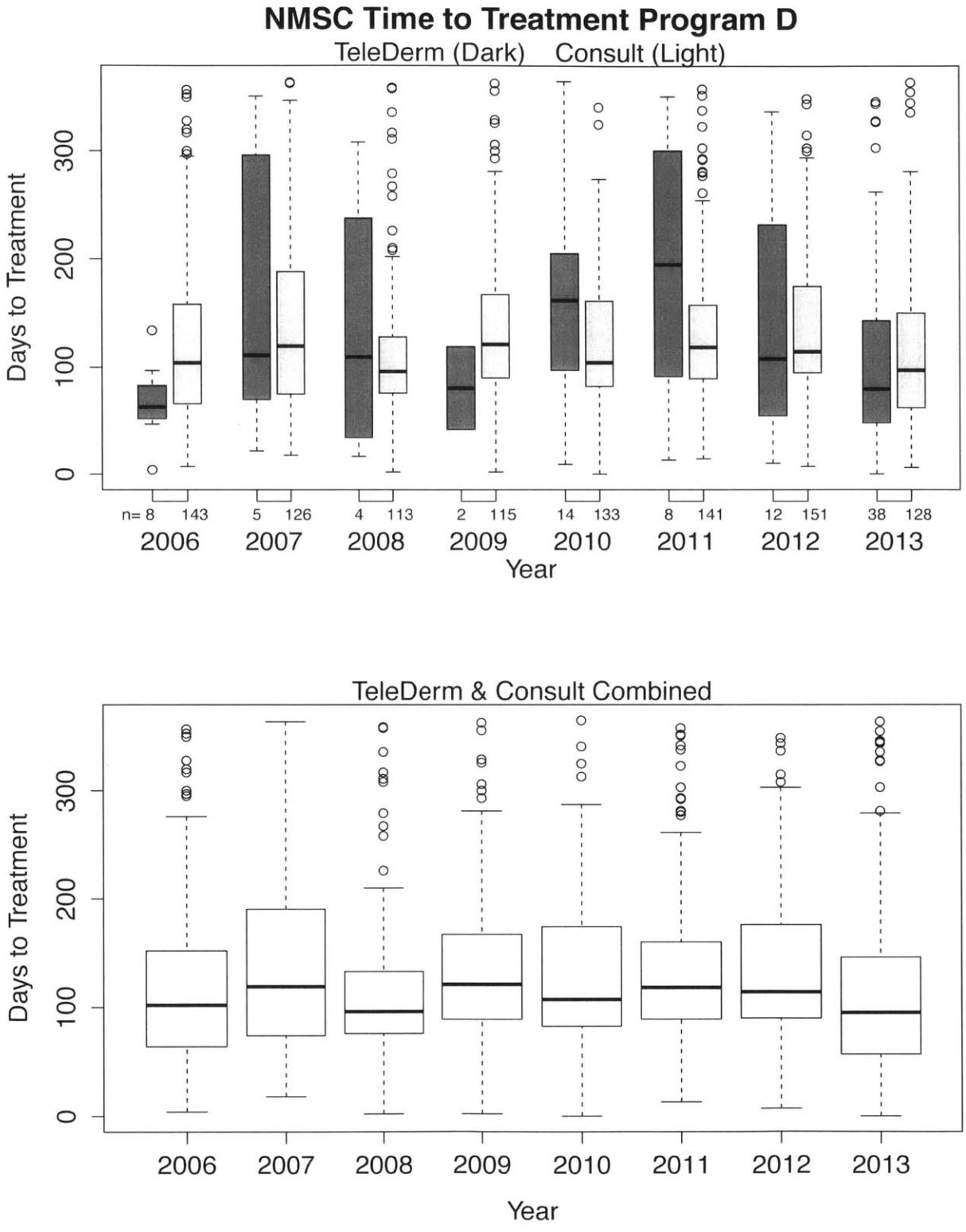


Figure D-4. NMSC time to treatment for Program D, 2006-2013

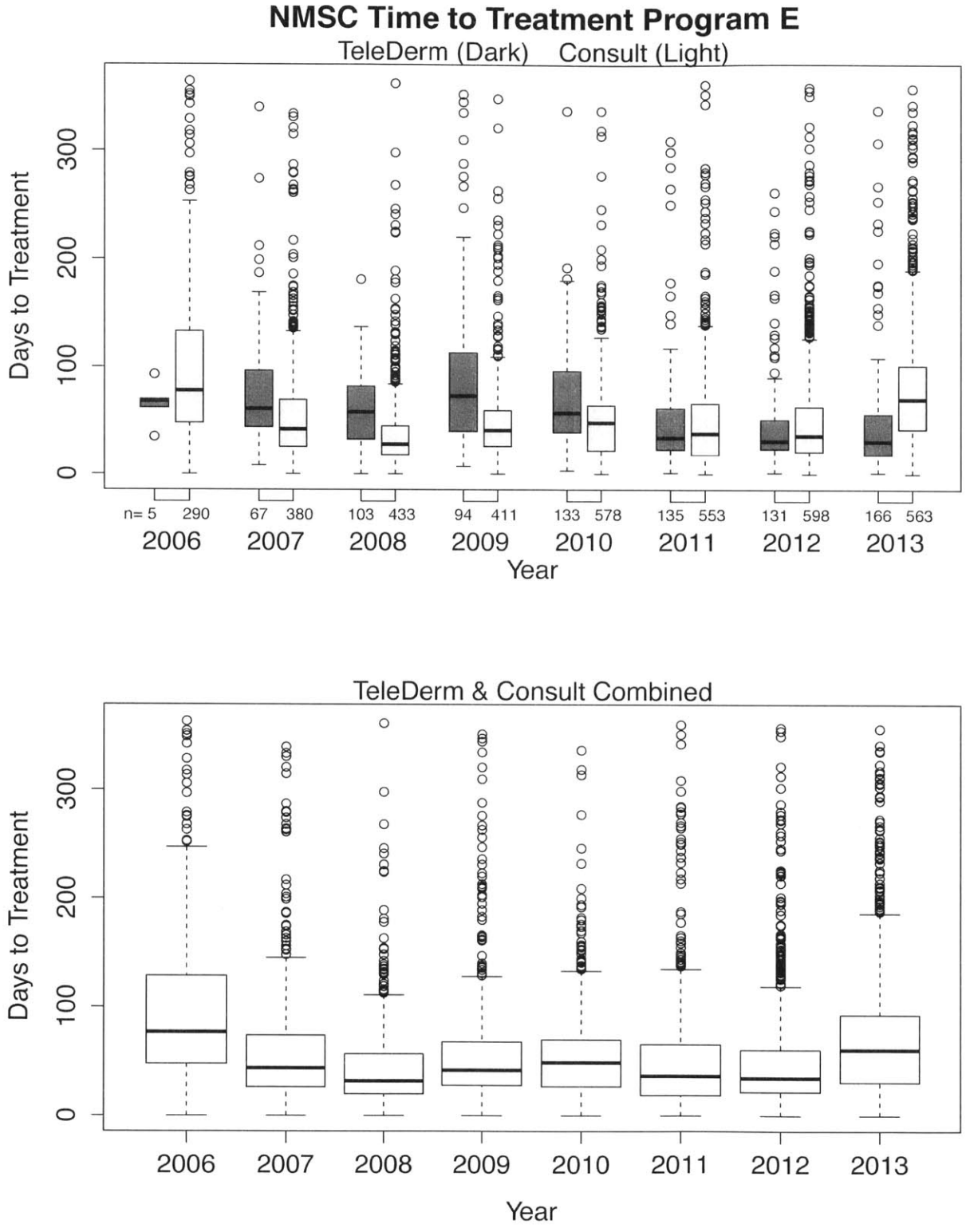


Figure D-5. NMSC time to treatment for Program E, 2006-2013

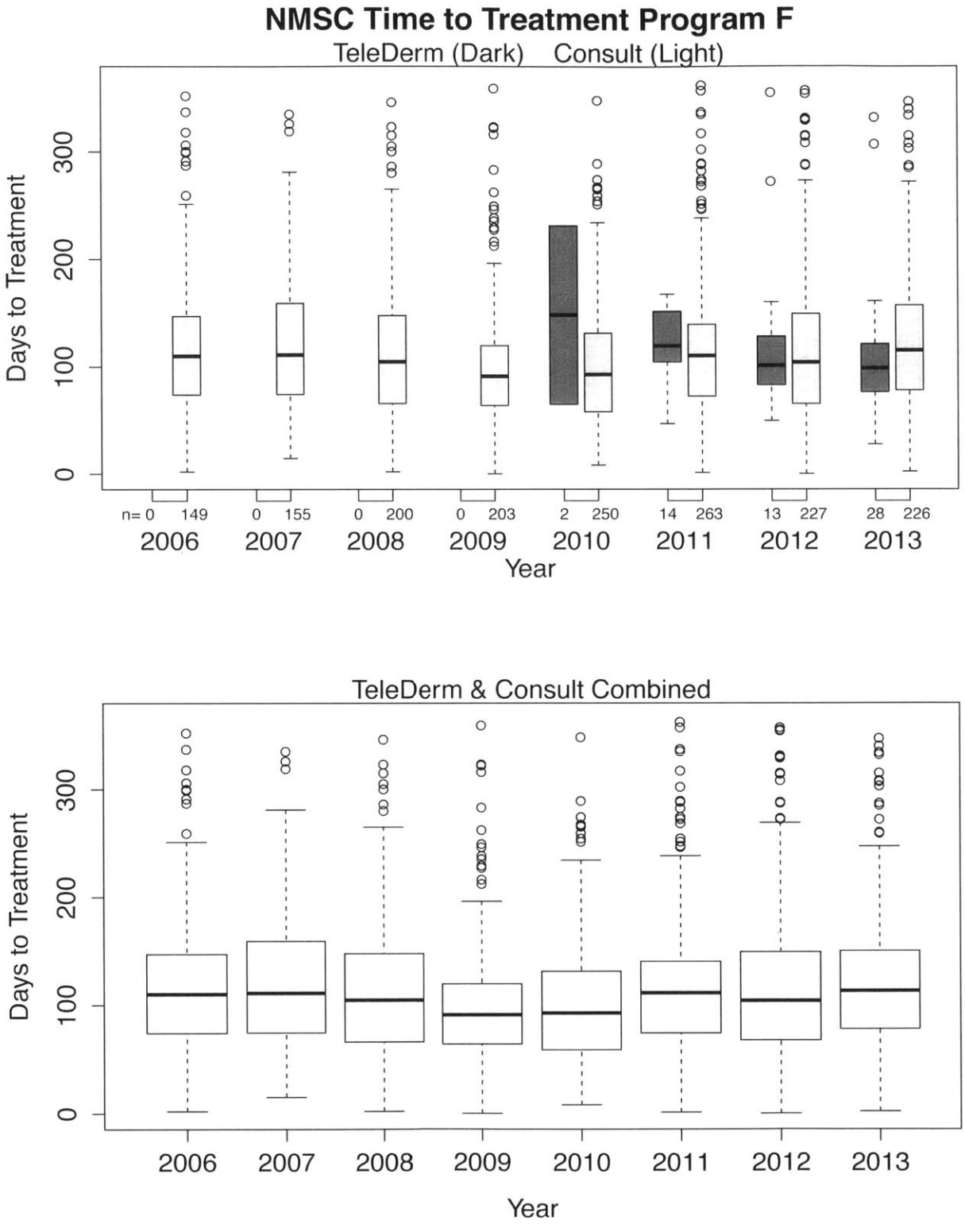


Figure D-6. NMSC time to treatment for Program F, 2006-2013

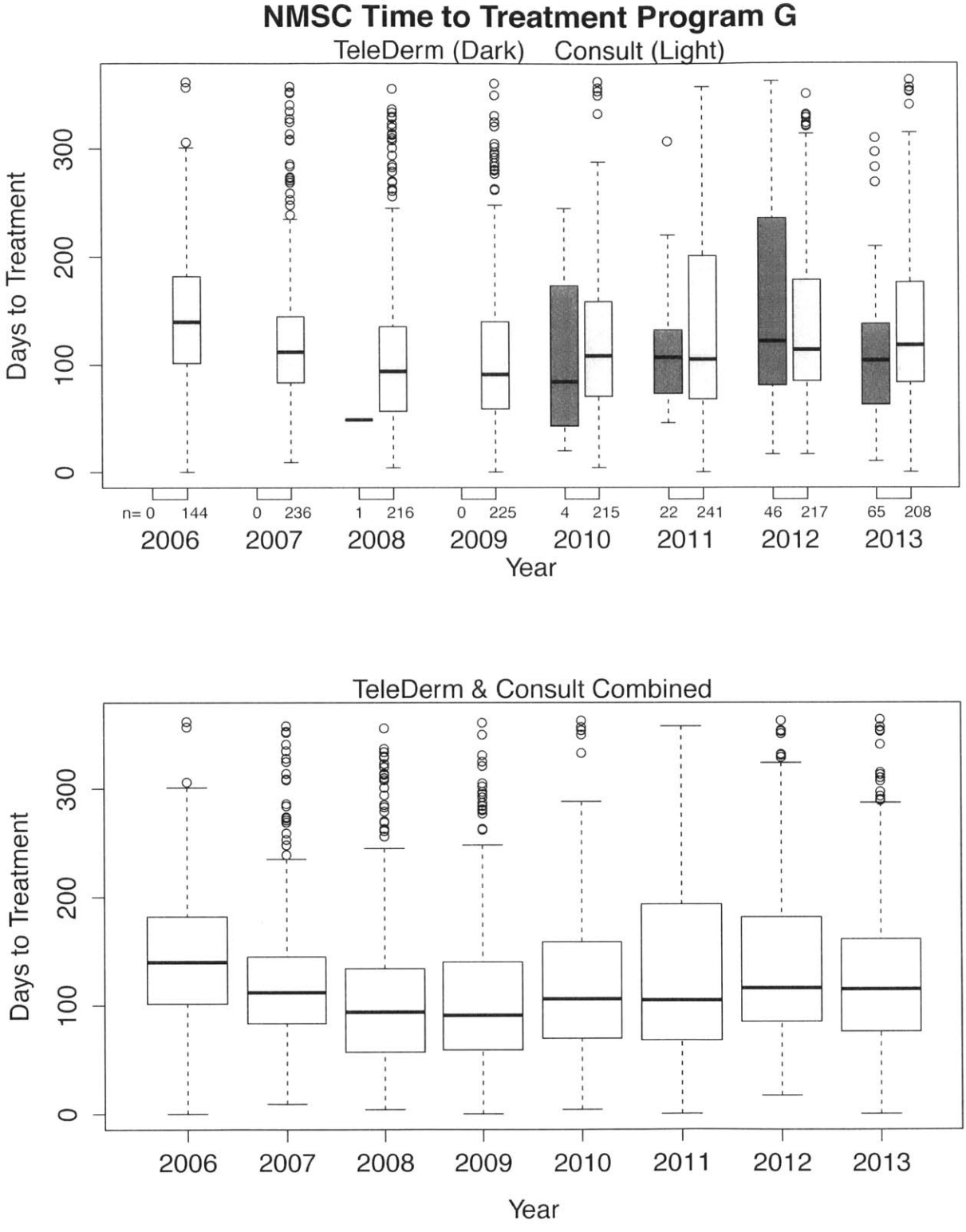


Figure D-7. NMSC time to treatment for Program G, 2006-2013

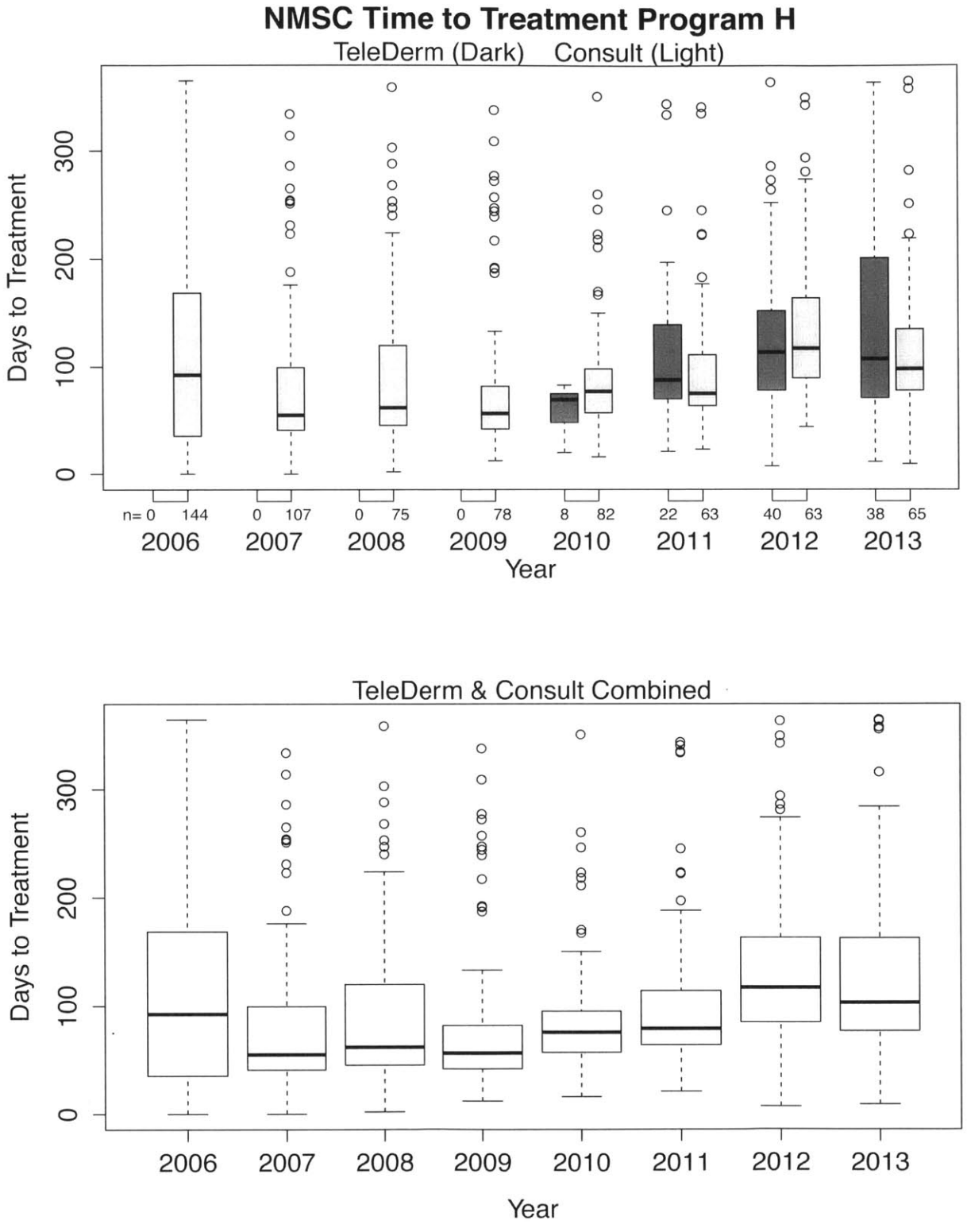


Figure D-8. NMSC time to treatment for Program H, 2006-2013

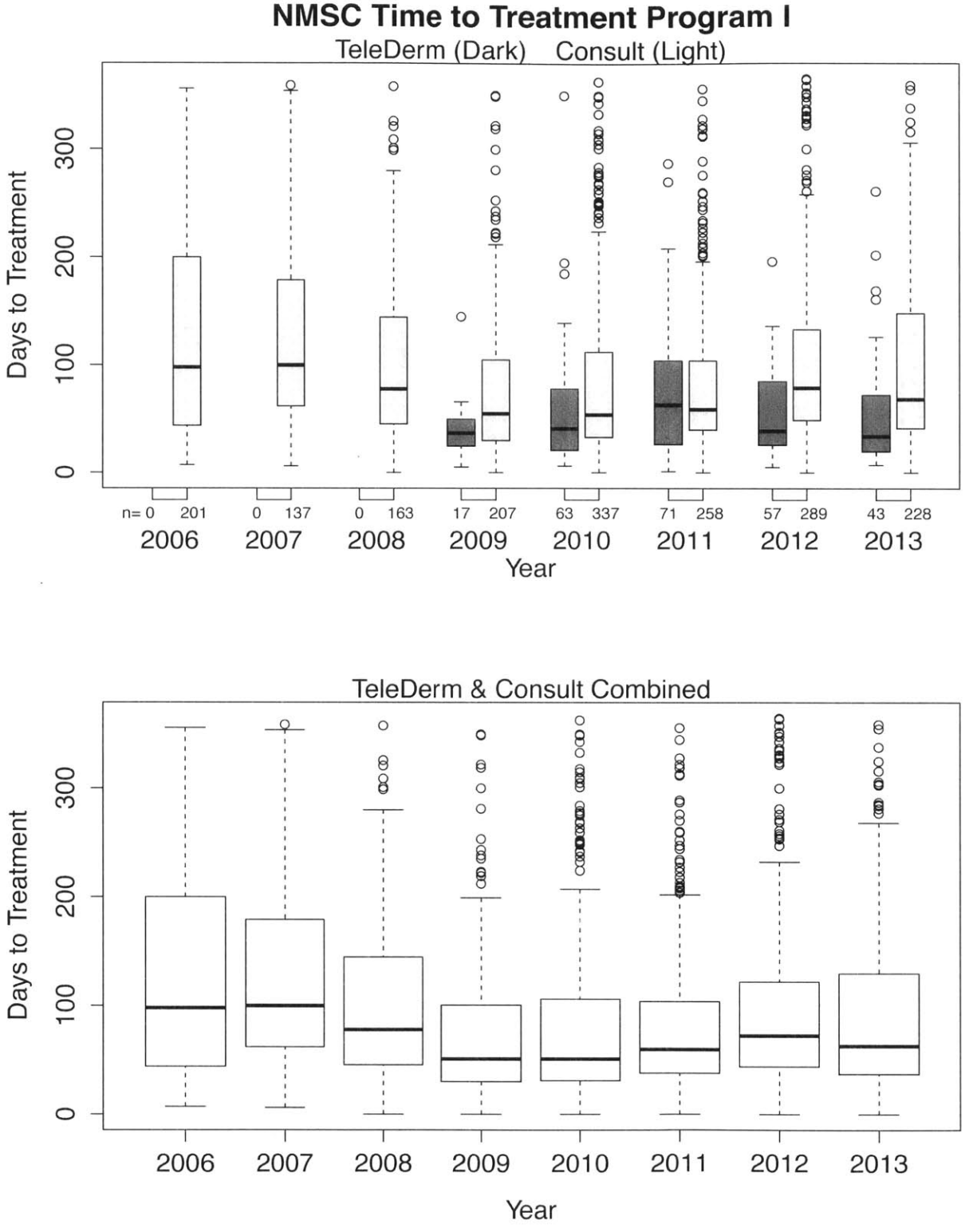


Figure D-9. NMSC time to treatment for Program I, 2006-2013

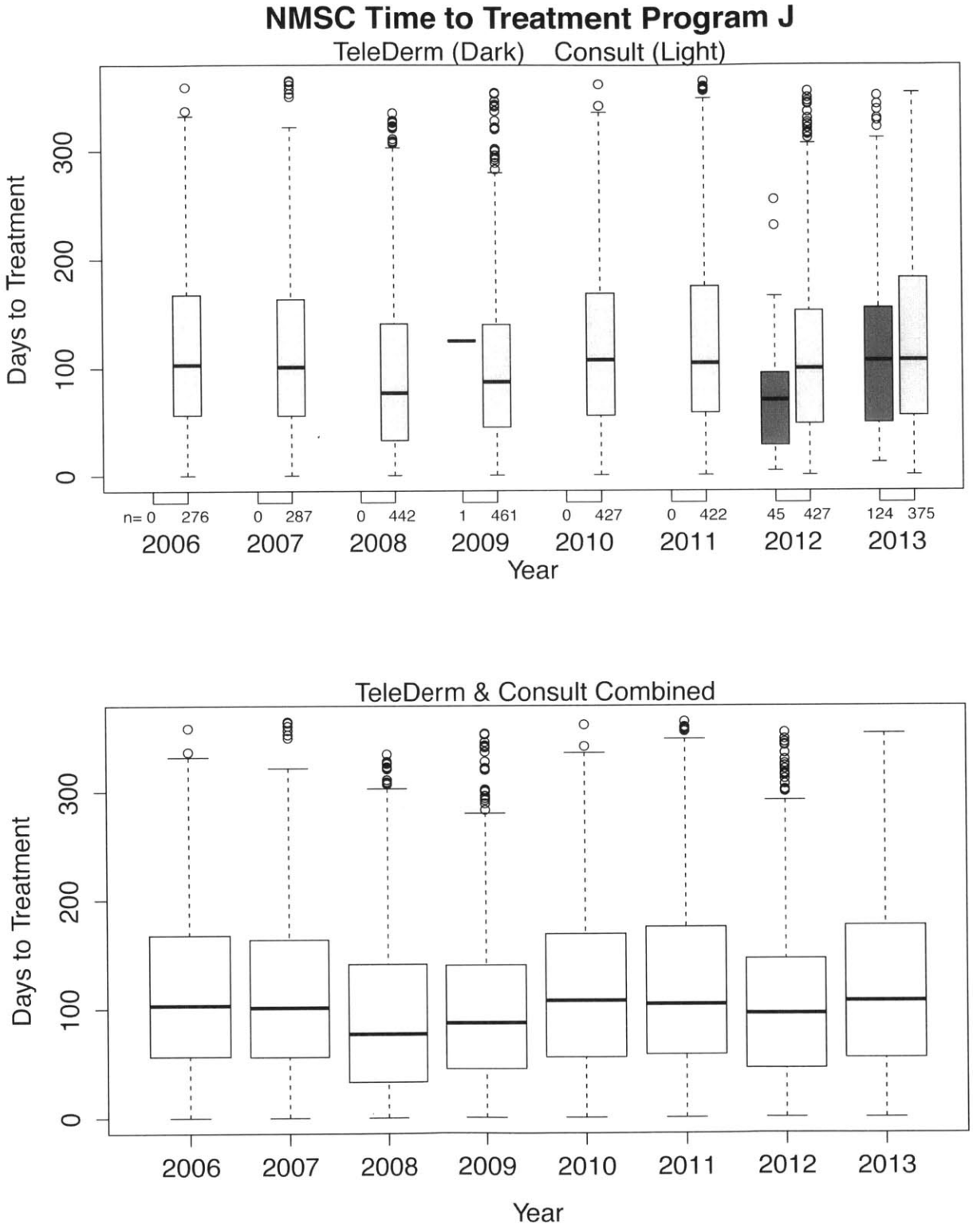


Figure D-10. NMSC time to treatment for Program J, 2006-2013

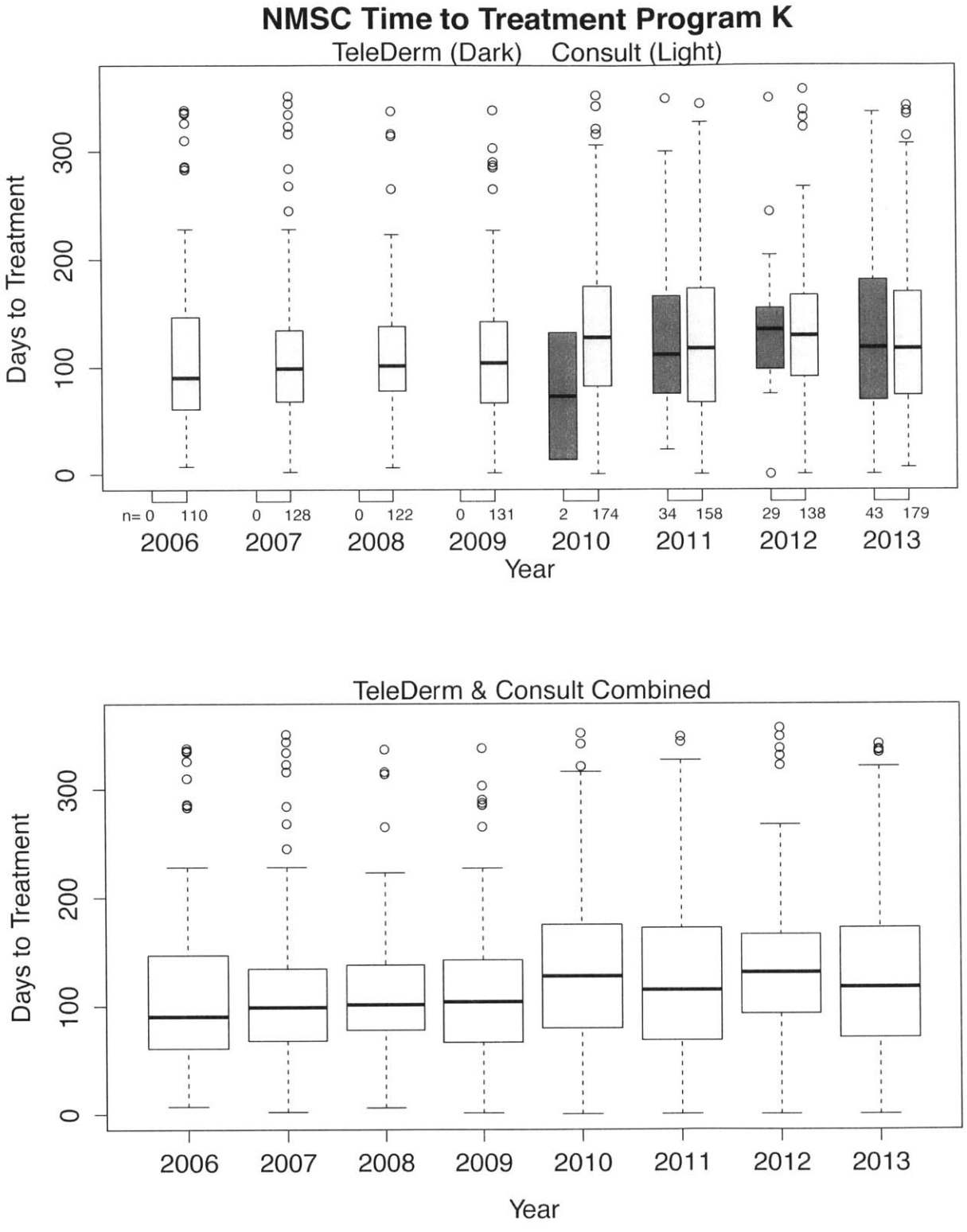


Figure D-11. NMSC time to treatment for Program K, 2006-2013

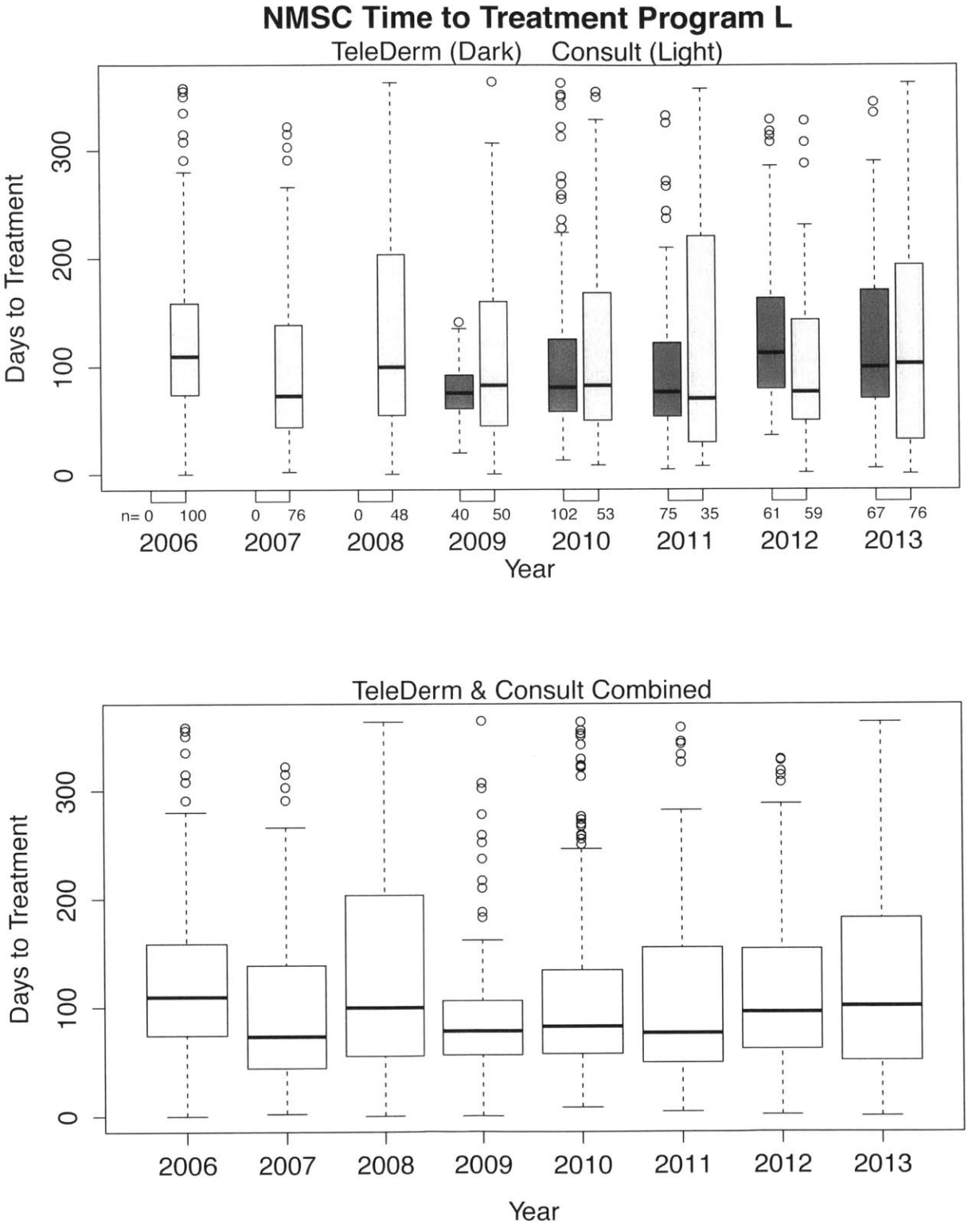


Figure D-12. NMSC time to treatment for Program L, 2006-2013

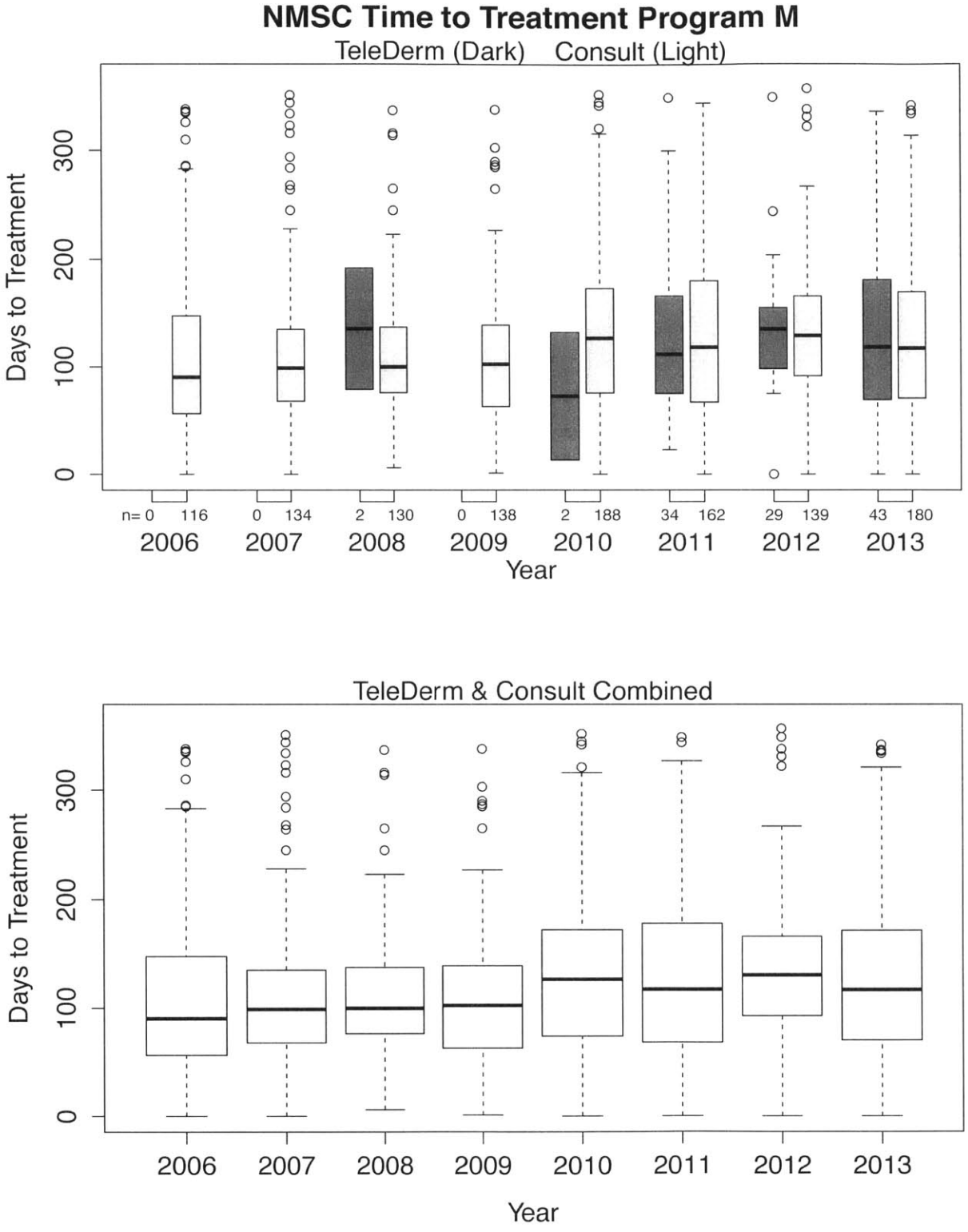


Figure D-13. NMSC time to treatment for Program M, 2006-2013

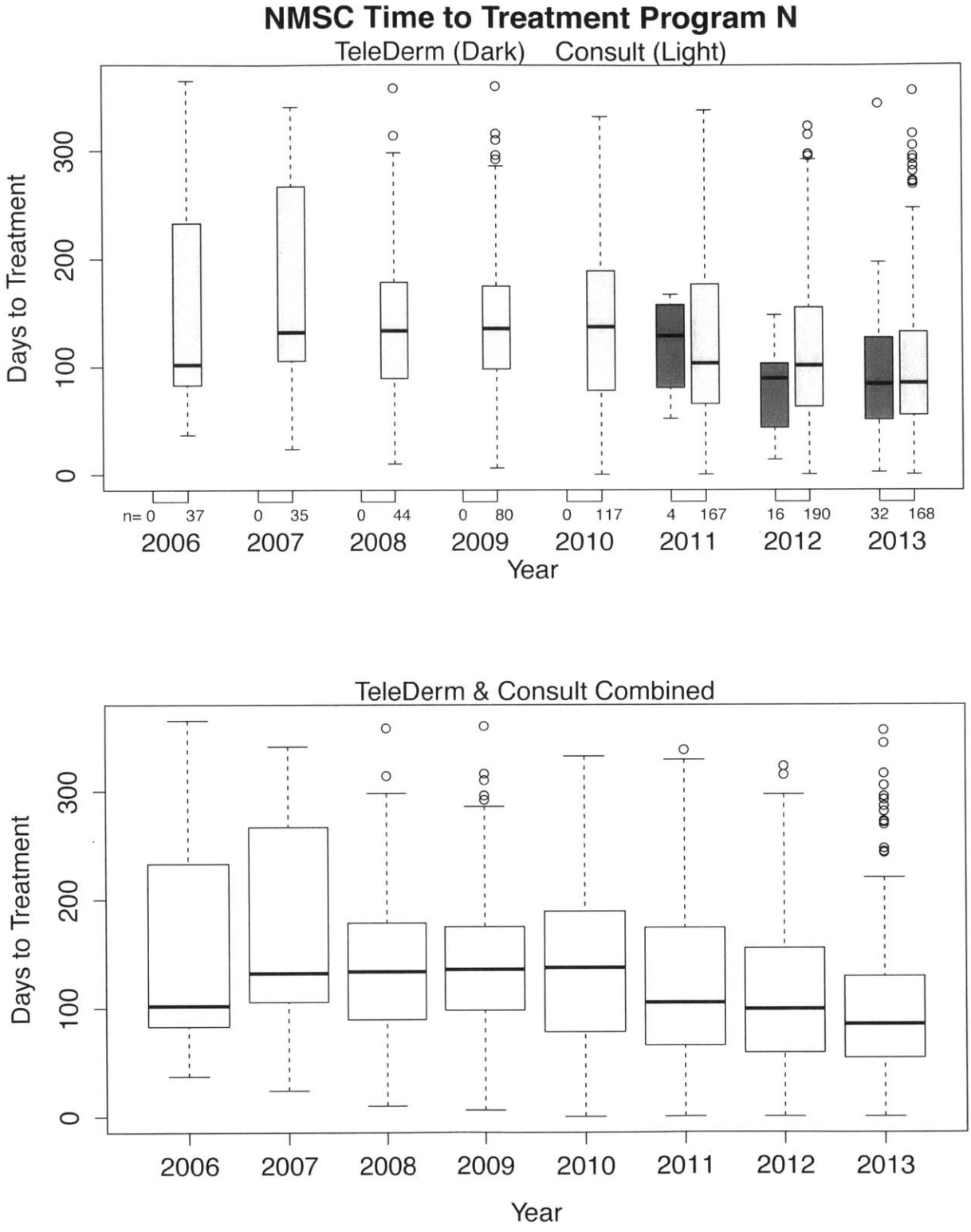


Figure D-14. NMSC time to treatment for Program N, 2006-2013

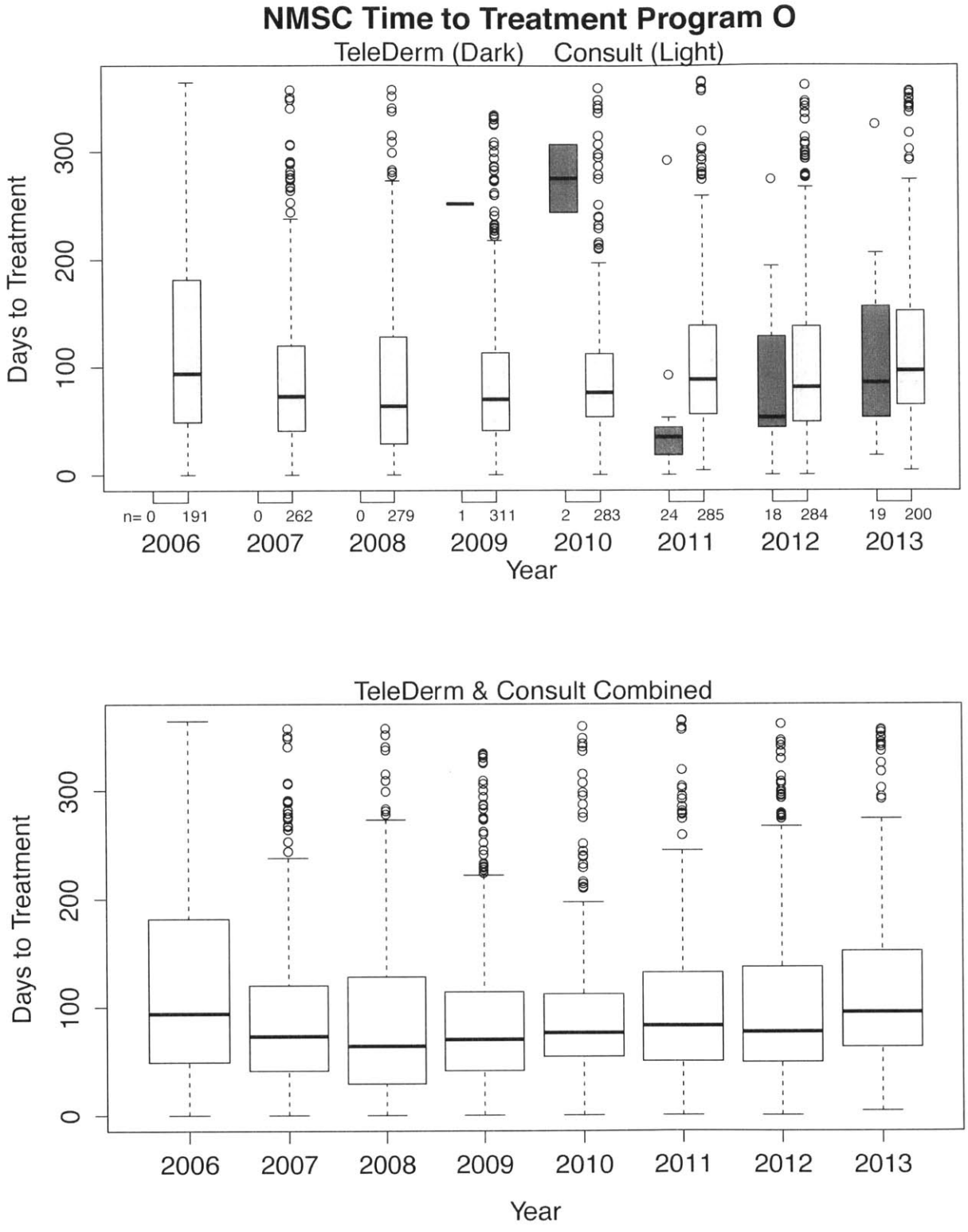


Figure D-15. NMSC time to treatment for Program O, 2006-2013

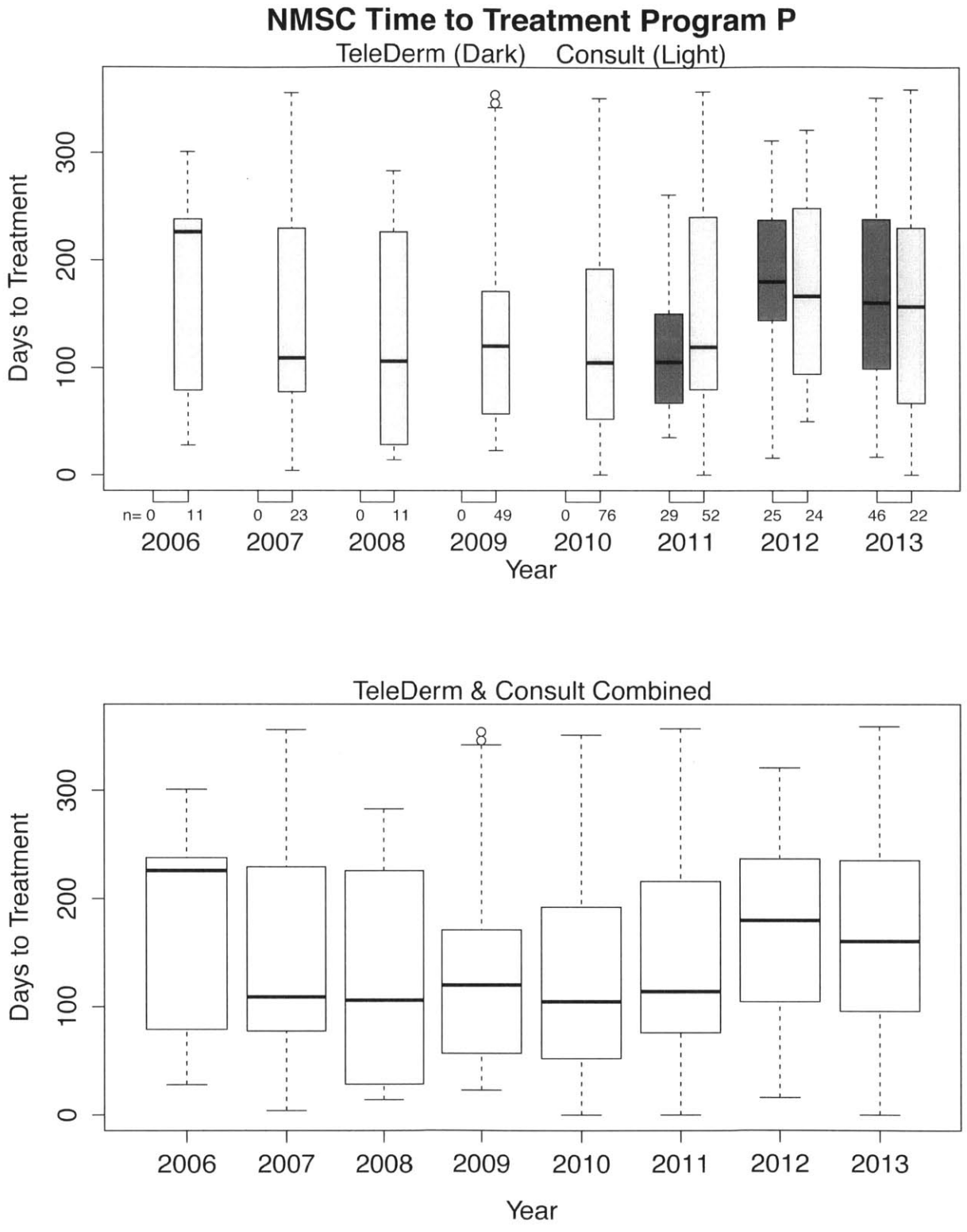


Figure D-16. NMSC time to treatment for Program P, 2006-2013

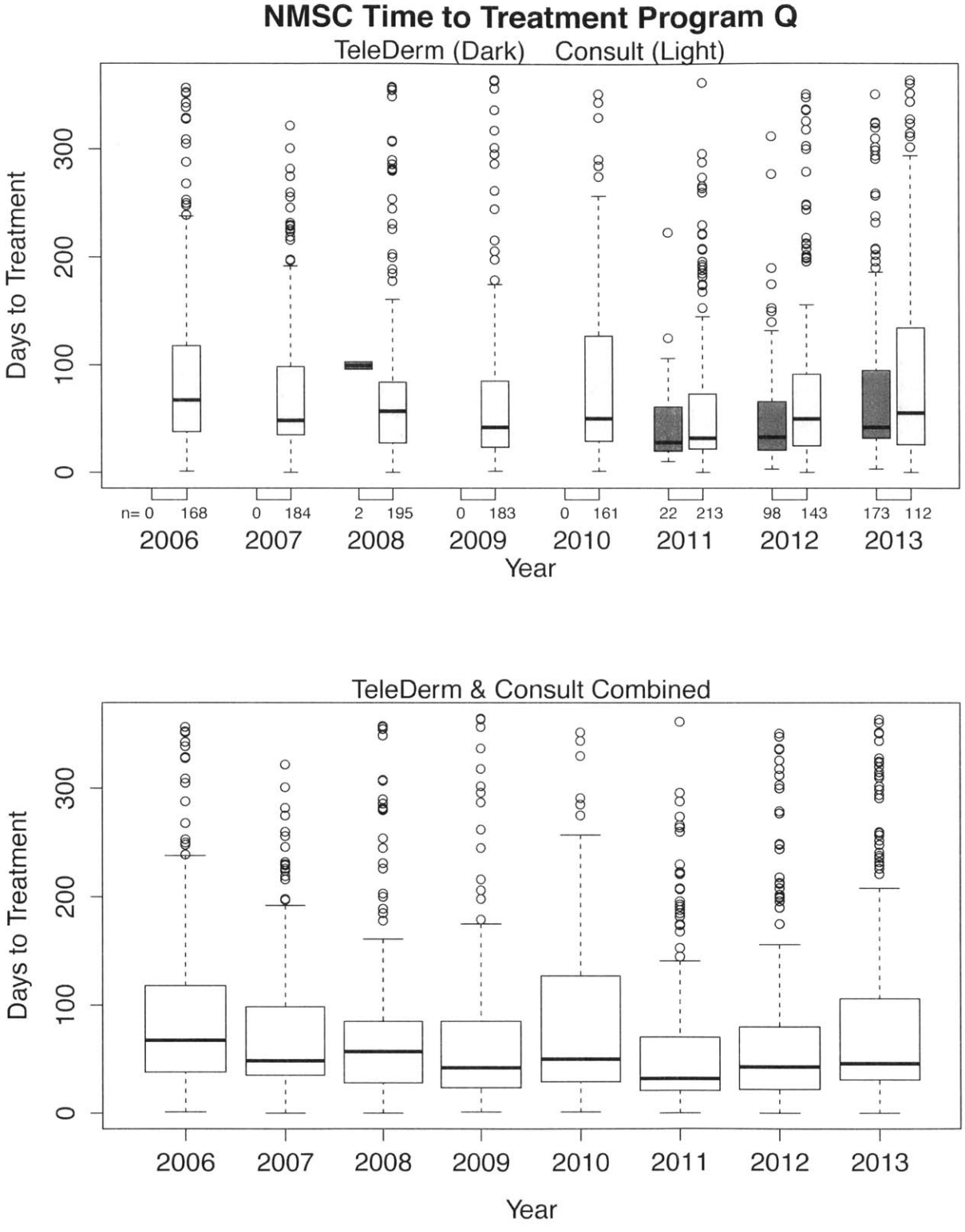


Figure D-17. NMSC time to treatment for Program Q, 2006-2013

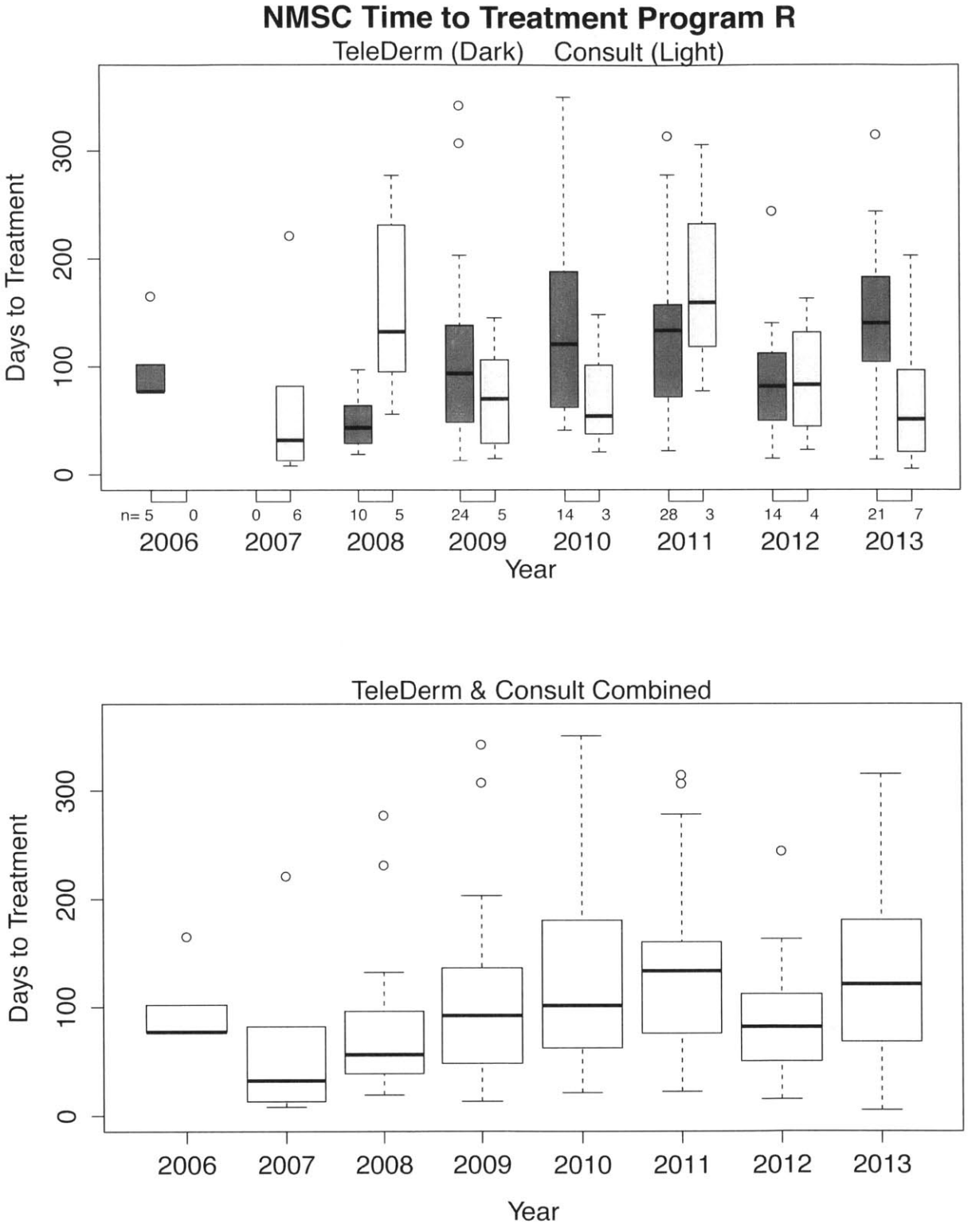


Figure D-18. NMSC time to treatment for Program R, 2006-2013

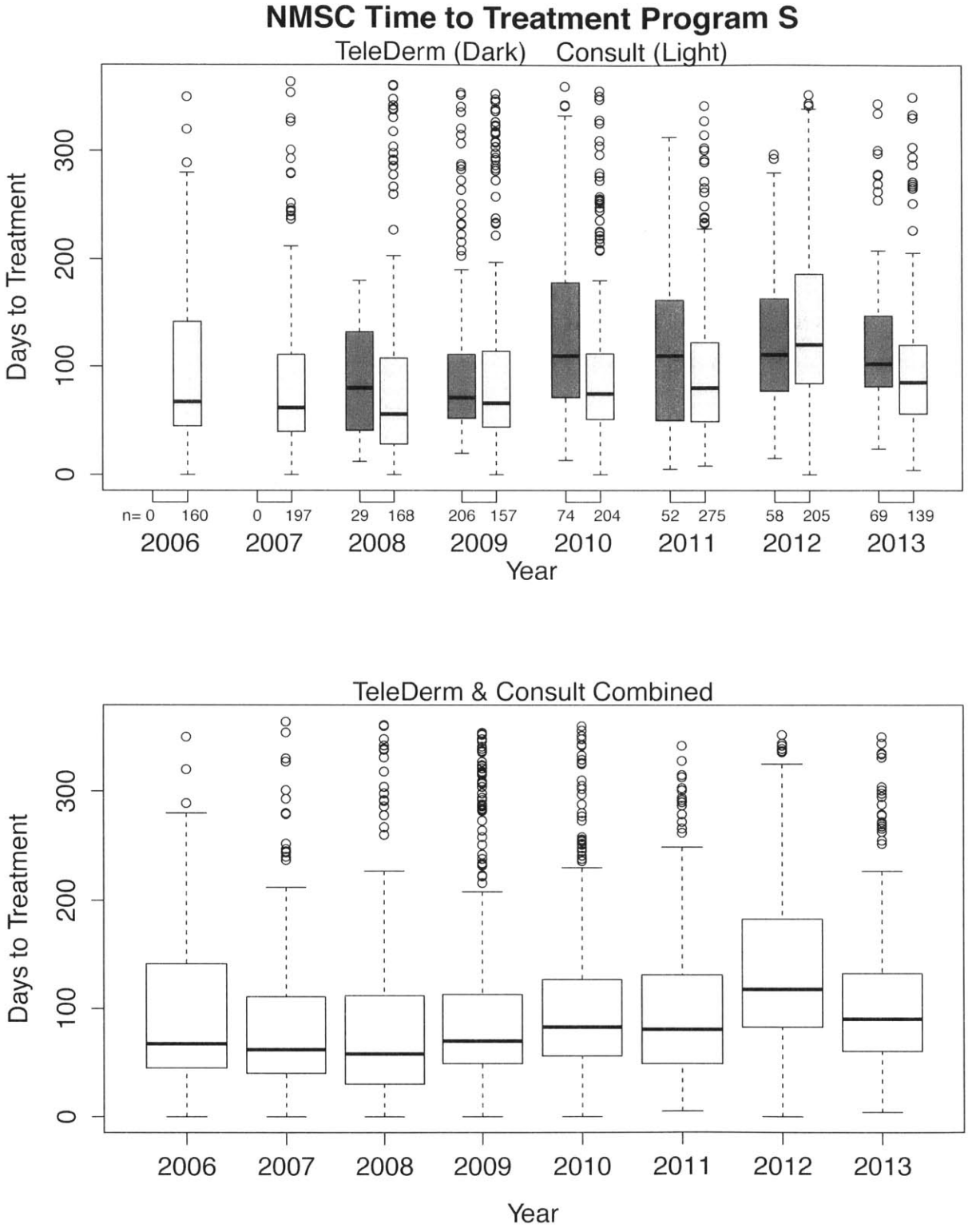


Figure D-19. NMSC time to treatment for Program S, 2006-2013

Appendix E Diagnosis codes for dermatology concerns

The list of International Classification of Disease, 9th Revision (ICD-9) codes for dermatology diagnoses was started from the list on the "DermAdvocate" website.[228]

The first validation of this diagnosis code list was comparing it to the billing sheet with diagnosis codes for a local non-VHA hospital. Any missing diagnoses codes were added to the initial list. The second validation was adding any missing diagnosis from the list of diagnosis codes used to analyze the treatment of dermatology concerns treated by primary care providers in *Dermatologic Disease in Family Medicine*.[229]

The next stage of validation was to compare the diagnoses to those used in VHA. The ICD-9 codes stored as primary or secondary diagnoses for dermatology visits in VHA were tallied, 3.7% of diagnoses were NULL. The top 300 ICD-9 codes, by occurrence, were added to the initial list. The 300th diagnosis was used 2,147 times over 10 years and all of the remaining diagnoses occurrences combined were only 3.7% of the total occurrences. Next, the ICD-9 codes for teledermatology patient imaging and dermatologists' analysis where tallied. Any diagnosis code used more than 10 times was included on the list. For patient imaging appointments there were 243 diagnoses, which included 98.7% of the results (0.6% were NULL). For dermatologists' analysis of the images there were 347 diagnoses included, comprising 99.1% of all occurrences (0.6% were NULL).

To verify that all of these concerns were for dermatology, and not just co-existing conditions listed as secondary diagnoses, the use in dermatology was compared to other specialties. The use of each diagnosis code on the compiled list was totaled for all specialties, excluding laboratories. The diagnoses were only included in the final list if they were used for dermatology more than all other specialties combined, excluding primary care. When this analysis was completed some dermatology concerns, particularly neoplasms, were excluded because they were seen by dermatology and then sent to surgery or some other specialty. For this reason the diagnoses listed in Table from family medicine paper slightly altered (not including chronic ulcer because this is generally not

dermatology in the VA, adding melanomas) were also included. The rejections were carefully scrutinized and the following was brought back in: 782.1 Rash and other non specific skin eruption.

Table E-1. Diagnosis codes for dermatology concerns from Dermatologic Disease in Family Medicine[229]

Combined diagnosis	ICD-9 Codes
Dermatitis	454.10, 690.10, 691.00-691.90, 692.00-692.0
Pyoderma	680.00-682.90, 684.00-686.00,686.00, 686.90
Melanoma	172.00-172.90
Malignant neoplasm (non-melanoma)	173.00-173.90, 238.00-238.90
Carcinoma in situ of skin	232.00-232.90
Benign neoplasm	214.10-214.90, 216.00-216.90
Puritis	698.00-698.90
Alopecia	704.00-704.10
Candida, all	112.00-112.90
Tinea, all	110.00-111.90
Warts	078.10, 078.19

The final list of dermatology ICD-9 code after all validation that is used in this thesis can be seen in Table.

Table E-2. Final list of dermatology ICD-9 codes and their descriptions

ICD-9 Code	Description from CDW
39	CUTANEOUS ACTINOMYCOTIC INFECTION
78	MOLLUSCUM CONTAGIOSUM
78.1	OTHER DISEASES DUE TO VIRUSES AND CHLAMYDIAE, VIRAL WARTS, UNSPECIFIED
78.19	OTHER DISEASES DUE TO VIRUSES AND CHLAMYDIAE,OTHER SPEC VIRAL WARTS
110	DERMATOPHYTOSIS OF SCALP AND BEARD
110.1	DERMATOPHYTOSIS OF NAIL
110.2	DERMATOPHYTOSIS OF HAND
110.3	DERMATOPHYTOSIS OF GROIN AND PERIANAL AREA
110.4	DERMATOPHYTOSIS OF FOOT
110.5	DERMATOPHYTOSIS OF THE BODY
110.8	DERMATOPHYTOSIS OF OTHER SPECIFIED SITES

ICD-9 Code	Description from CDW
110.9	DERMATOPHYTOSIS OF UNSPECIFIED SITE
111	PITYRIASIS VERSICOLOR
111.9	DERMATOMYCOSIS, UNSPECIFIED
112	CANDIDIASIS OF MOUTH
112.2	CANDIDIASIS OF OTHER UROGENITAL SITES
112.3	CANDIDIASIS OF SKIN AND NAILS
112.9	CANDIDIASIS OF UNSPECIFIED SITE
172	MALIGNANT MELANOMA OF SKIN OF LIP
172.1	MALIGNANT MELANOMA OF SKIN OF EYELID, INCLUDING CANTHUS
172.3	MALIGNANT MELANOMA OF SKIN OF OTHER AND UNSPECIFIED PARTS OF FACE OF FACE
172.4	MALIGNANT MELANOMA OF SKIN OF SCALP AND NECK
172.5	MALIGNANT MELANOMA OF SKIN OF TRUNK, EXCEPT SCROTUM
172.6	MALIGNANT MELANOMA OF SKIN OF UPPER LIMB, INCLUDING SHOULDER
172.7	MALIGNANT MELANOMA OF SKIN OF LOWER LIMB, INCLUDING HIP
172.8	MALIGNANT MELANOMA OF OTHER SPECIFIED SITES OF SKIN
172.9	MELANOMA OF SKIN, SITE UNSPECIFIED
173	OTHER MALIGNANT NEOPLASM OF SKIN OF LIP
173	NULL
173.01	NULL
173.02	NULL
173.09	NULL
173.1	OTHER MALIGNANT NEOPLASM OF SKIN OF EYELID, INCLUDING CANTHUS
173.1	NULL
173.11	NULL
173.12	NULL
173.19	NULL
173.2	OTHER MALIGNANT NEOPLASM OF SKIN OF EAR AND EXTERNAL AUDITORY CANAL
173.2	NULL
173.21	NULL
173.22	NULL
173.29	NULL
173.3	OTHER MALIGNANT NEOPLASM OF SKIN OF OTHER AND UNSPECIFIED PARTS OF FACE
173.3	NULL
173.31	NULL
173.32	NULL
173.39	NULL
173.4	OTHER MALIGNANT NEOPLASM OF SCALP AND SKIN OF NECK
173.4	NULL
173.41	NULL
173.42	NULL

ICD-9 Code	Description from CDW
173.49	NULL
173.5	OTHER MALIGNANT NEOPLASM OF SKIN OF TRUNK, EXCEPT SCROTUM
173.5	NULL
173.51	NULL
173.52	NULL
173.59	NULL
173.6	OTHER MALIGNANT NEOPLASM OF SKIN OF UPPER LIMB, INCLUDING SHOULDER SHOULDER
173.6	NULL
173.61	NULL
173.62	NULL
173.69	NULL
173.7	OTHER MALIGNANT NEOPLASM OF SKIN OF LOWER LIMB, INCLUDING HIP
173.7	NULL
173.71	NULL
173.72	NULL
173.79	NULL
173.8	OTHER MALIGNANT NEOPLASM OF OTHER SPECIFIED SITES OF SKIN
173.8	NULL
173.81	NULL
173.82	NULL
173.89	NULL
173.9	OTHER MALIGNANT NEOPLASM OF SKIN, SITE UNSPECIFIED
173.9	NULL
173.91	NULL
173.92	NULL
173.99	NULL
202.1	MYCOSIS FUNGOIDES, UNSPECIFIED SITE, EXTRANODAL AND SOLID ORGAN SITES
214.1	LIPOMA OF OTHER SKIN AND SUBCUTANEOUS TISSUE
214.9	LIPOMA, UNSPECIFIED SITE
216	BENIGN NEOPLASM OF SKIN OF LIP
216.1	BENIGN NEOPLASM OF EYELID, INCLUDING CANTHUS
216.2	BENIGN NEOPLASM OF EAR AND EXTERNAL AUDITORY CANAL
216.3	BENIGN NEOPLASM OF SKIN OF OTHER AND UNSPECIFIED PARTS OF FACE
216.4	BENIGN NEOPLASM OF SCALP AND SKIN OF NECK
216.5	BENIGN NEOPLASM OF SKIN OF TRUNK, EXCEPT SCROTUM
216.6	BENIGN NEOPLASM OF SKIN OF UPPER LIMB, INCLUDING SHOULDER
216.7	BENIGN NEOPLASM OF SKIN OF LOWER LIMB, INCLUDING HIP
216.8	BENIGN NEOPLASM OF OTHER SPECIFIED SITES OF SKIN
216.9	BENIGN NEOPLASM OF SKIN, SITE UNSPECIFIED
228	HEMANGIOMA OF UNSPECIFIED SITE

ICD-9 Code	Description from CDW
228.01	HEMANGIOMA OF SKIN AND SUBCUTANEOUS TISSUE
232	CARCINOMA IN SITU OF SKIN OF LIP
232.1	CARCINOMA IN SITU OF EYELID, INCLUDING CANTHUS
232.2	CARCINOMA IN SITU OF SKIN OF EAR AND EXTERNAL AUDITORY CANAL
232.3	CARCINOMA IN SITU OF SKIN OF OTHER AND UNSPECIFIED PARTS OF FACE
232.4	CARCINOMA IN SITU OF SCALP AND SKIN OF NECK
232.5	CARCINOMA IN SITU OF SKIN OF TRUNK, EXCEPT SCROTUM
232.6	CARCINOMA IN SITU OF SKIN OF UPPER LIMB, INCLUDING SHOULDER
232.7	CARCINOMA IN SITU OF SKIN OF LOWER LIMB, INCLUDING HIP
232.8	CARCINOMA IN SITU OF OTHER SPECIFIED SITES OF SKIN
238.1	NEOPLASM OF UNCERTAIN BEHAVIOR OF CONNECTIVE AND OTHER SOFT TISSUE
238.2	NEOPLASM OF UNCERTAIN BEHAVIOR OF SKIN
238.3	NEOPLASM OF UNCERTAIN BEHAVIOR OF BREAST
238.8	NEOPLASM OF UNCERTAIN BEHAVIOR OF OTHER SPECIFIED SITES
238.9	NEOPLASM OF UNCERTAIN BEHAVIOR, SITE UNSPECIFIED
239.2	NEOPLASM OF UNSPECIFIED NATURE OF BONE, SOFT TISSUE, AND SKIN
287.2	OTHER NONTHROMBOCYTOPENIC PURPURAS
373.31	ECZEMATOUS DERMATITIS OF EYELID
448.1	NEVUS, NON-NEOPLASTIC
448.9	OTHER AND UNSPECIFIED CAPILLARY DISEASES
454.1	VARICOSE VEINS OF LOWER EXTREMITIES WITH INFLAMMATION
521.34	EROSION, LOCALIZED
680	CARBUNCLE AND FURUNCLE OF FACE
680.2	CARBUNCLE AND FURUNCLE OF TRUNK
680.6	CARBUNCLE AND FURUNCLE OF LEG, EXCEPT FOOT
680.9	CARBUNCLE AND FURUNCLE OF UNSPECIFIED SITE
681.01	FELON
681.02	ONYCHIA AND PARONYCHIA OF FINGER
681.11	ONYCHIA AND PARONYCHIA OF TOE
681.9	CELLULITIS AND ABSCESS OF UNSPECIFIED DIGIT
682	CELLULITIS AND ABSCESS OF FACE
682.2	CELLULITIS AND ABSCESS OF TRUNK
682.3	CELLULITIS AND ABSCESS OF UPPER ARM AND FOREARM
682.6	CELLULITIS AND ABSCESS OF LEG, EXCEPT FOOT
682.8	CELLULITIS AND ABSCESS OF OTHER SPECIFIED SITES
682.9	CELLULITIS AND ABSCESS OF UNSPECIFIED SITES
684	IMPETIGO
686	OTHER LOCAL INFECTION OF SKIN AND SUBCUTANEOUS TISSUE, PYODERMA, UNSPECIFIED
686.09	OTHER LOCAL INFECTION OF SKIN AND SUBCUTANEOUS TISSUE, OTHER PYODERMA
686.9	UNSPECIFIED LOCAL INFECTION OF SKIN AND SUBCUTANEOUS TISSUE

ICD-9 Code	Description from CDW
690.1	SEBORRHEIC DERMATITIS, UNSPECIFIED
690.18	OTHER SEBORRHEIC DERMATITIS
691	DIAPER OR NAPKIN RASH
691.8	OTHER ATOPIC DERMATITIS AND RELATED CONDITIONS
692	CONTACT DERMATITIS AND OTHER ECZEMA DUE TO DETERGENTS
692.2	CONTACT DERMATITIS AND OTHER ECZEMA DUE TO SOLVENTS
692.3	CONTACT DERMATITIS AND OTHER ECZEMA DUE TO DRUGS AND MEDICINES IN CONTACT WITH SKIN
692.4	CONTACT DERMATITIS AND OTHER ECZEMA DUE TO OTHER CHEMICAL PRODUCTS
692.6	CONTACT DERMATITIS AND OTHER ECZEMA DUE TO PLANTS (EXCEPT FOOD)
692.7	UNSPECIFIED DERMATITIS DUE TO SUN
692.71	SUNBURN
692.72	ACUTE DERMATITIS DUE TO SOLAR RADIATION
692.73	ACTINIC RETICULOID AND ACTINIC GRANULOMA
692.74	OTHER CHRONIC DERMATITIS DUE TO SOLAR RADIATION
692.75	DISSEMINATED SUPERFICIAL ACTINIC POROKERATOSIS (DSAP)
692.79	OTHER DERMATITIS DUE TO SOLAR RADIATION
692.82	DERMATITIS DUE TO OTHER RADIATION
692.83	DERMATITIS DUE TO METALS
692.89	CONTACT DERMATITIS AND OTHER ECZEMA DUE TO OTHER SPECIFIED AGENTS
692.9	CONTACT DERMATITIS AND OTHER ECZEMA, UNSPECIFIED CAUSE
693	DERMATITIS DUE TO DRUGS AND MEDICINES TAKEN INTERNALLY
694	DERMATITIS HERPETIFORMIS
694.4	PEMPHIGUS
694.5	PEMPHIGOID
694.9	UNSPECIFIED BULLOUS DERMATOSES
695	TOXIC ERYTHEMA
695.1	ERYTHEMA MULTIFORME
695.1	ERYTHEMA MULTIFORME, UNSPECIFIED
695.11	ERYTHEMA MULTIFORME MINOR
695.3	ROSACEA
695.89	OTHER SPECIFIED ERYTHEMATOUS CONDITIONS
696.1	OTHER PSORIASIS AND SIMILAR DISORDERS
696.2	PARAPSORIASIS
696.3	PITYRIASIS ROSEA
696.4	PITYRIASIS RUBRA PILARIS
696.5	OTHER AND UNSPECIFIED PITYRIASIS
696.8	OTHER PSORIASIS AND SIMILAR DISORDERS
697	LICHEN PLANUS
697.1	LICHEN NITIDUS
697.8	OTHER LICHEN, NOT ELSEWHERE CLASSIFIED

ICD-9 Code	Description from CDW
698	PRURITUS ANI
698.1	PRURITUS OF GENITAL ORGANS
698.2	PRURIGO
698.3	LICHENIFICATION AND LICHEN SIMPLEX CHRONICUS
698.4	DERMATITIS FACTITIA (ARTEFACTA)
698.8	OTHER SPECIFIED PRURITIC CONDITIONS
698.9	UNSPECIFIED PRURITIC DISORDER
701	CIRCUMSCRIBED SCLERODERMA
701.3	STRIAE ATROPHICAE
701.4	KELOID SCAR
701.9	UNSPECIFIED HYPERTROPHIC AND ATROPHIC CONDITIONS OF SKIN
702	ACTINIC KERATOSIS
702.11	INFLAMED SEBORRHEIC KERATOSIS
702.19	OTHER SEBORRHEIC KERATOSIS
704	ALOPECIA, UNSPECIFIED
704.01	ALOPECIA AREATA
704.02	TELOGEN EFFLUVIUM
704.09	OTHER ALOPECIA
704.1	HIRSUTISM
704.8	OTHER SPECIFIED DISEASES OF HAIR AND HAIR FOLLICLES
704.9	UNSPECIFIED DISEASE OF HAIR AND HAIR FOLLICLES
705.81	DYSHIDROSIS
706	ACNE VARIOLIFORMIS
706.1	OTHER ACNE
706.3	SEBORRHEA
706.8	OTHER SPECIFIED DISEASES OF SEBACEOUS GLANDS
706.9	UNSPECIFIED DISEASE OF SEBACEOUS GLANDS
709	DYSCHROMIA
709	DYSCHROMIA, UNSPECIFIED
709.01	VITILIGO
709.09	OTHER DYSCHROMIA
709.1	VASCULAR DISORDERS OF SKIN
757.1	ICHTHYOSIS CONGENITA
757.32	VASCULAR HAMARTOMAS
757.4	SPECIFIED CONGENITAL ANOMALIES OF HAIR
782.1	RASH AND OTHER NONSPECIFIC SKIN ERUPTION
919.8	OTHER AND UNSPECIFIED SUPERFICIAL INJURY OF OTHER, MULTIPLE, AND UNSPECIFIED SITES, WITHOUT MENTION OF INFECTION
V10.82	PERSONAL HISTORY OF MALIGNANT MELANOMA OF SKIN
V10.83	PERSONAL HISTORY OF OTHER MALIGNANT NEOPLASM OF SKIN

ICD-9 Code	Description from CDW
V13.3	PERSONAL HISTORY OF DISEASES OF SKIN AND SUBCUTANEOUS TISSUE
V16.8	FAMILY HISTORY OF OTHER SPECIFIED MALIGNANT NEOPLASM
V19.4	FAMILY HISTORY OF SKIN CONDITIONS
V76.43	SCREENING FOR MALIGNANT NEOPLASMS OF THE SKIN
V82.0	SCREENING FOR SKIN CONDITIONS

Appendix F Details on in-person wait time ARIMA model

The times series analysis of the in-person wait time data for the teledermatology programs was evaluated with an ARIMA model. The dependent variable is the mean wait time for an in-person dermatology appointment. The independent variable is the number of teledermatology appointments per month. Covariates to the wait time data are number of dermatology appointments per month (supply) and number of PCP visits for a skin concern per month (demand). The (p,d,q) and seasonal (p,d,q) components were automatically generated with the *auto-arima* function in the *forecast* package of R 3.1.0. The (p,d,q) components for each teledermatology program are listed in Table.

Table F-1. (p,d,q)(p,d,q)s components of wait time ARIMA models for all teledermatology programs

Program	ARIMA Parameters
A	$(1,0,0)(0,0,0)_{12}$
C	$(1,1,1)(0,0,0)_{12}$
F	$(1,0,0)(0,0,0)_{12}$
G	$(1,0,0)(0,0,0)_{12}$
H	$(2,0,0)(0,0,0)_{12}$
I	$(0,1,0)(0,0,0)_{12}$
J	$(1,0,0)(2,1,0)_{12}$
K	$(1,0,0)(0,0,0)_{12}$
M	$(2,0,2)(0,0,1)_{12}$
N	$(0,1,1)(0,0,0)_{12}$
O	$(1,0,0)(1,0,0)_{12}$
P	$(1,0,0)(0,0,0)_{12}$
Q	$(1,1,0)(1,0,0)_{12}$
S	$(0,1,0)(0,0,0)_{12}$

For each coefficient of each model the 95% confident interval is presented in Table. Bolded results in Table are statistically significant.

Table F-2. 95% confidence intervals of ARIMA model coefficients, s=seasonal component, ar=auto-regressive(p) coefficients, ma=moving average (q) coefficients

Program	Variable	Confidence Interval	
		2.50%	97.50%
	ar1	0.68	0.95
	Demand	-0.01	0.01
	intercept	10.09	23.92
	Supply	0.00	0.01
A	TeleDerm	-0.04	0.02
	ar1	0.06	0.63
	Demand	-0.13	0.00
	ma1	-0.96	-0.64
	Supply	0.01	0.03
C	TeleDerm	-0.11	0.04
	ar1	0.50	0.93
	Demand	-0.01	0.05
	intercept	10.45	31.25
	Supply	0.00	0.02
F	TeleDerm	-0.17	0.04
	ar1	0.50	0.86
	Demand	-0.01	0.03
	intercept	9.05	24.15
	Supply	0.00	0.02
G	TeleDerm	-0.03	0.02
	ar1	0.22	0.75
	ar2	-0.01	0.46
	Demand	-0.04	0.03
	intercept	21.81	39.74
	Supply	-0.02	0.02
H	TeleDerm	-0.02	0.06
	ar1	0.83	1.03
	Demand	-0.02	0.02
	intercept	20.18	57.69
	Supply	0.00	0.01
I	TeleDerm	-0.07	0.04
	ar1	0.50	0.93
	Demand	-0.05	0.00
	sar1	-0.99	-0.35
	sar2	-0.75	-0.08
	Supply	-0.01	0.01
J	TeleDerm	-0.03	0.06

Program	Variable	Confidence Interval	
		2.50%	97.50%
	ar1	0.37	0.79
	Demand	-0.02	0.03
	intercept	21.64	34.09
	Supply	-0.01	0.00
K	TeleDerm	-0.03	0.04
	ar1	1.00	1.61
	ar2	-0.97	-0.40
	Demand	0.00	0.04
	intercept	17.13	30.32
	ma1	-1.26	-0.57
	ma2	0.38	1.05
	sma1	-0.09	0.62
	Supply	-0.01	0.00
M	TeleDerm	-0.04	0.03
	Demand	-0.12	0.12
	ma1	-0.78	-0.24
	Supply	-0.01	0.06
N	TeleDerm	-0.51	0.55
	ar1	0.46	0.83
	Demand	-0.03	0.00
	intercept	43.29	69.94
	sar1	-0.04	0.46
	Supply	0.00	0.01
O	TeleDerm	-0.18	0.01
	ar1	1.56	2.02
	Demand	-0.13	0.08
	intercept	50.01	118.83
	Supply	0.01	0.10
P	TeleDerm	-0.18	0.00
	ar1	-0.43	0.04
	Demand	-0.05	0.01
	sar1	0.18	0.73
	Supply	-0.01	0.02
Q	TeleDerm	-0.07	0.03
	Demand	-0.03	0.02
	Supply	-0.01	0.00
S	TeleDerm	-0.03	0.02

To test the assumptions of the model, the Box-Ljung statistic was calculated (Table) and the residuals plots were produced.

Table F-3. Box-Ljung *p*-value for ARIMA model residuals

Program	Box-Ljung *p*-value
A	0.78
C	0.96
F	0.25
G	0.34
H	0.94
I	0.22
J	0.82
K	0.81
M	0.63
N	0.49
O	0.89
P	0.76
Q	1.00
S	0.47

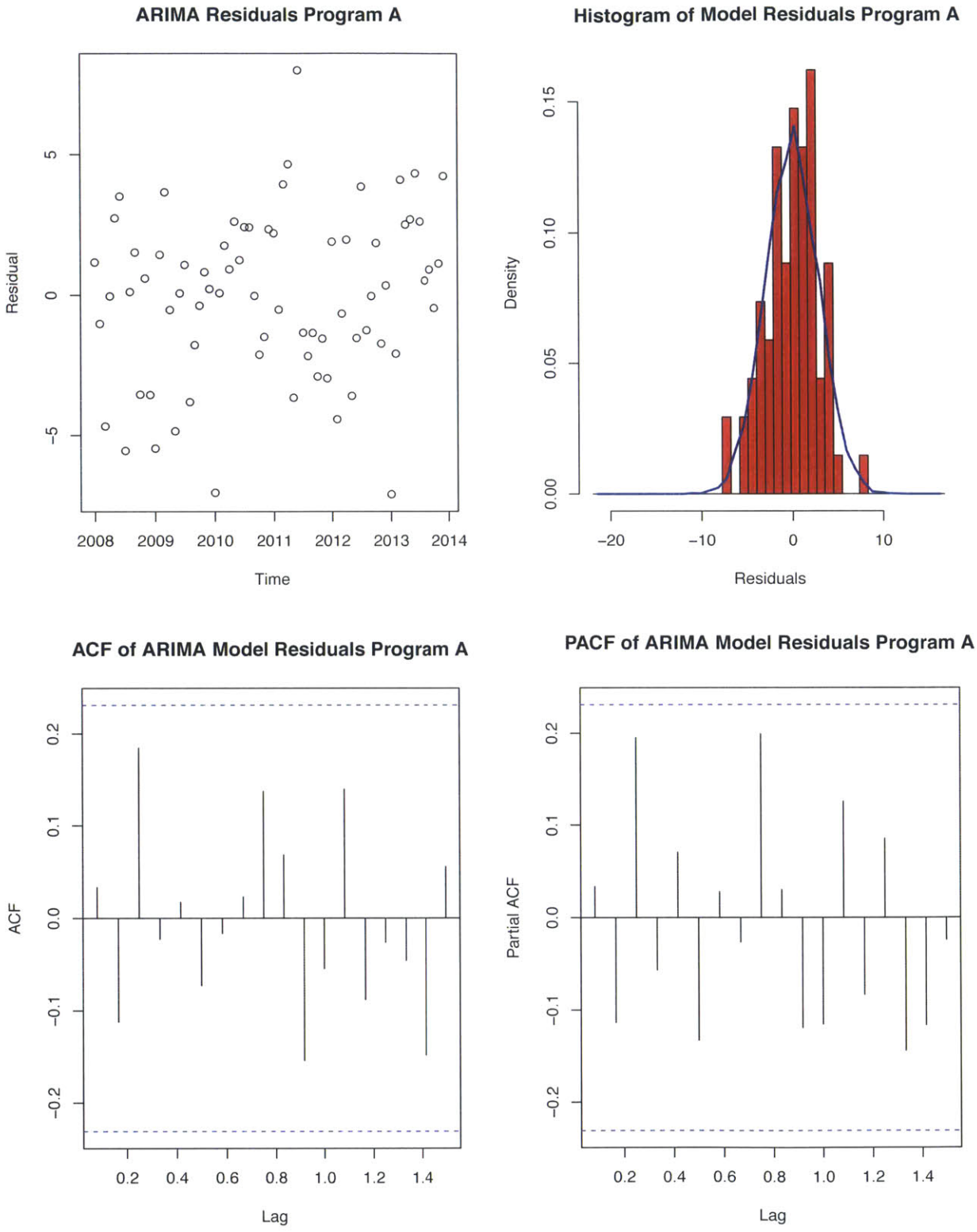


Figure F-1. Graphs verifying ARIMA assumptions, Program A

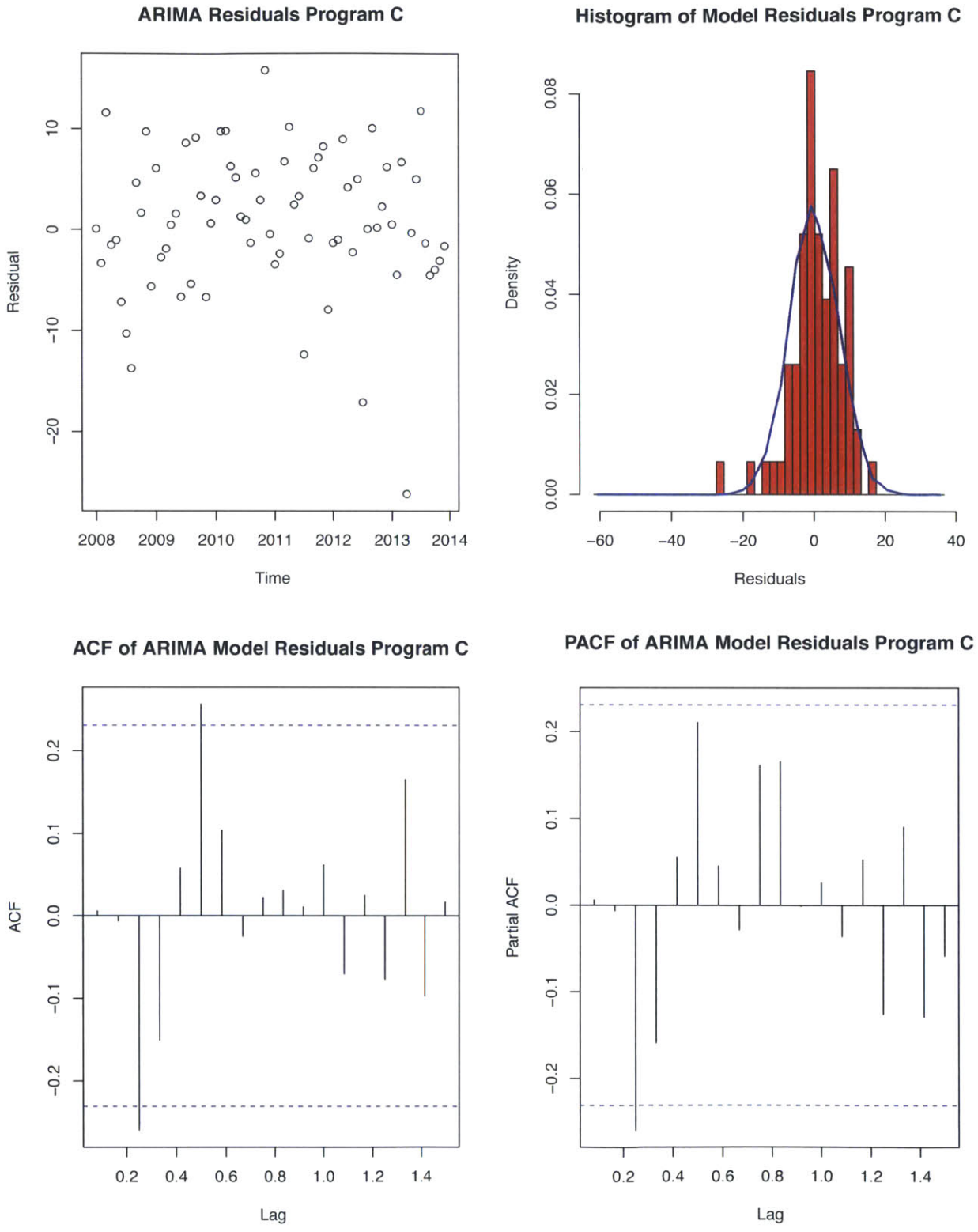


Figure F-2. Graphs verifying ARIMA assumptions, Program C

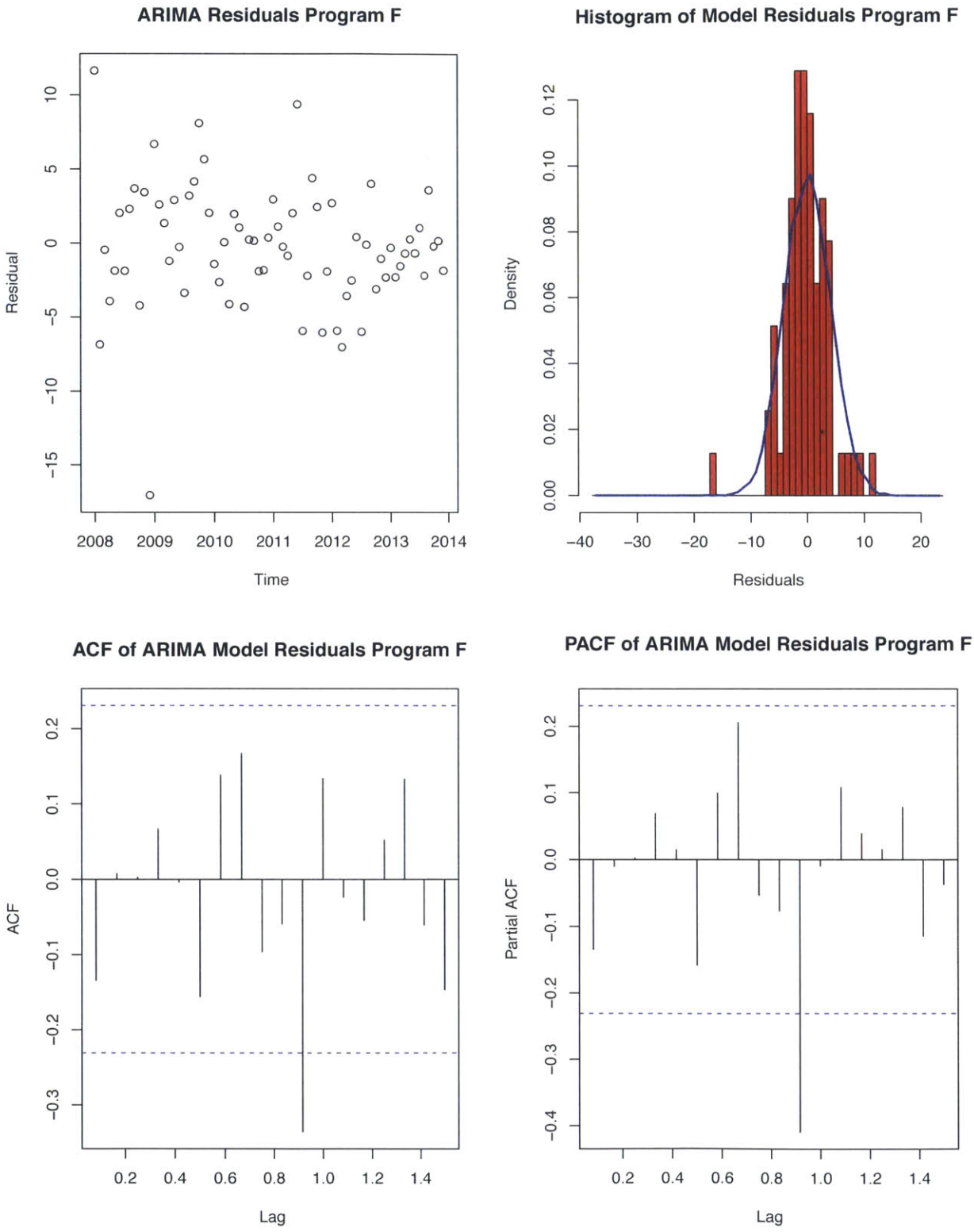


Figure F-3. Graphs verifying ARIMA assumptions, Program F

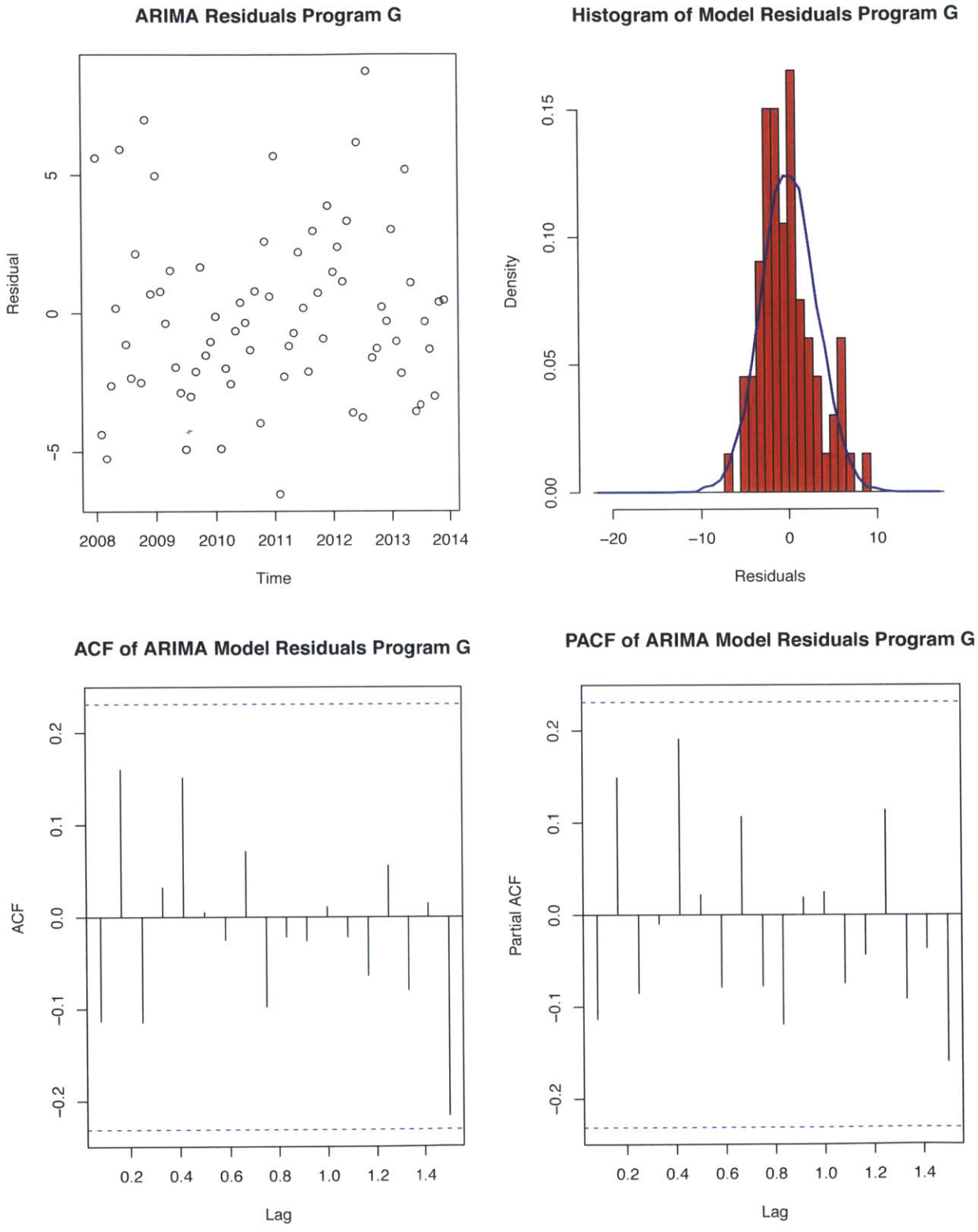


Figure F-4. Graphs verifying ARIMA assumptions, Program G

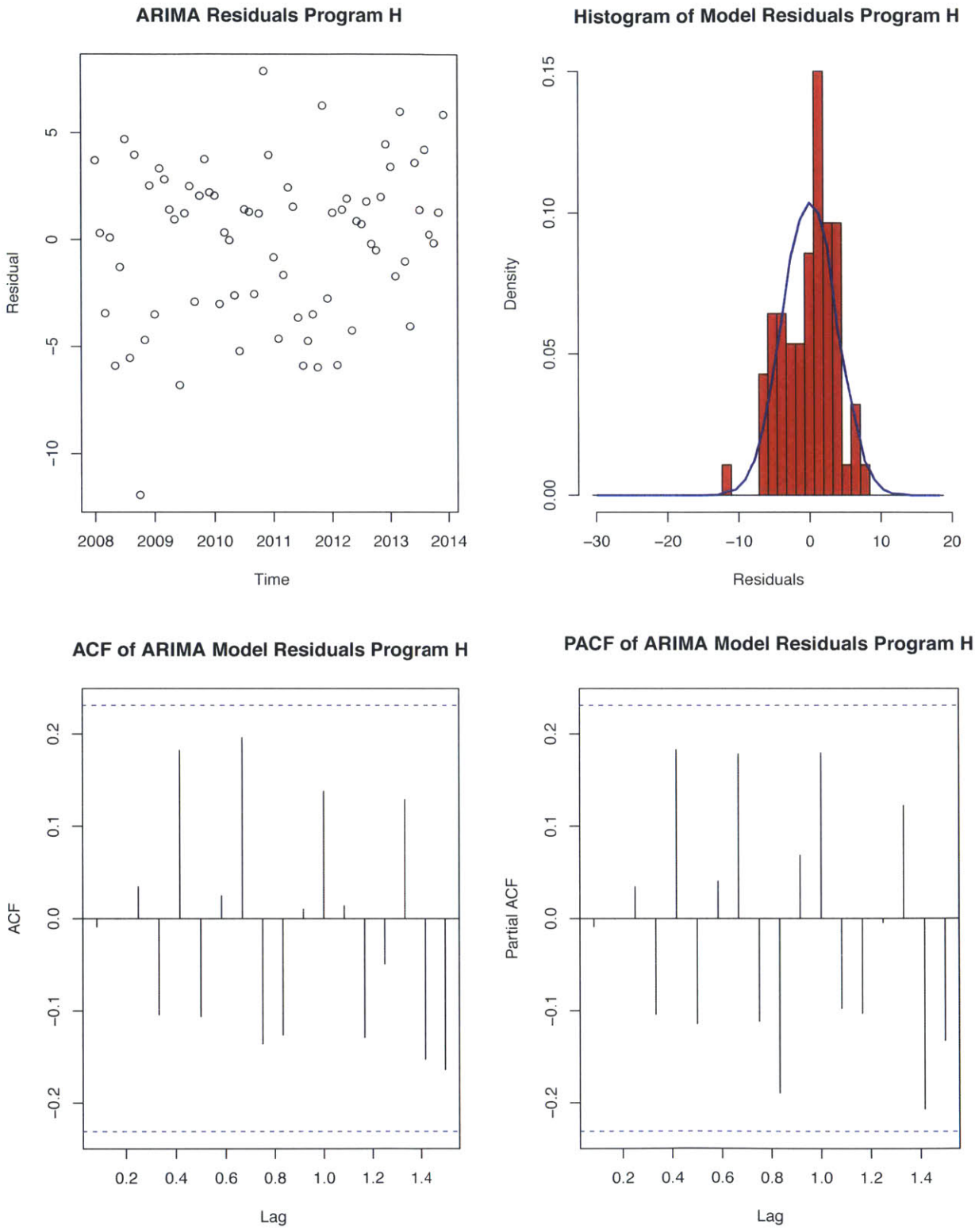


Figure F-5. Graphs verifying ARIMA assumptions, Program H

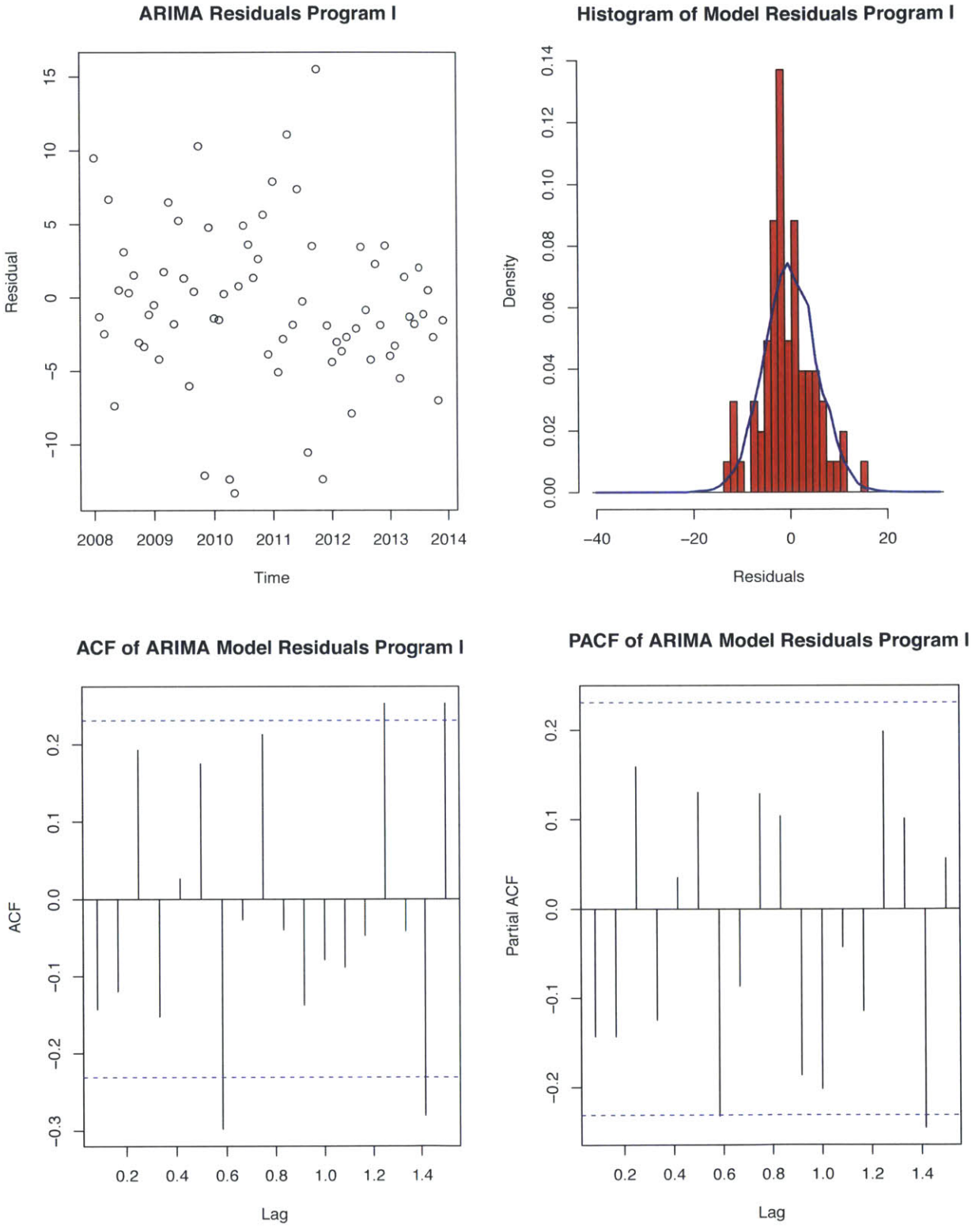


Figure F-6. Graphs verifying ARIMA assumptions, Program I

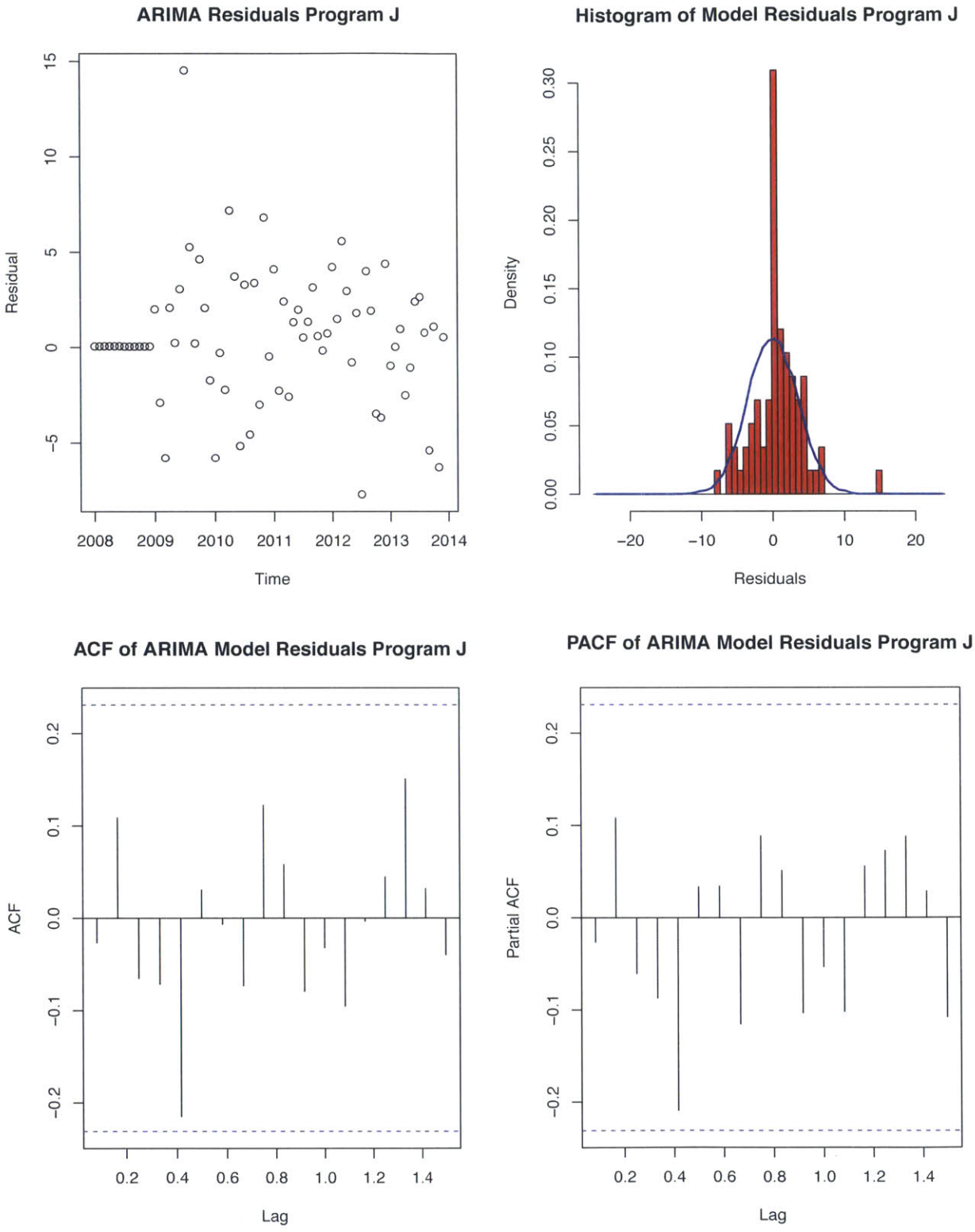


Figure F-7. Graphs verifying ARIMA assumptions, Program J

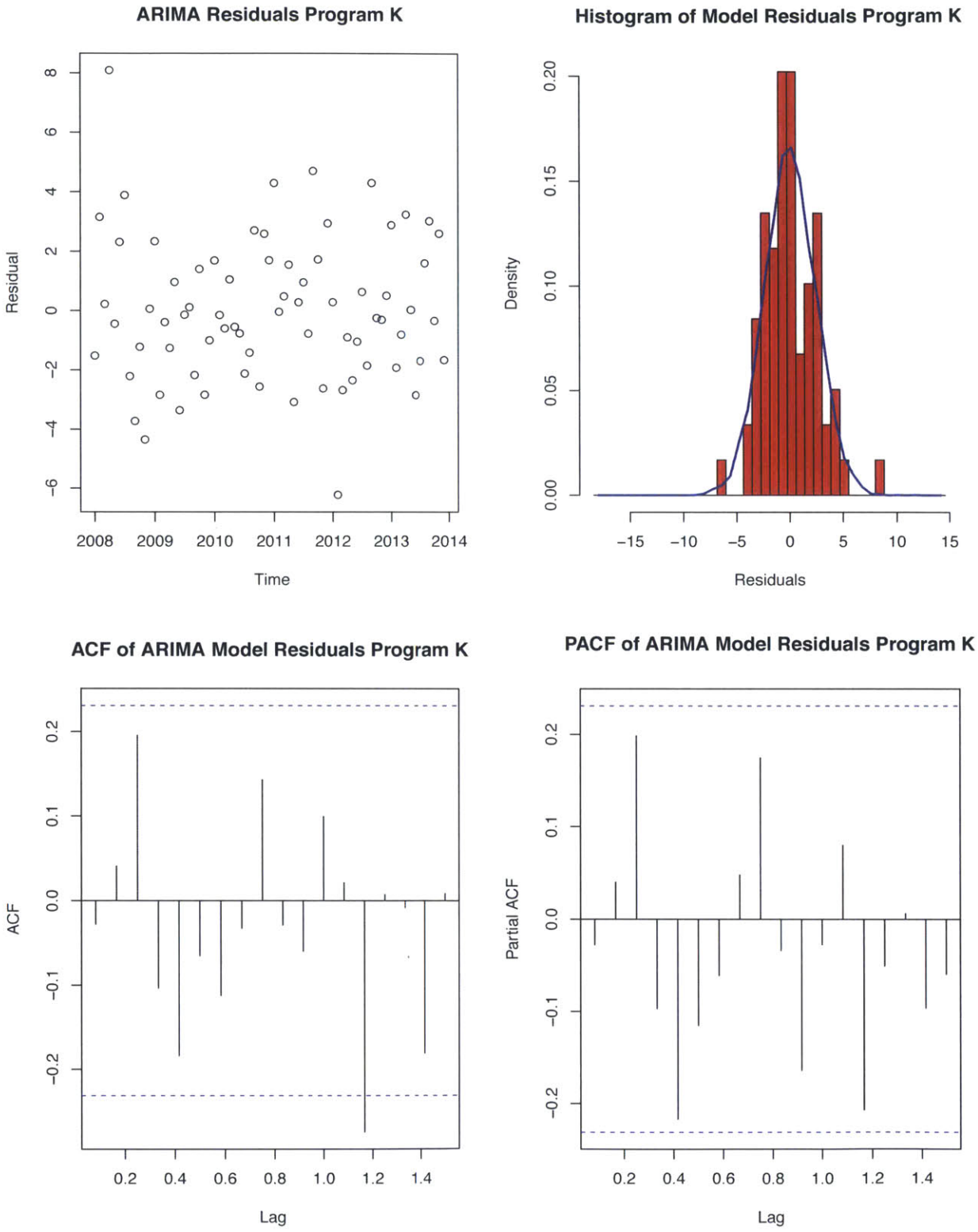


Figure F-8. Graphs verifying ARIMA assumptions, Program K

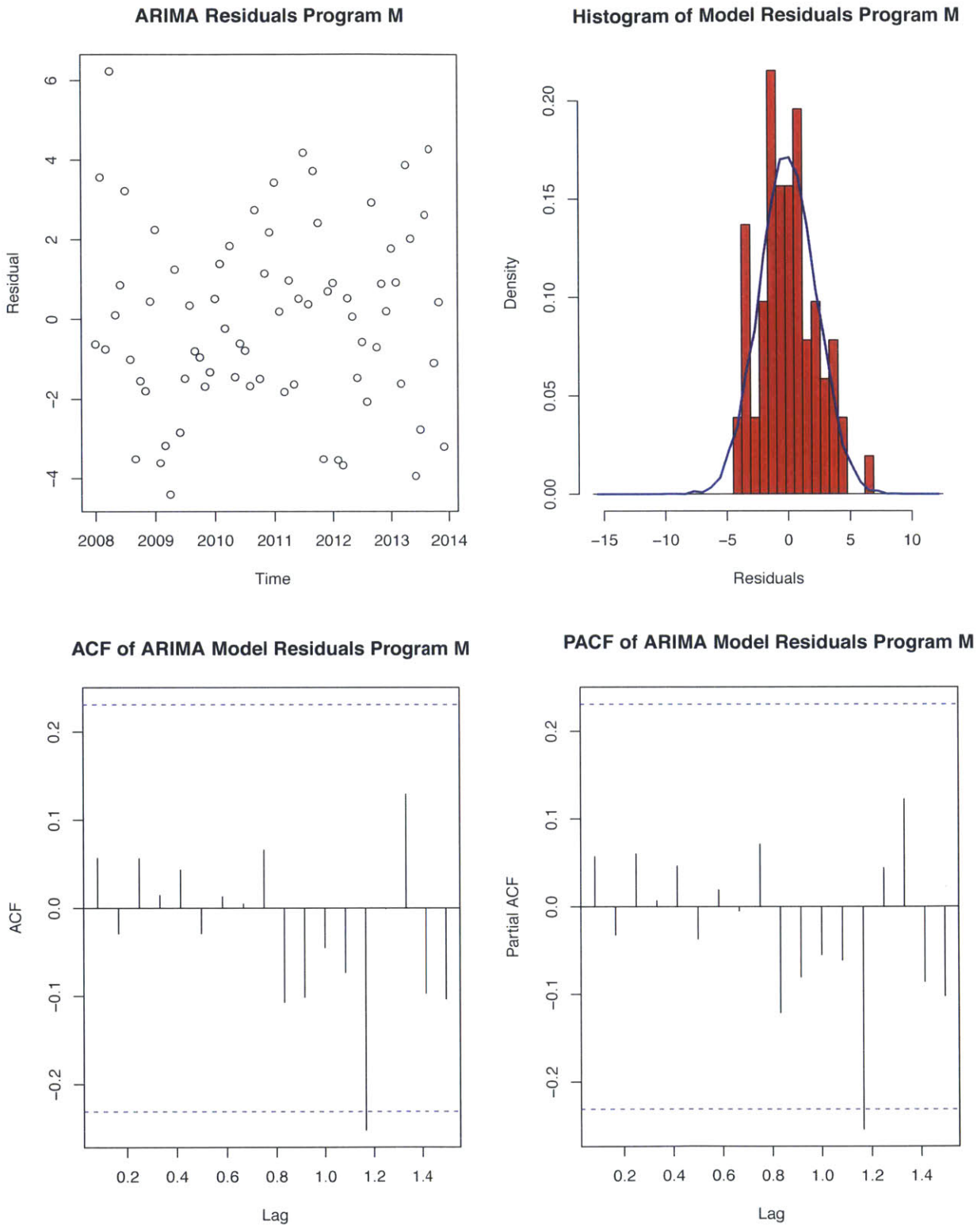


Figure F-9. Graphs verifying ARIMA assumptions, Program M

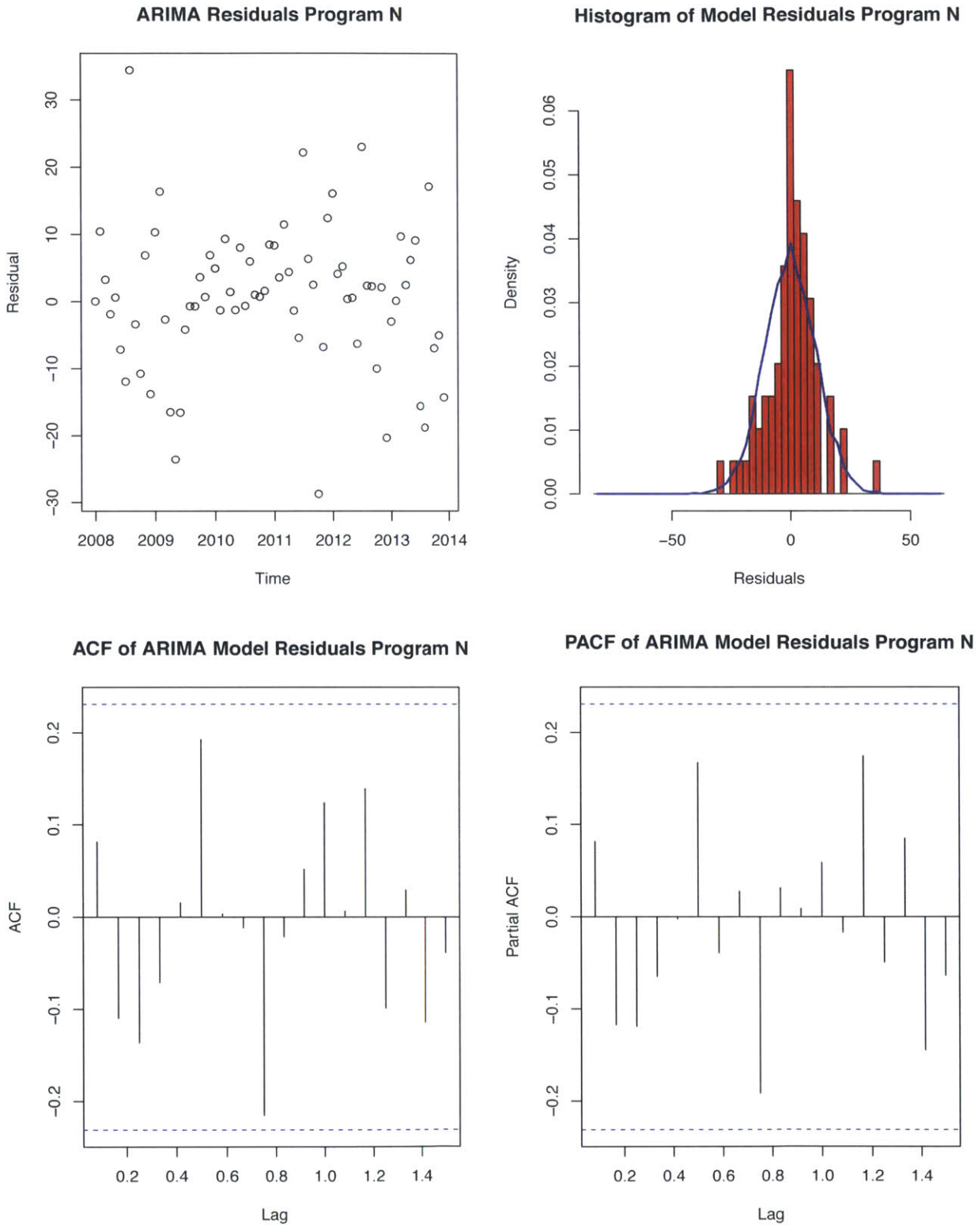


Figure F-10. Graphs verifying ARIMA assumptions, Program N

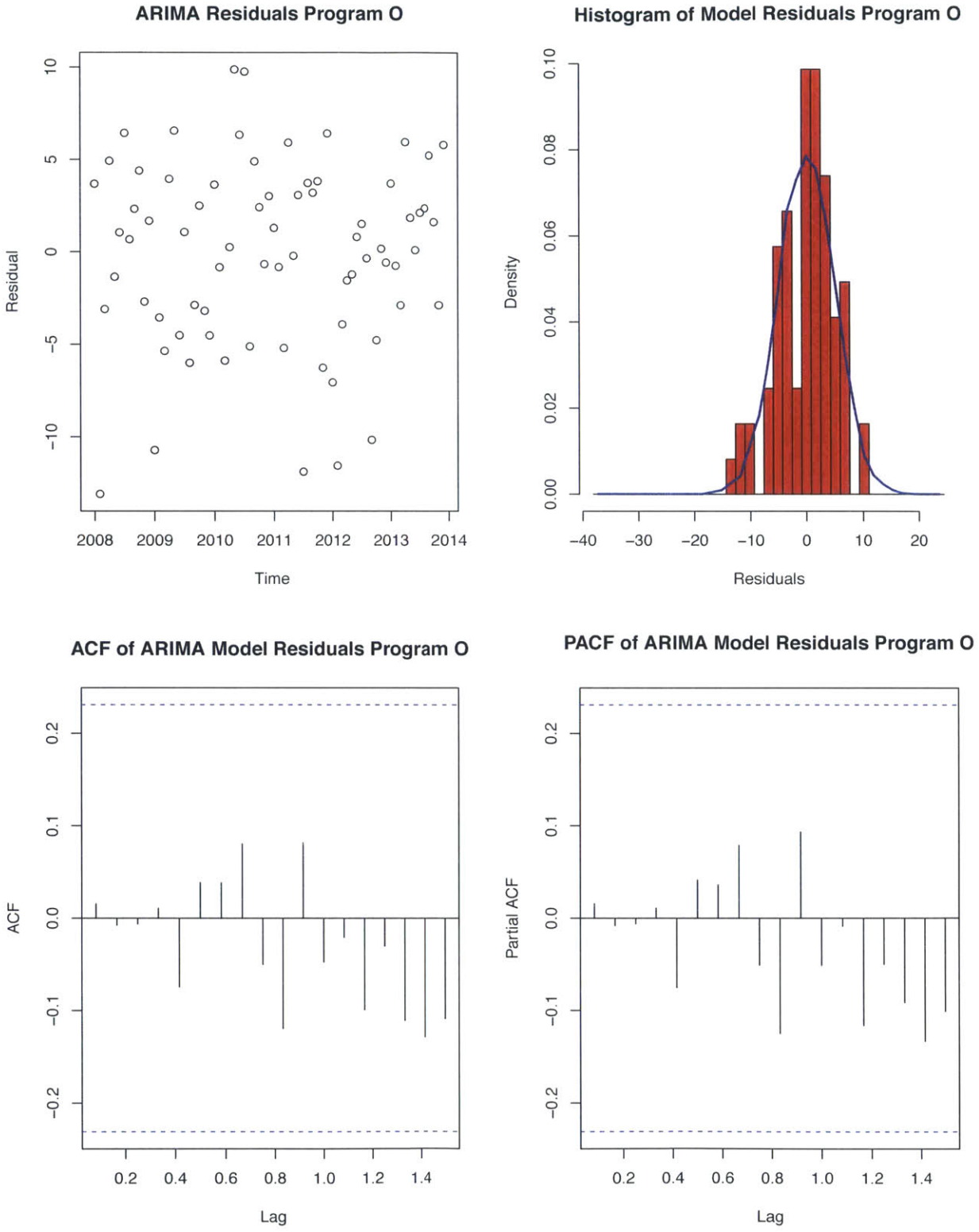


Figure F-11. Graphs verifying ARIMA assumptions, Program O

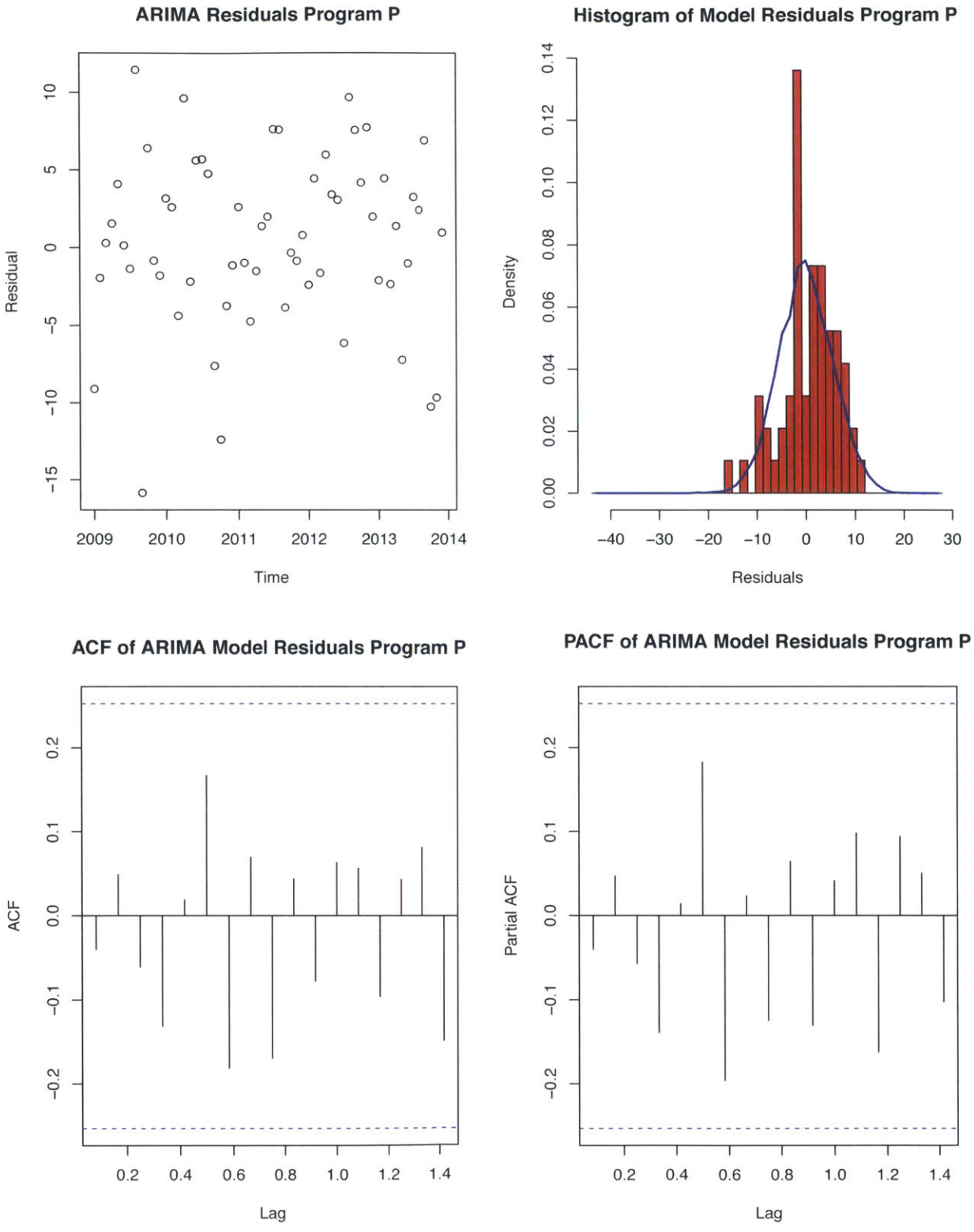


Figure F-12. Graphs verifying ARIMA assumptions, Program P

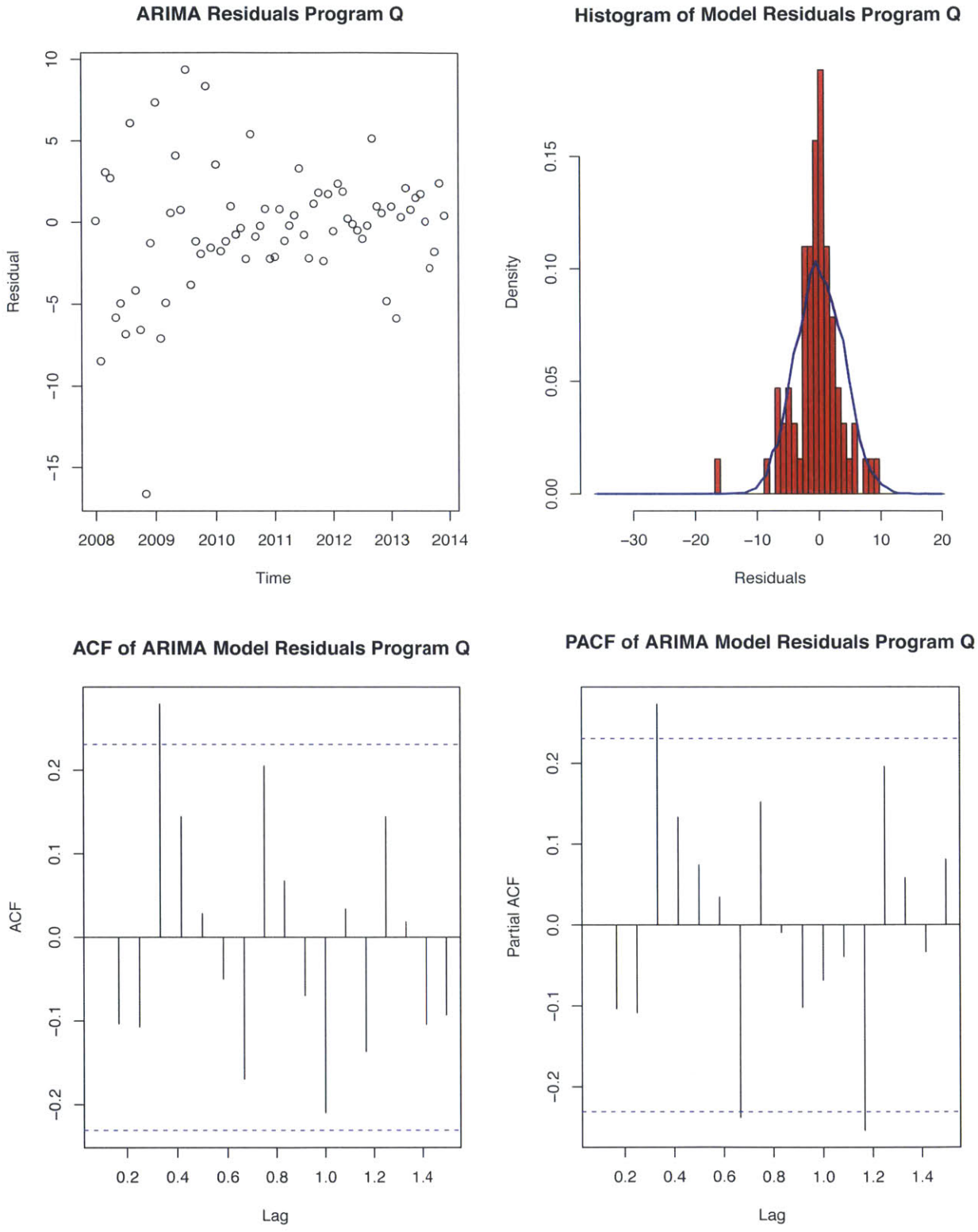


Figure F-13. Graphs verifying ARIMA assumptions, Program Q

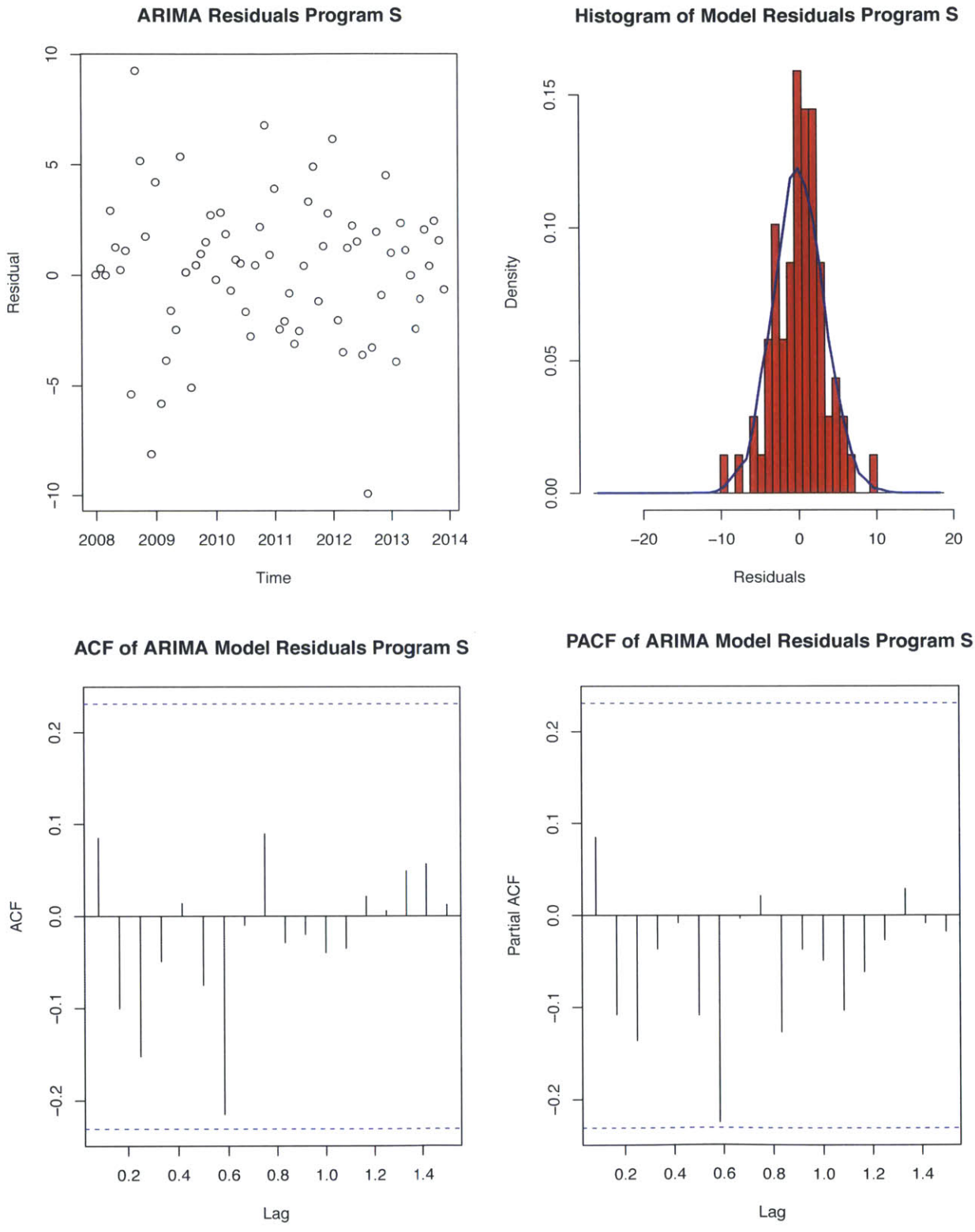


Figure F-14. Graphs verifying ARIMA assumptions, Program S

Appendix G Wait time for dermatology services by program

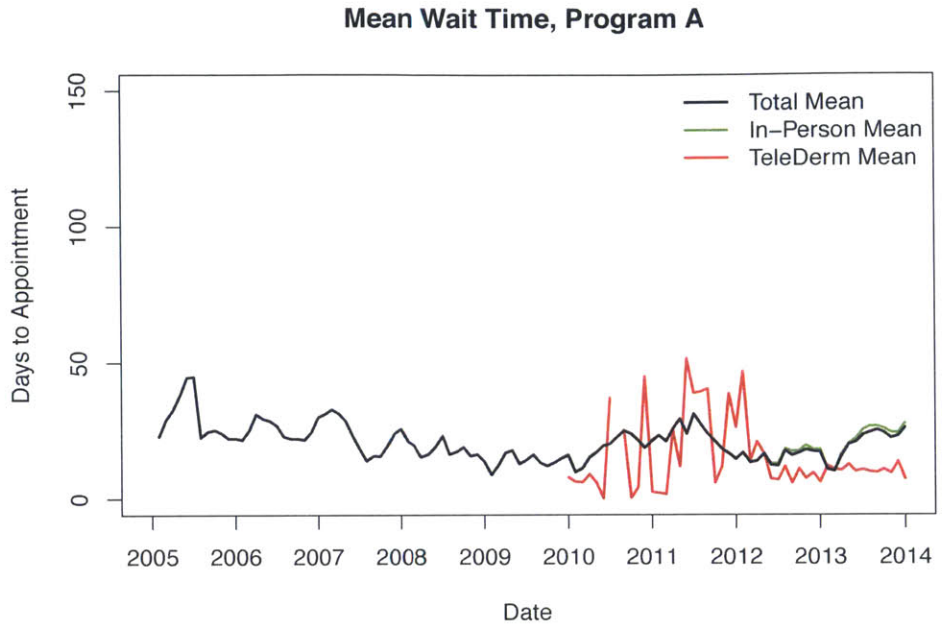


Figure G-1. Mean wait time for dermatology service 2005-2013, Program A

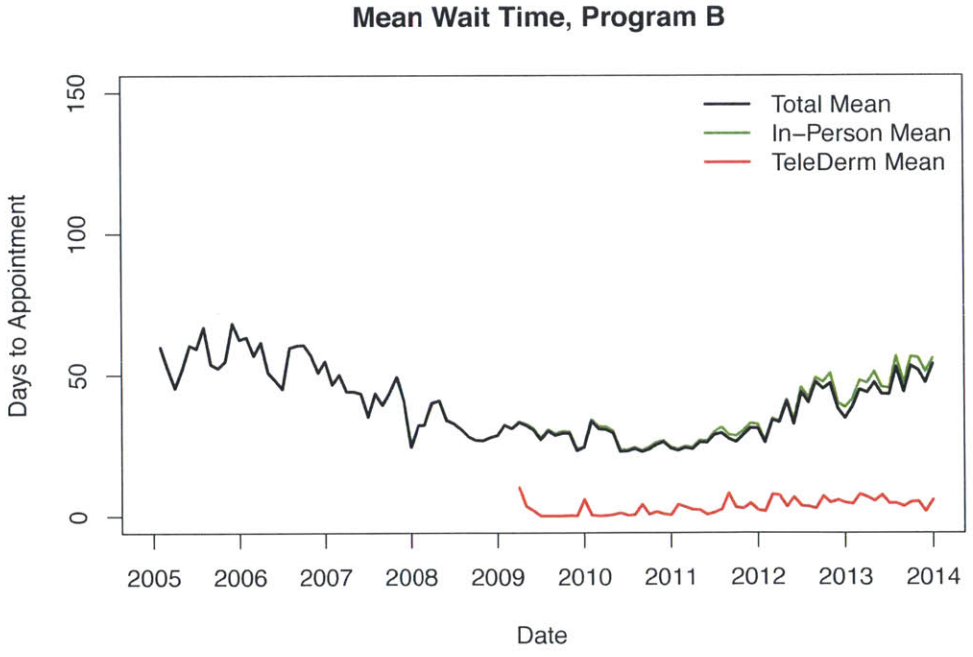


Figure G-2. Mean wait time for dermatology service 2005-2013, Program B

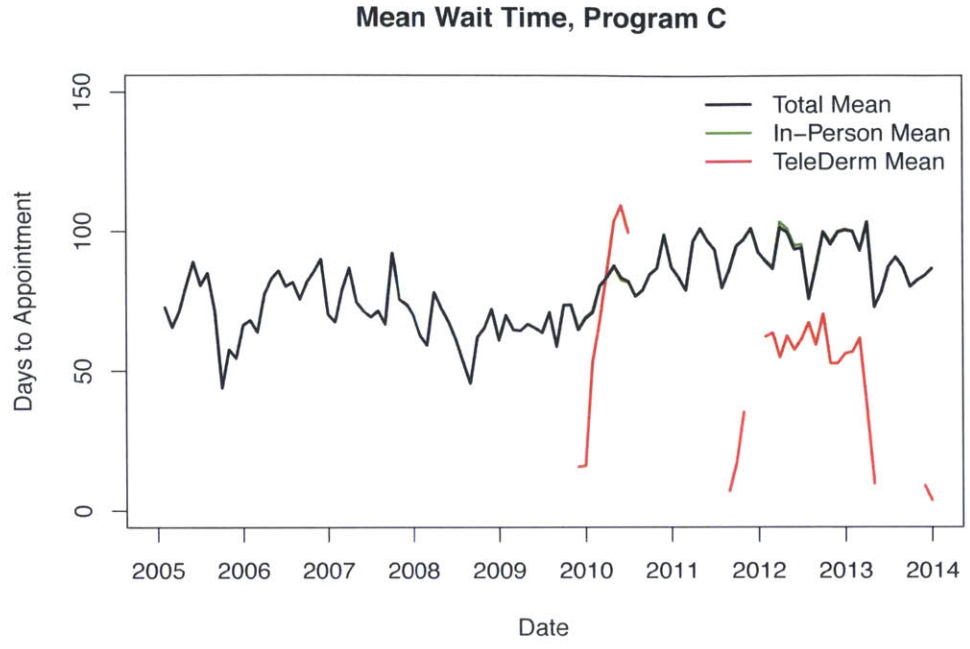


Figure G-3. Mean wait time for dermatology service 2005-2013, Program C

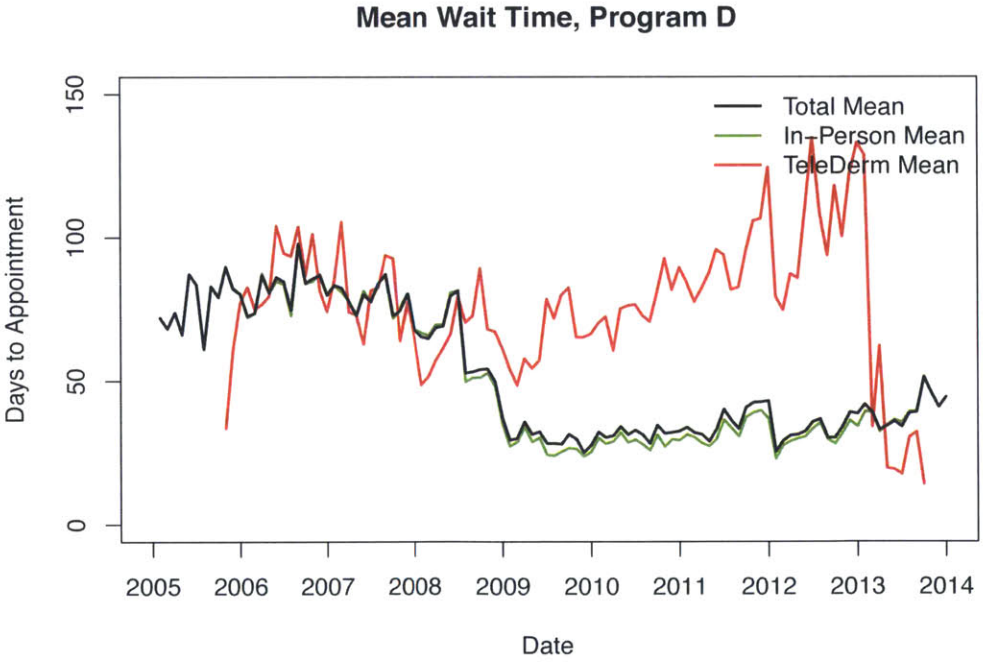


Figure G-4. Mean wait time for dermatology service 2005-2013, Program D

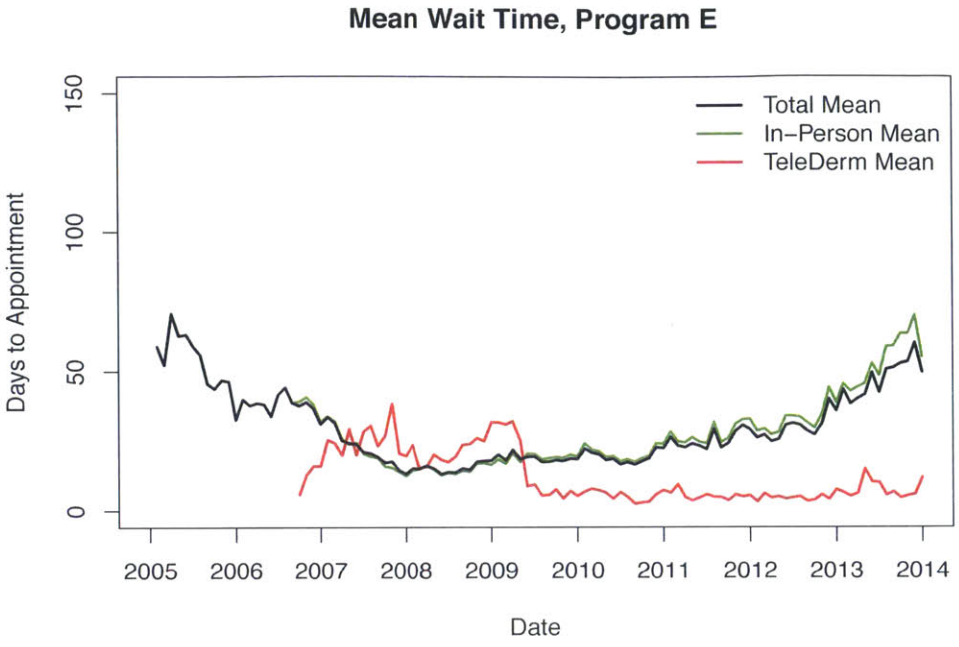


Figure G-5. Mean wait time for dermatology service 2005-2013, Program E

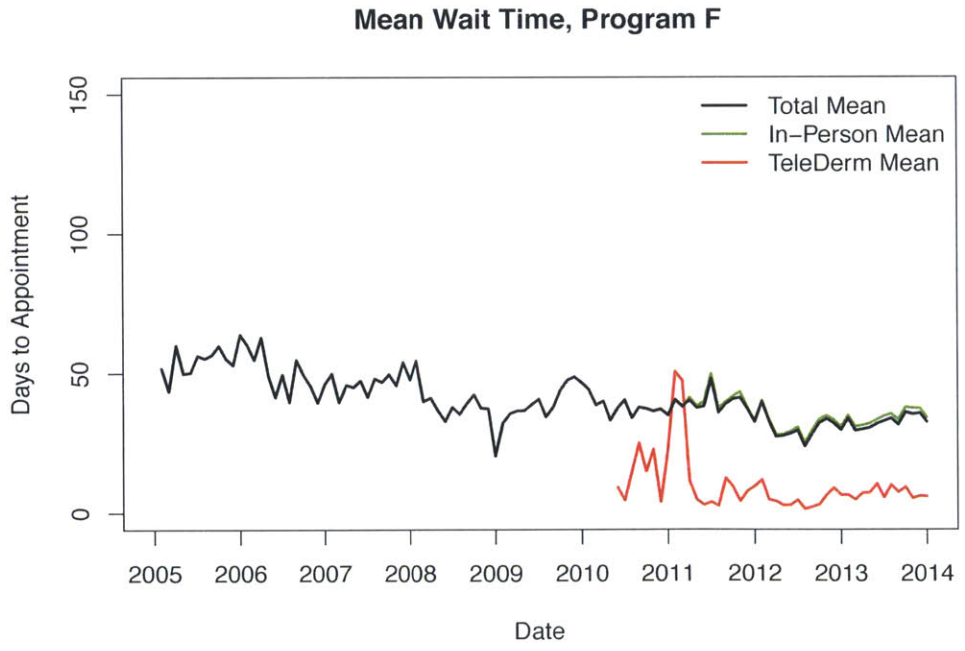


Figure G-6. Mean wait time for dermatology service 2005-2013, Program F

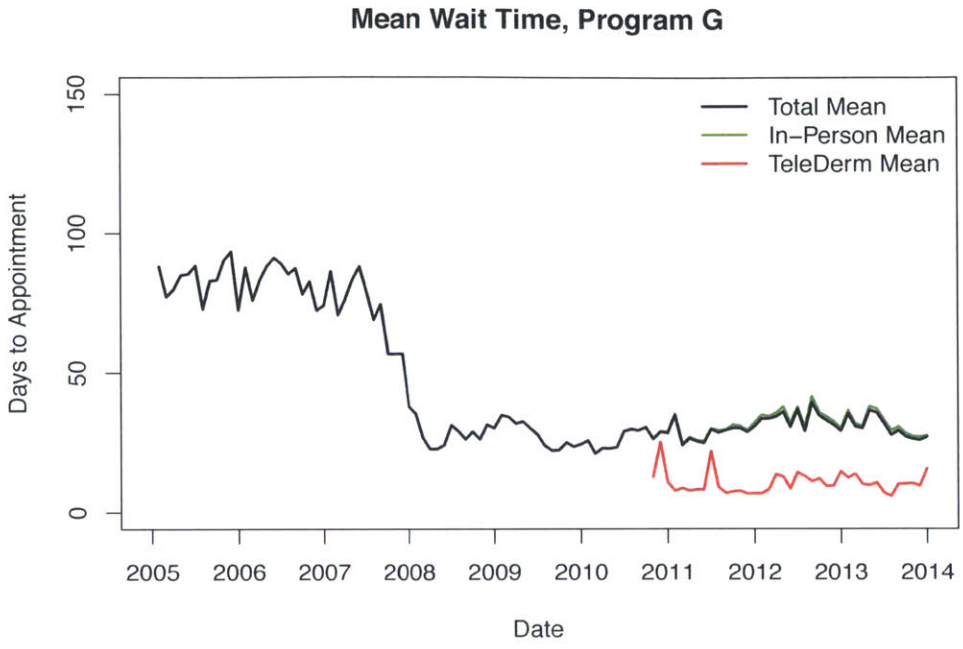


Figure G-7. Mean wait time for dermatology service 2005-2013, Program G

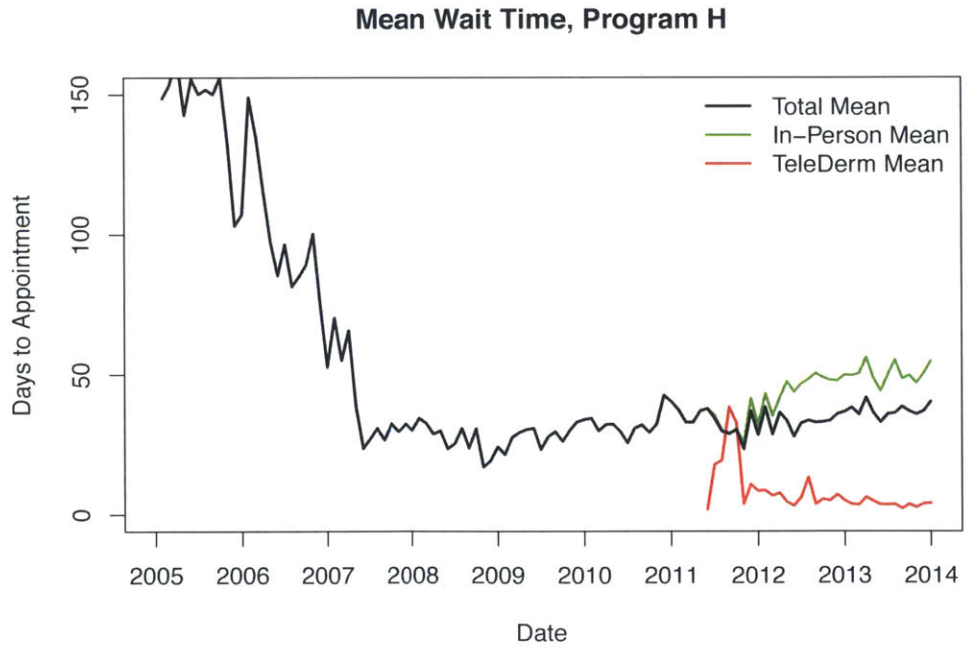


Figure G-8. Mean wait time for dermatology service 2005-2013, Program H

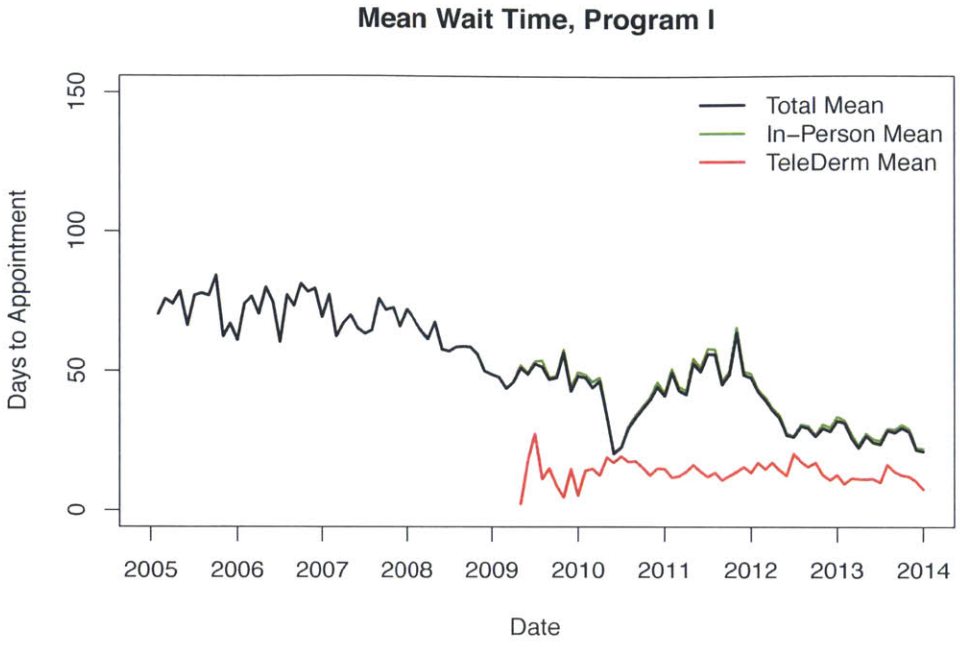


Figure G-9. Mean wait time for dermatology service 2005-2013, Program I

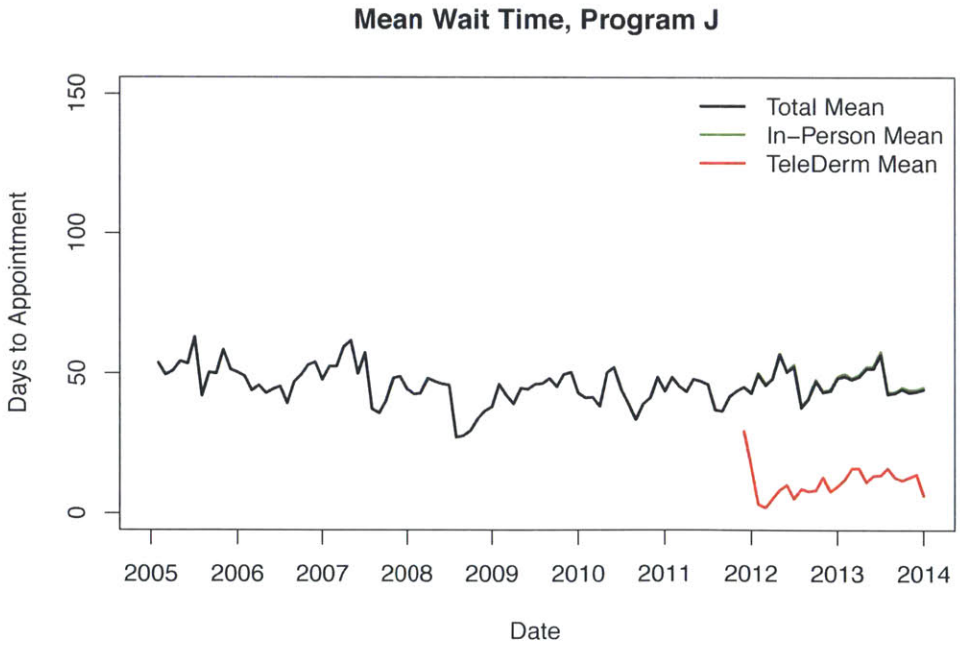


Figure G-10. Mean wait time for dermatology service 2005-2013, Program J

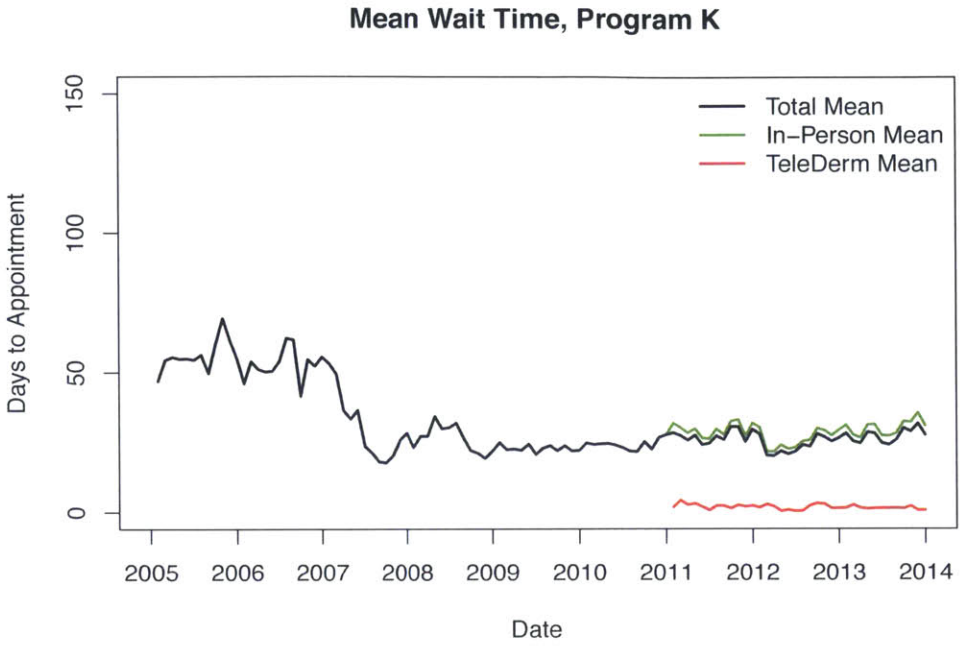


Figure G-11. Mean wait time for dermatology service 2005-2013, Program K

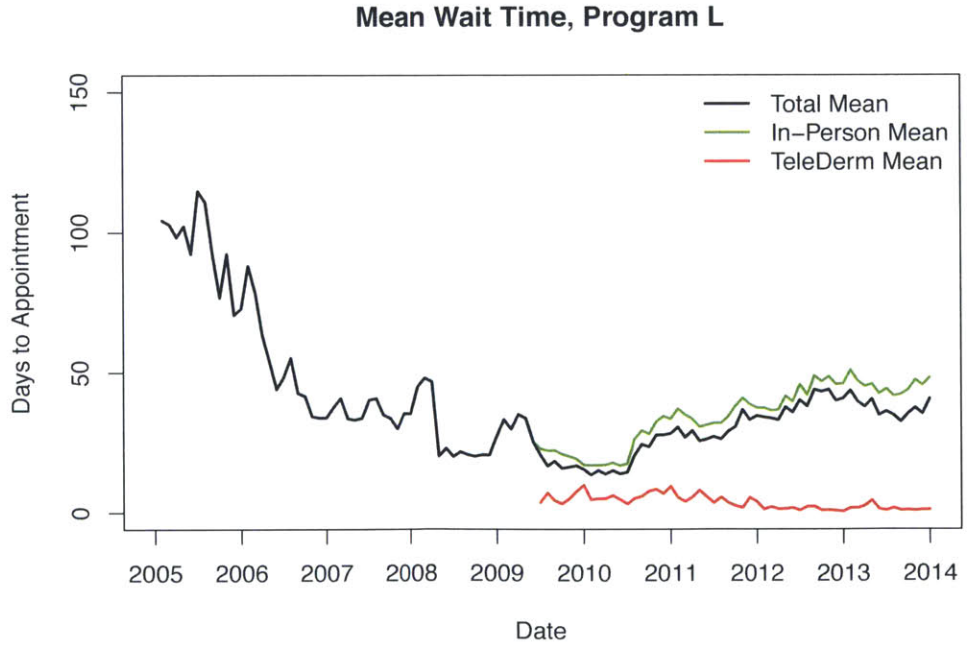


Figure G-12. Mean wait time for dermatology service 2005-2013, Program L

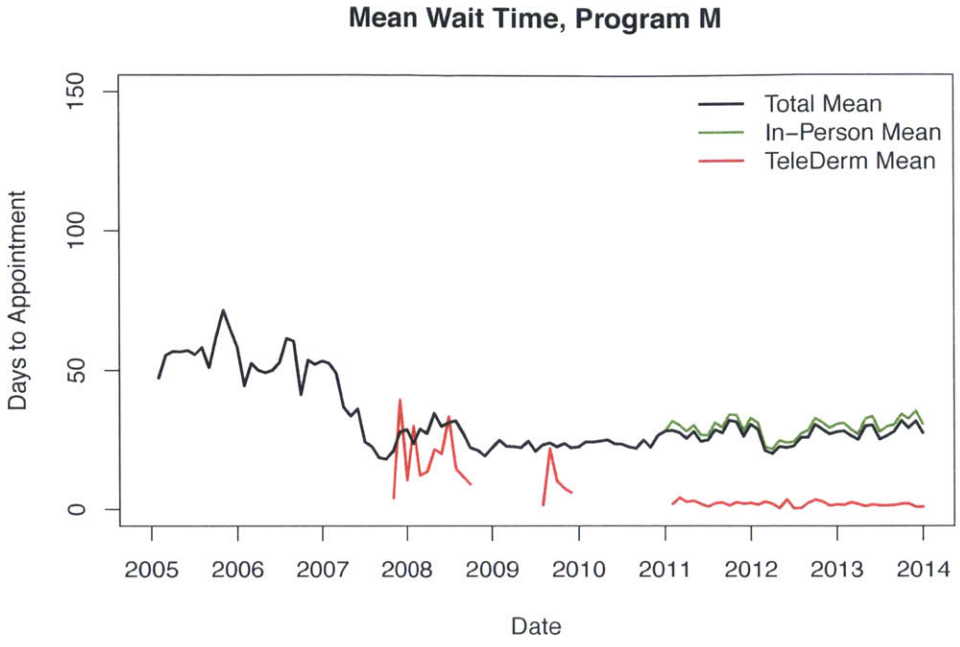


Figure G-13. Mean wait time for dermatology service 2005-2013, Program M

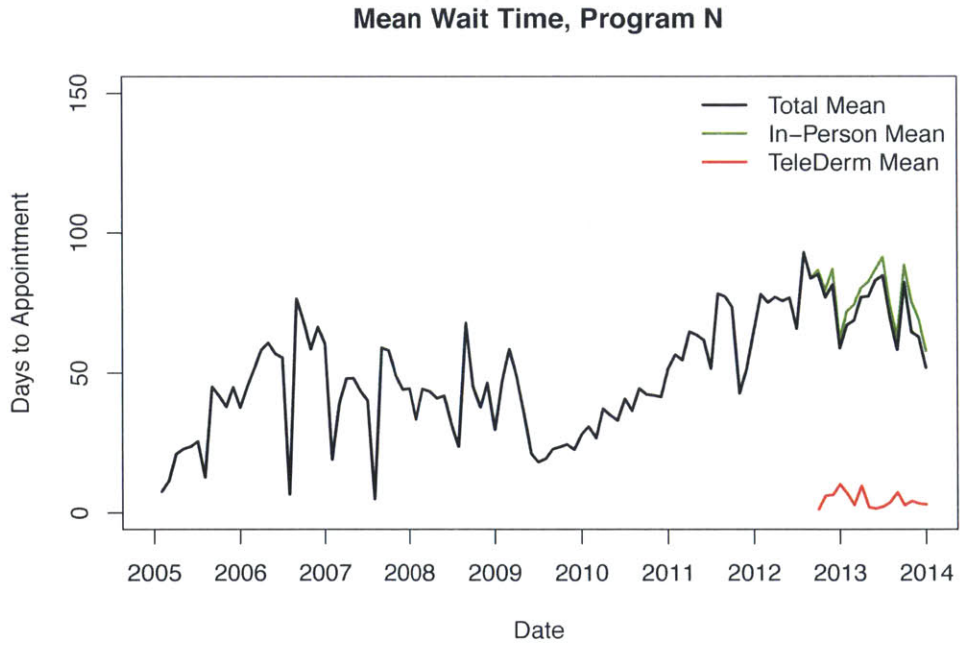


Figure G-14. Mean wait time for dermatology service 2005-2013, Program N

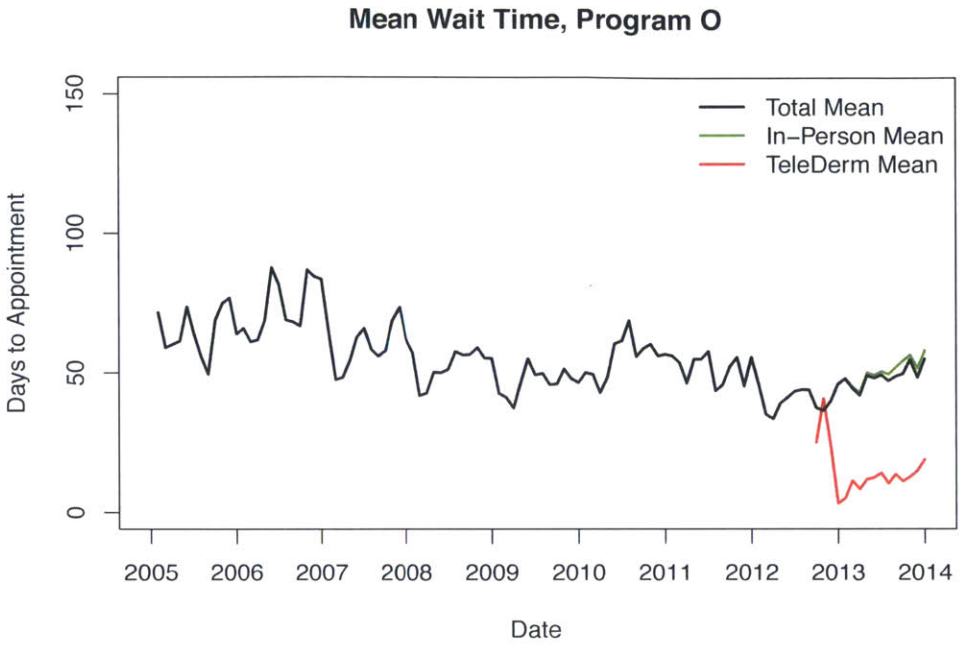


Figure G-15. Mean wait time for dermatology service 2005-2013, Program O

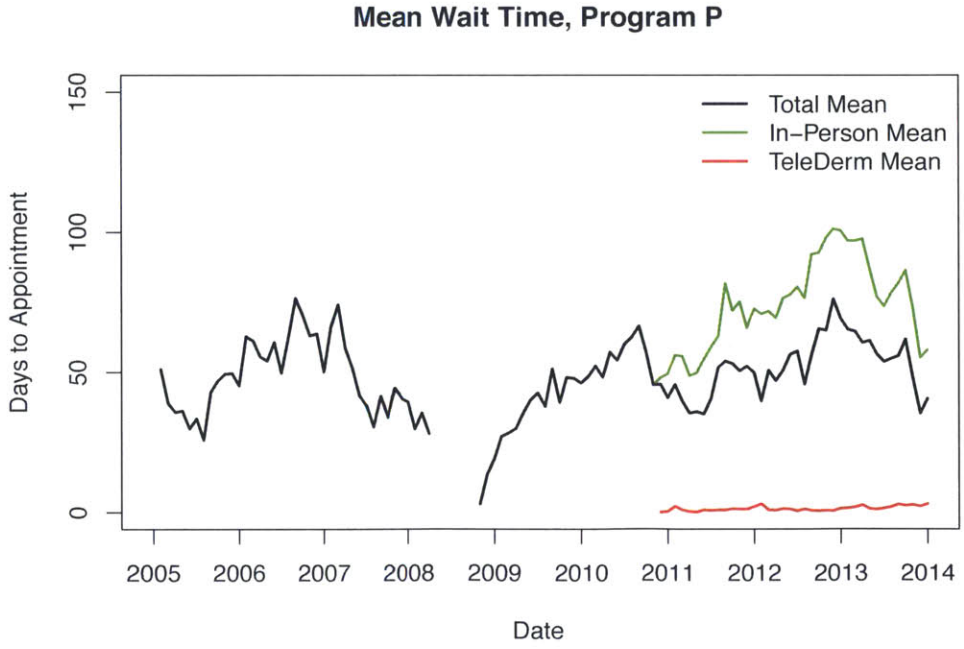


Figure G-16. Mean wait time for dermatology service 2005-2013, Program P

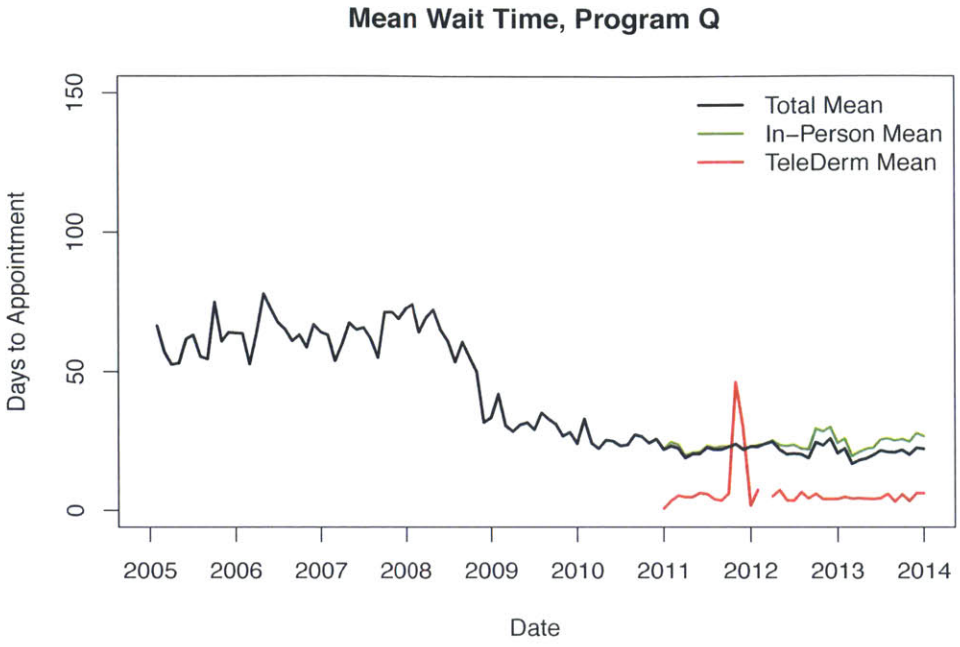


Figure G-17. Mean wait time for dermatology service 2005-2013, Program Q

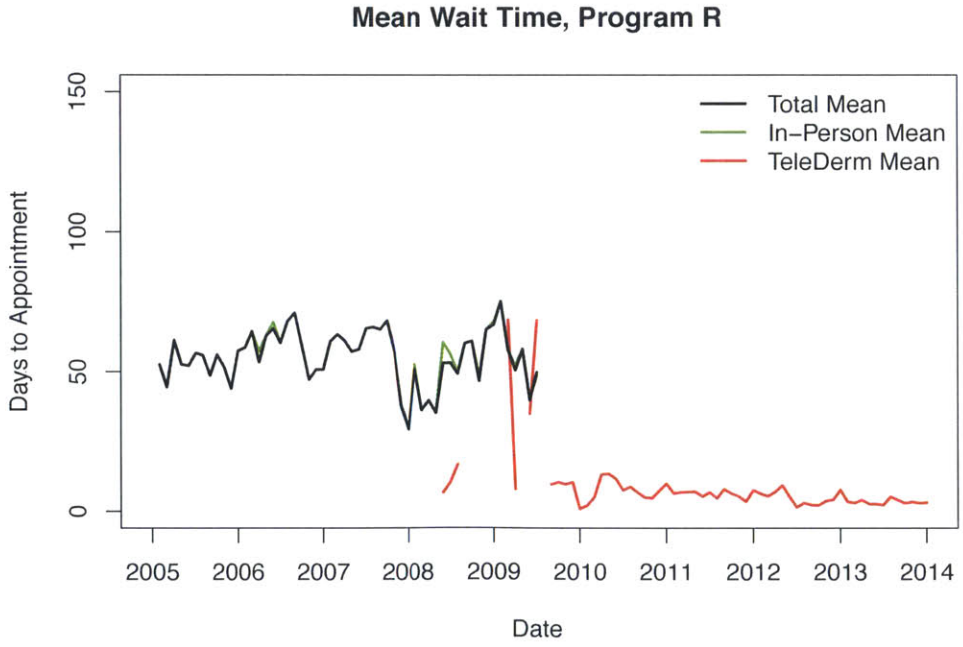


Figure G-18. Mean wait time for dermatology service 2005-2013, Program R

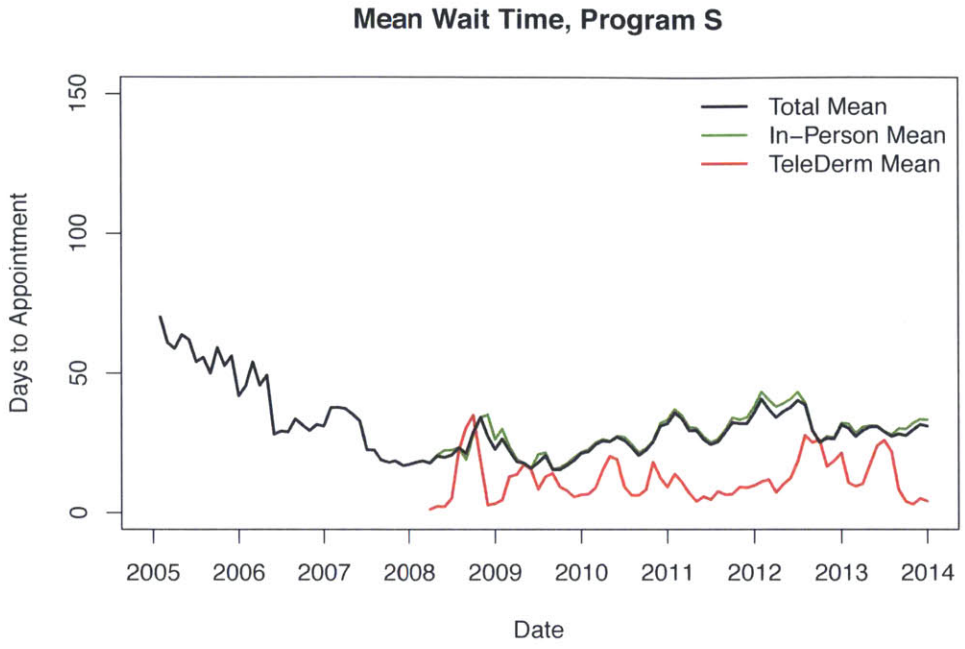


Figure G-19. Mean wait time for dermatology service 2005-2013, Program S

Appendix H Details of hierarchical linear regression of number of dermatology consults per month

Hierarchical linear regression was performed with the independent variable: number of consults per month to dermatology and the independent variables: 1) number of PCP visits per month for a skin concern and 2) number of teledermatology visits per month. The number of consults per month for each program can be found from Figure H-1 to Figure H-19. The coefficients for the linear regression models and their associate *p*-values can be found in Table. The graphs evaluating the residuals of the models can be found from Figure H-20 to Figure H-45.

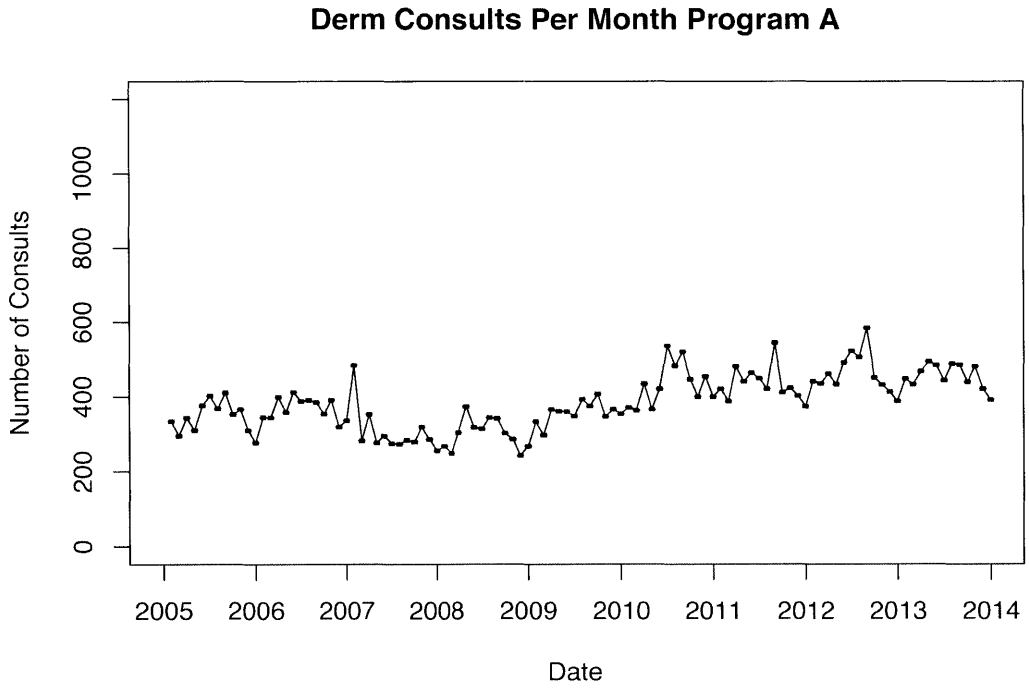


Figure H-1. Monthly consults to dermatology, Program A

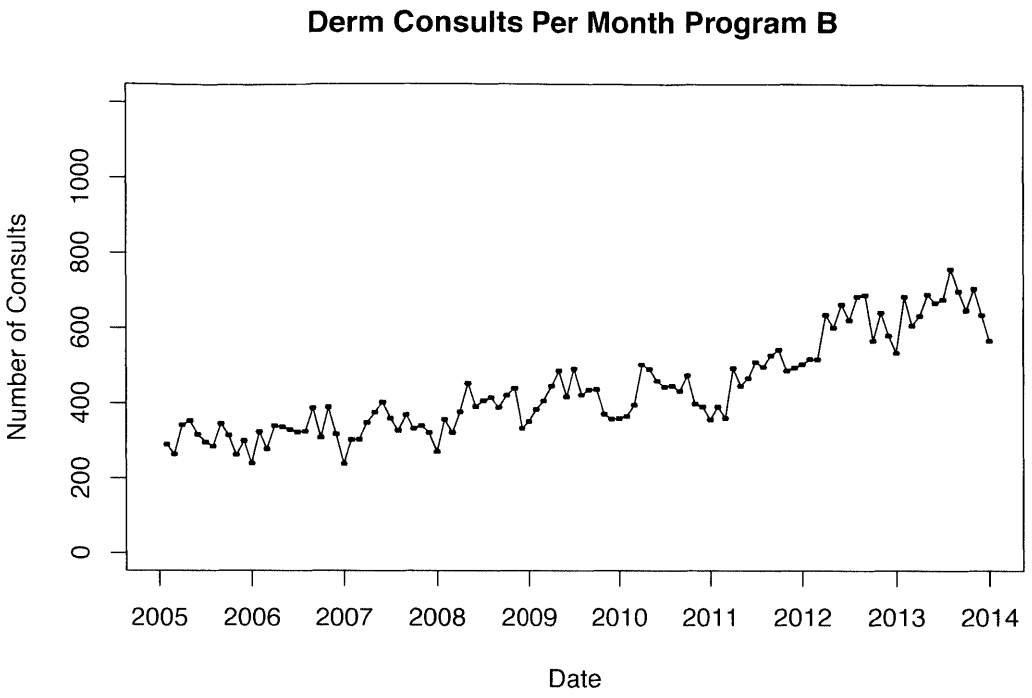


Figure H-2. Monthly consults to dermatology, Program B

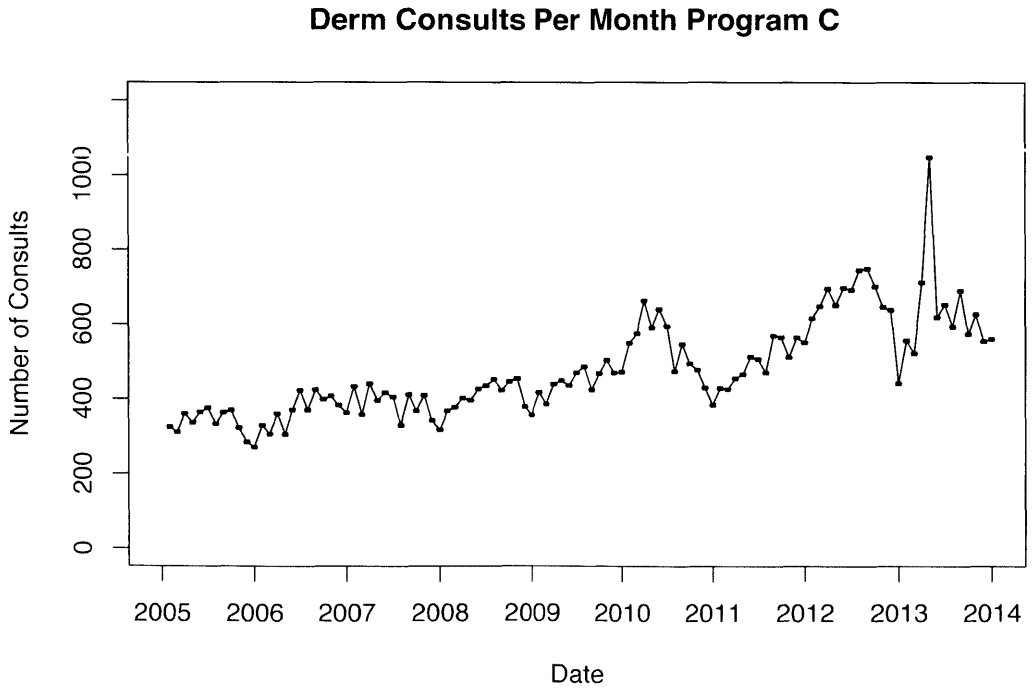


Figure H-3. Monthly consults to dermatology, Program C

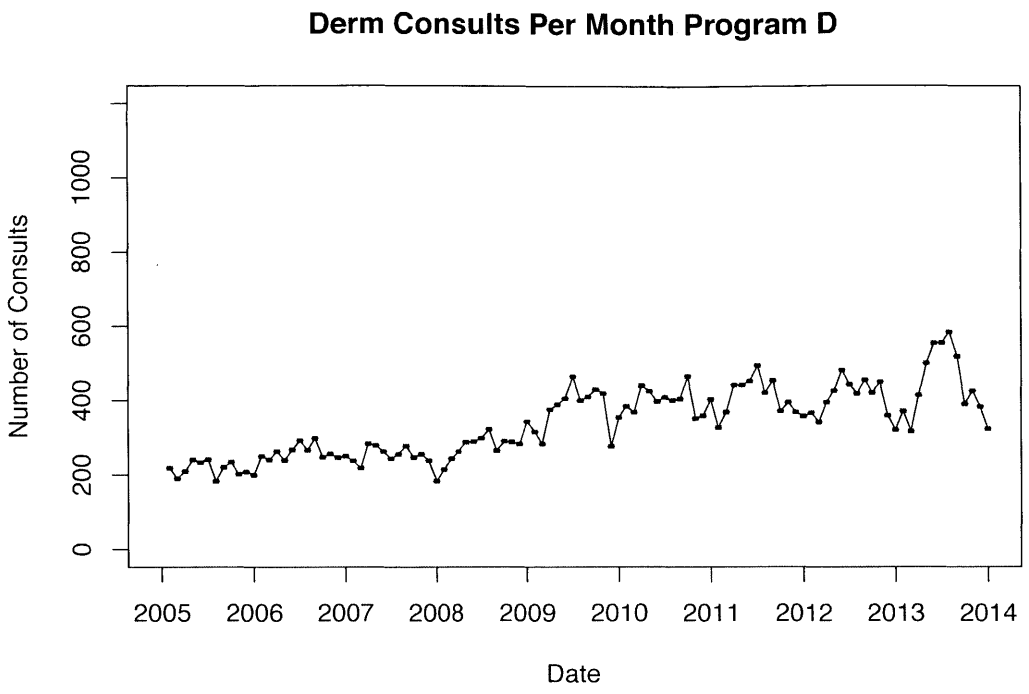


Figure H-4. Monthly consults to dermatology, Program D

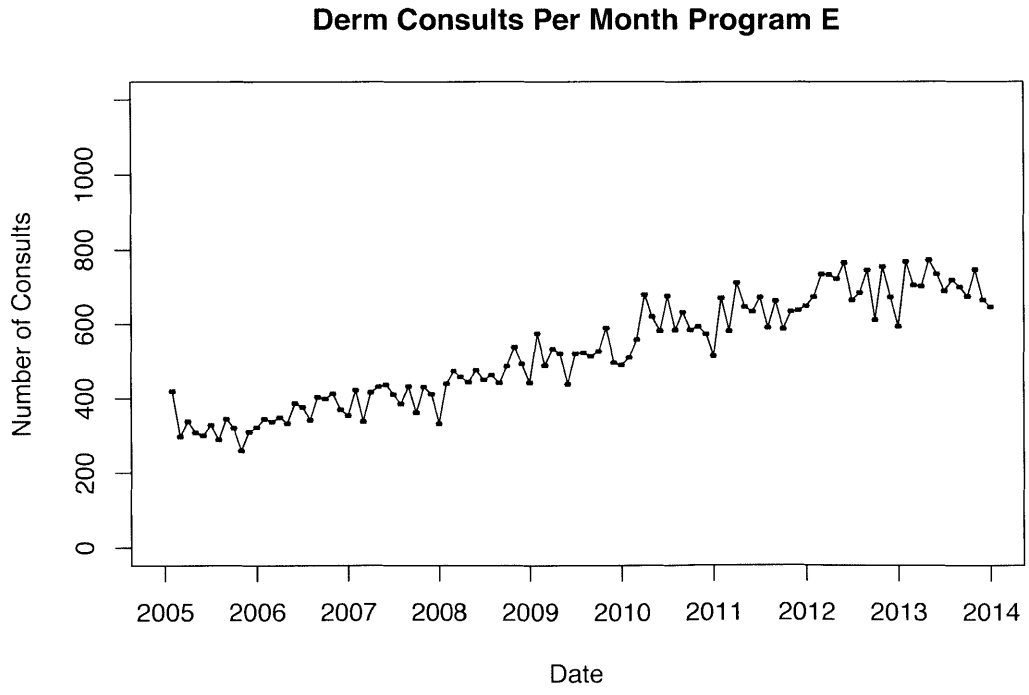


Figure H-5. Monthly consults to dermatology, Program E

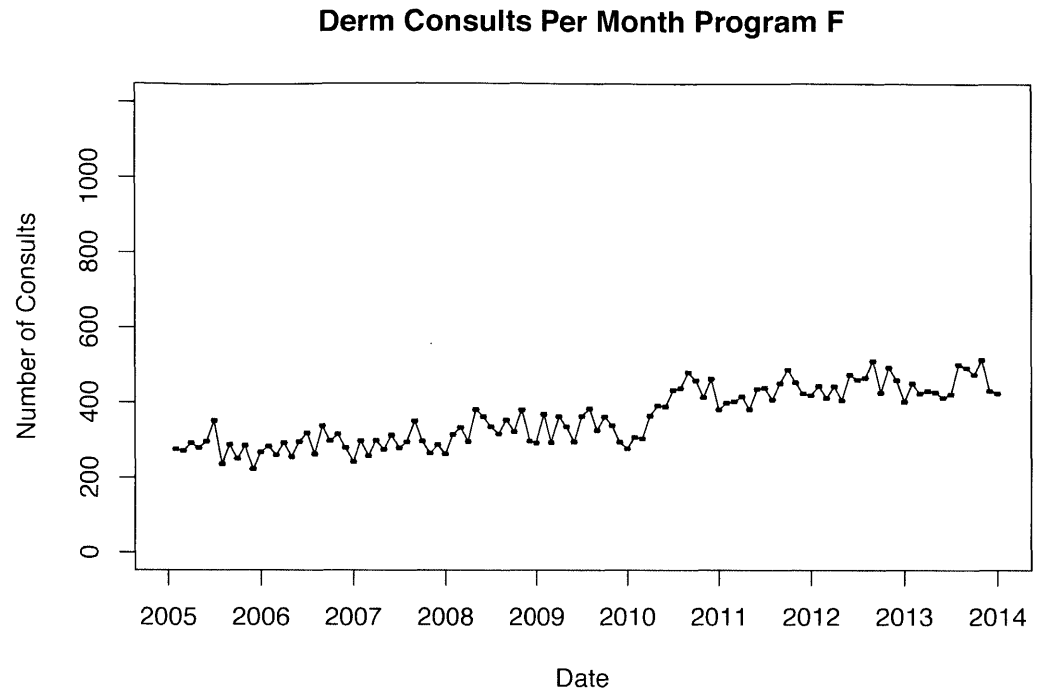


Figure H-6. Monthly consults to dermatology, Program F

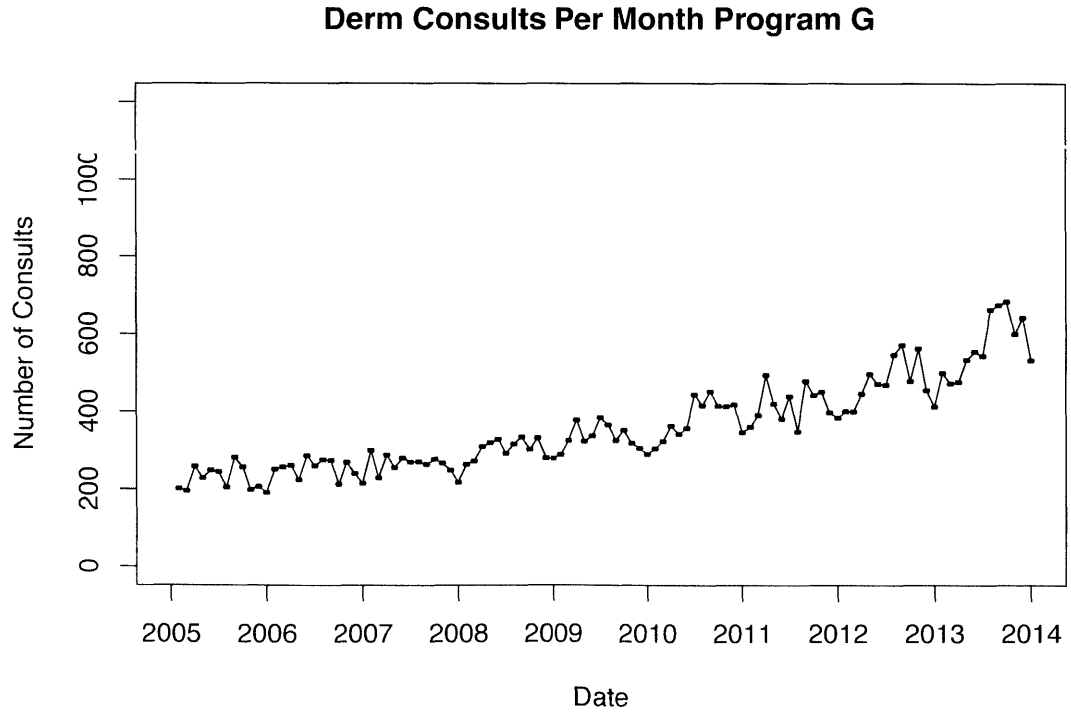


Figure H-7. Monthly consults to dermatology, Program G

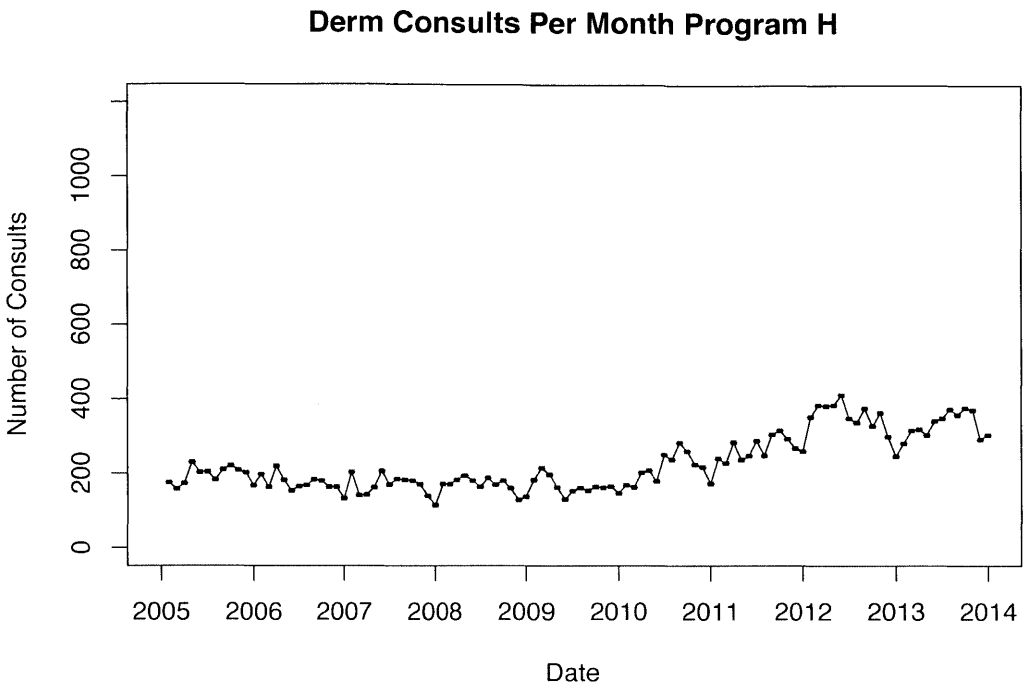


Figure H-8. Monthly consults to dermatology, Program H

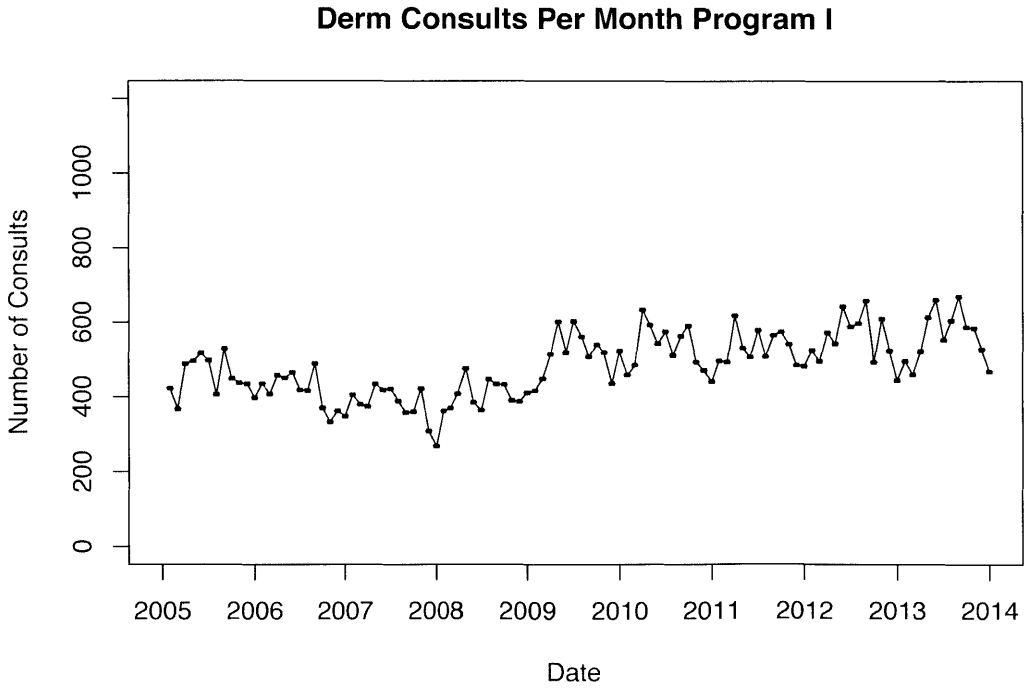


Figure H-9. Monthly consults to dermatology, Program I

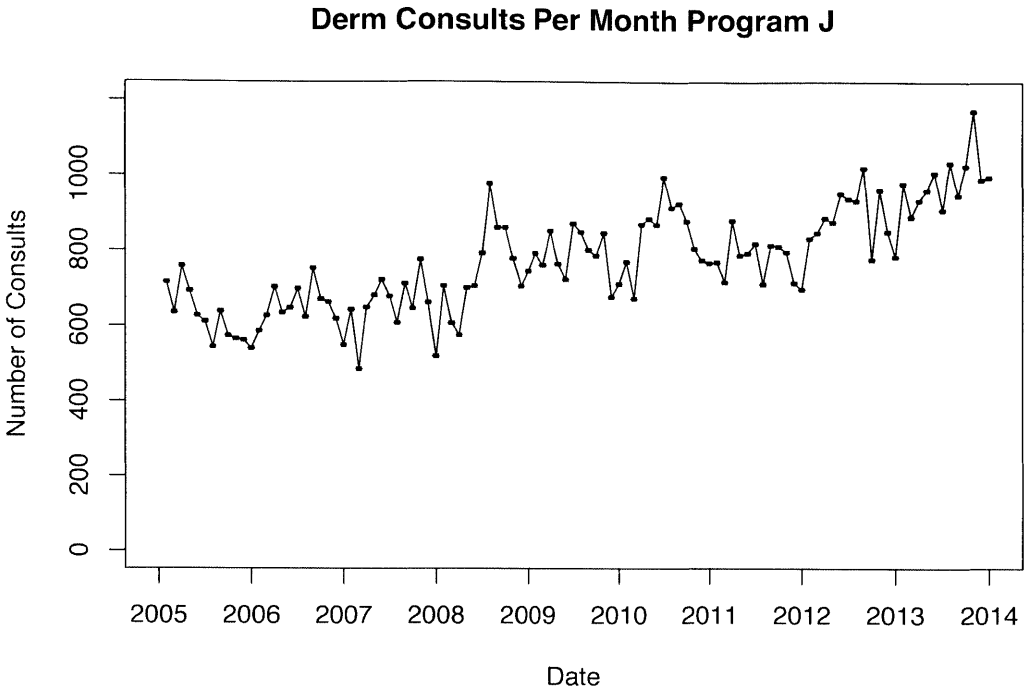


Figure H-10. Monthly consults to dermatology, Program J

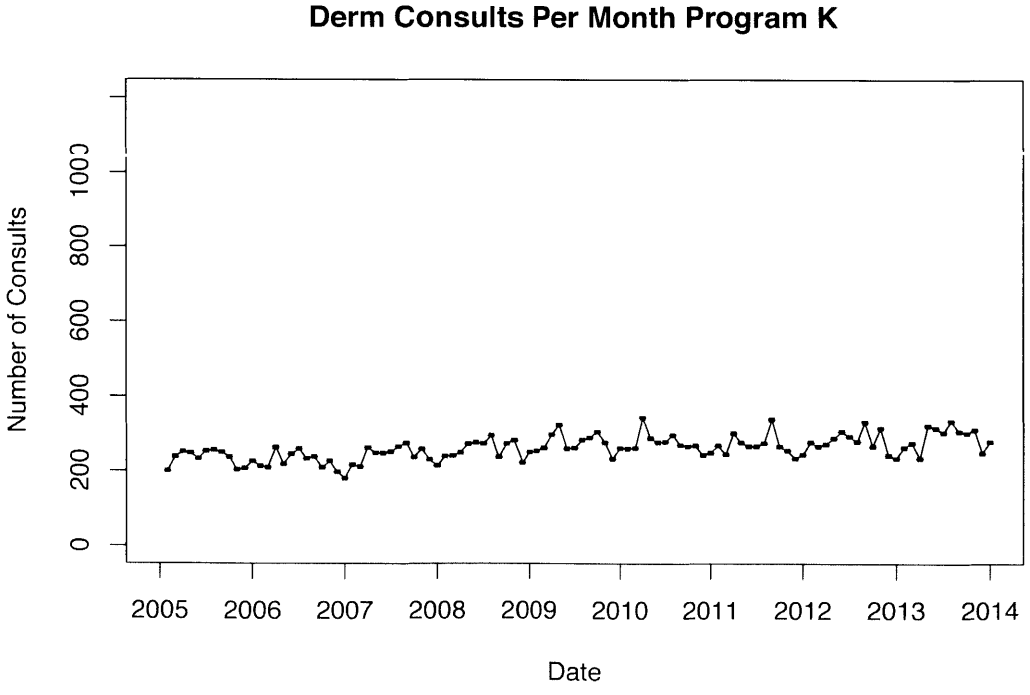


Figure H-11. Monthly consults to dermatology, Program K

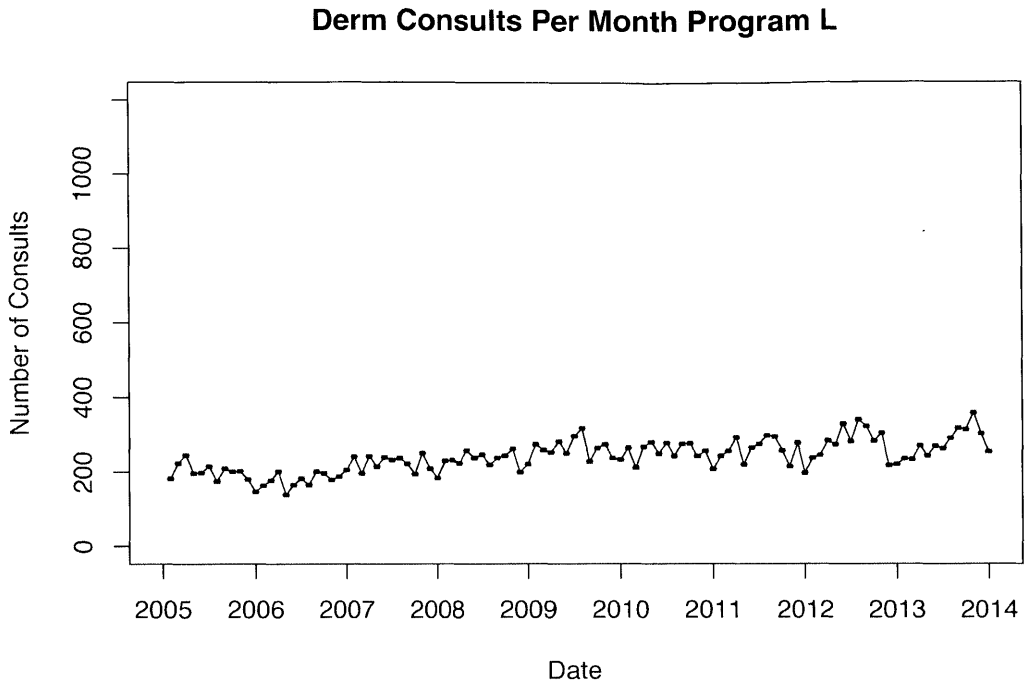


Figure H-12. Monthly consults to dermatology, Program L

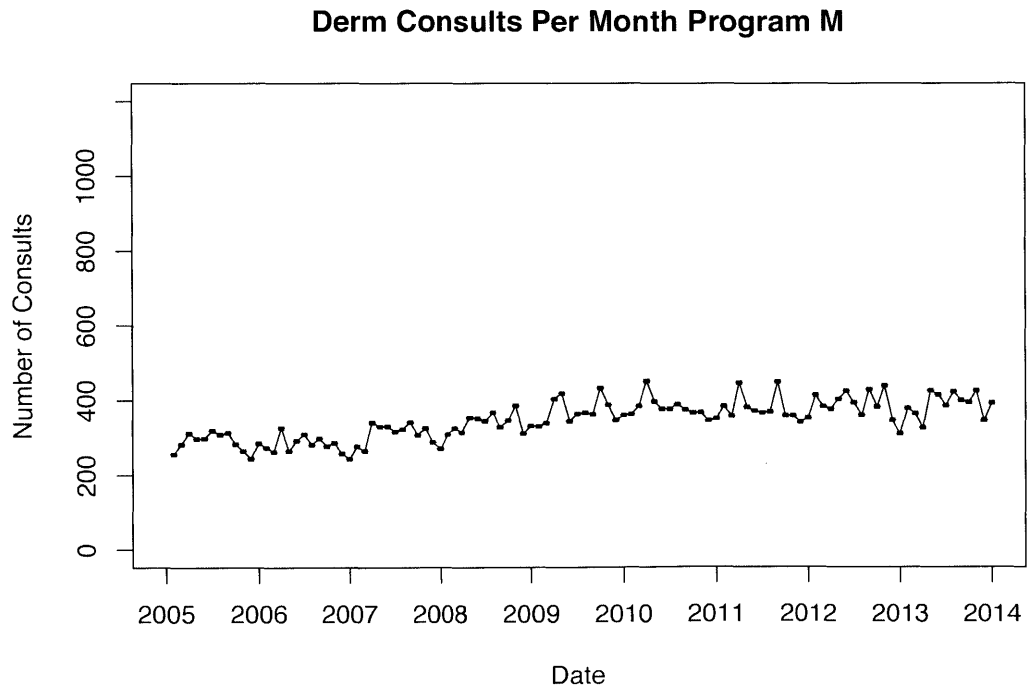


Figure H-13. Monthly consults to dermatology, Program M

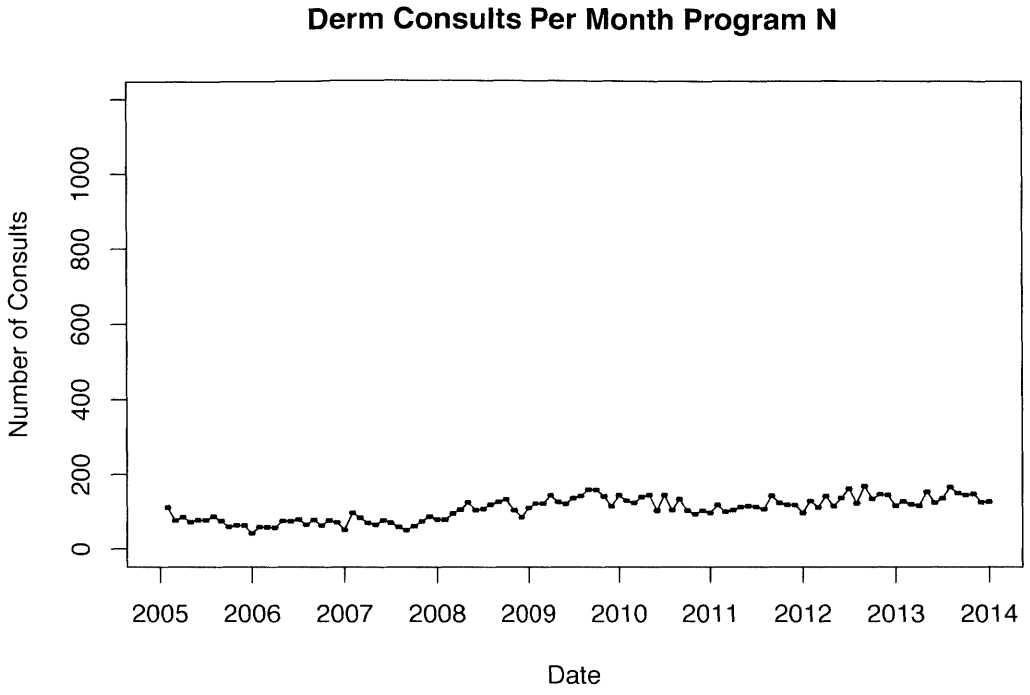


Figure H-14. Monthly consults to dermatology, Program N

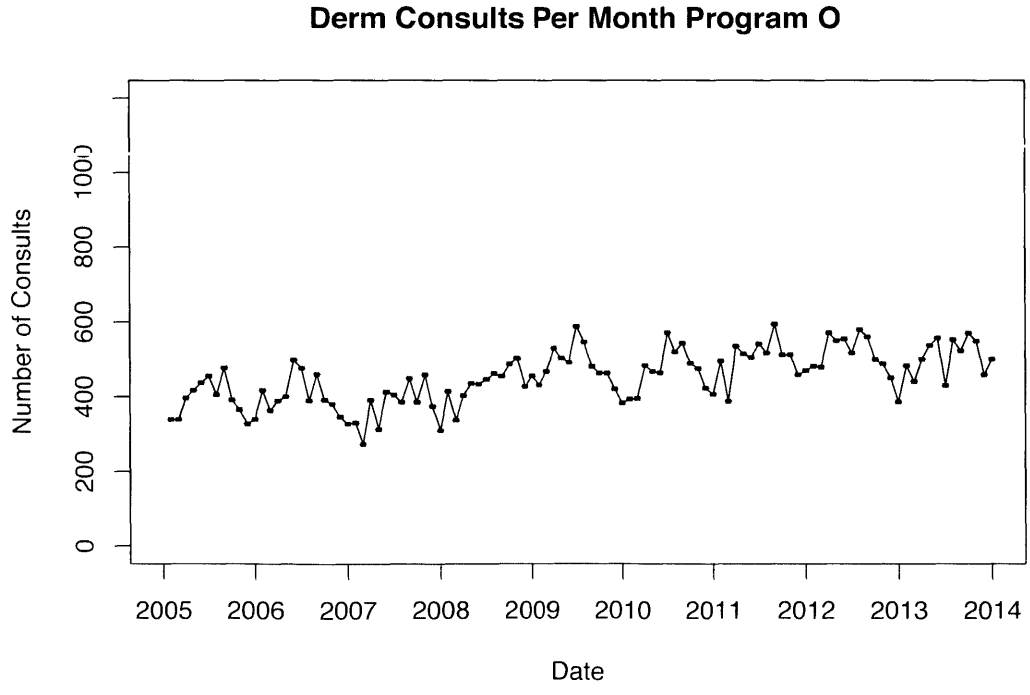


Figure H-15. Monthly consults to dermatology, Program O

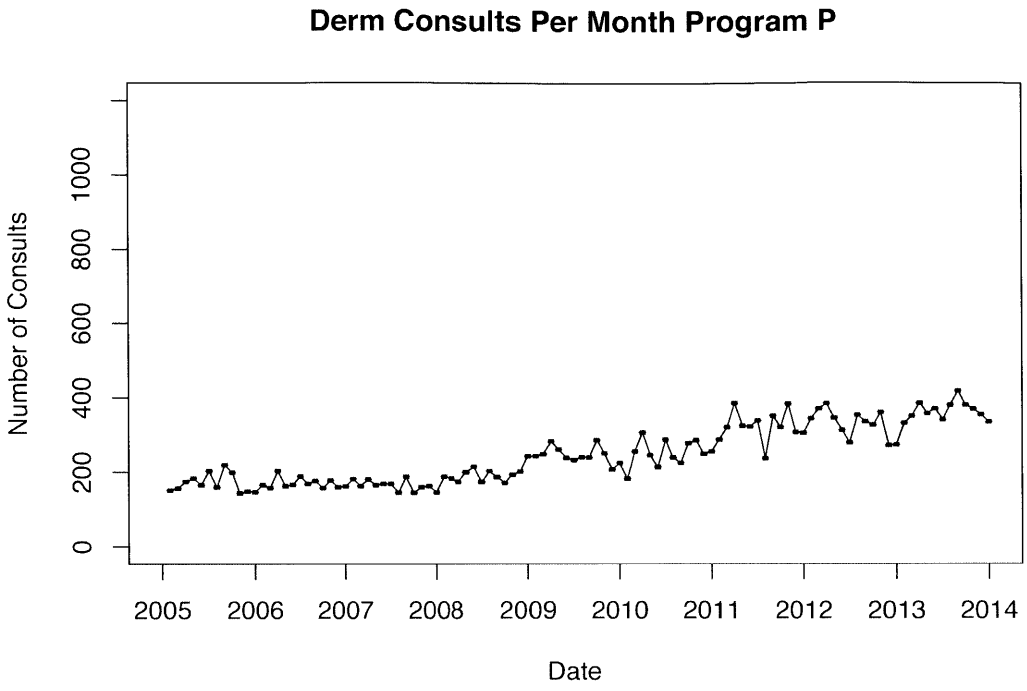


Figure H-16. Monthly consults to dermatology, Program P

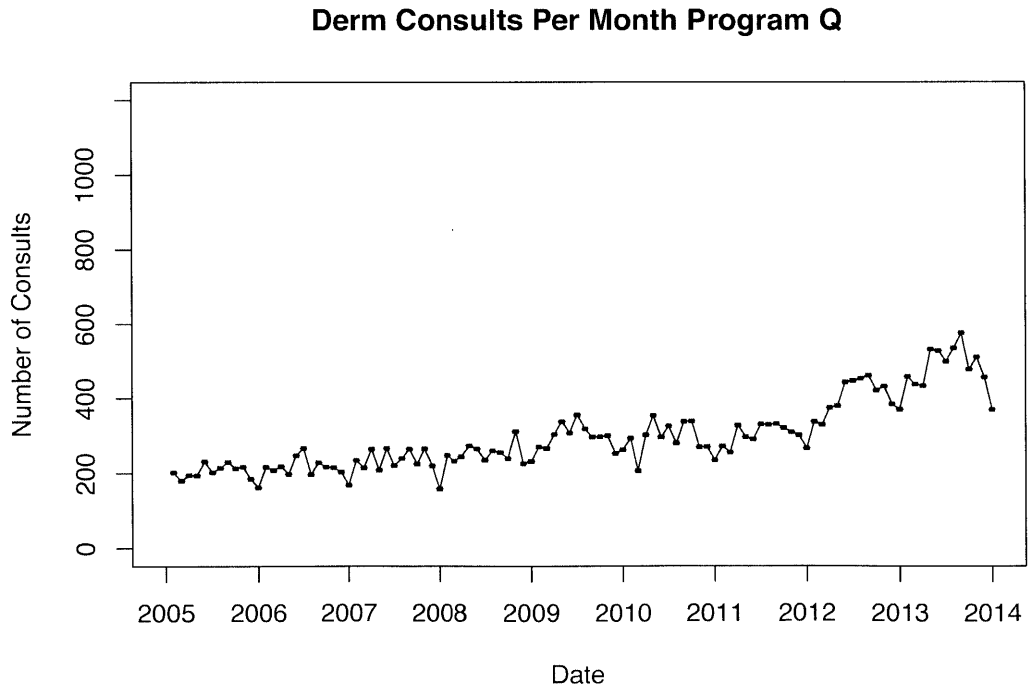


Figure H-17. Monthly consults to dermatology, Program Q

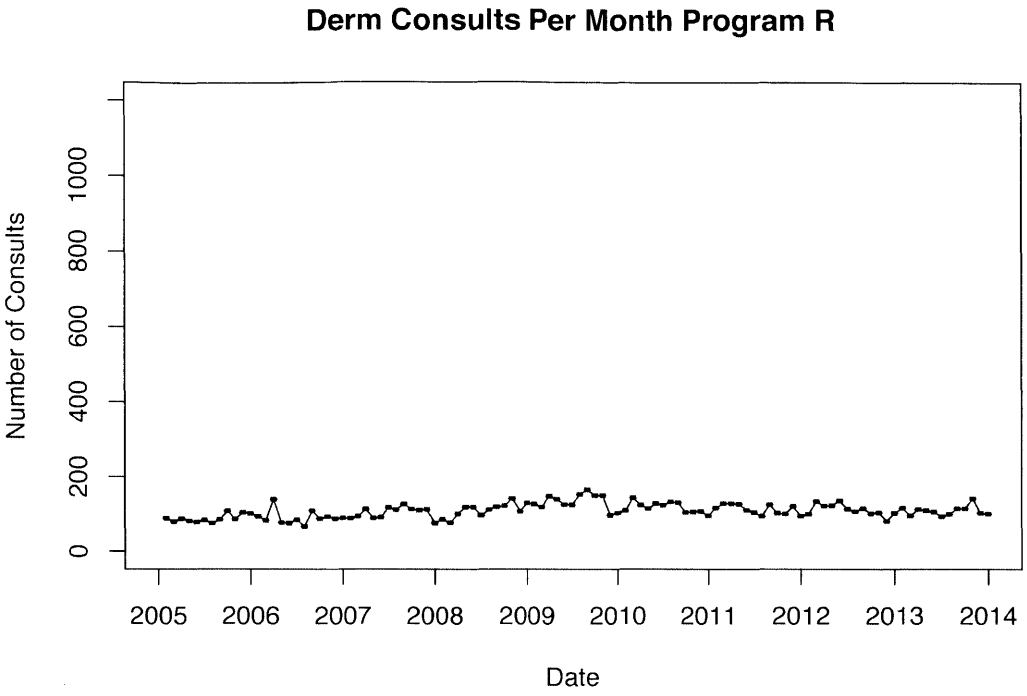


Figure H-18. Monthly consults to dermatology, Program R

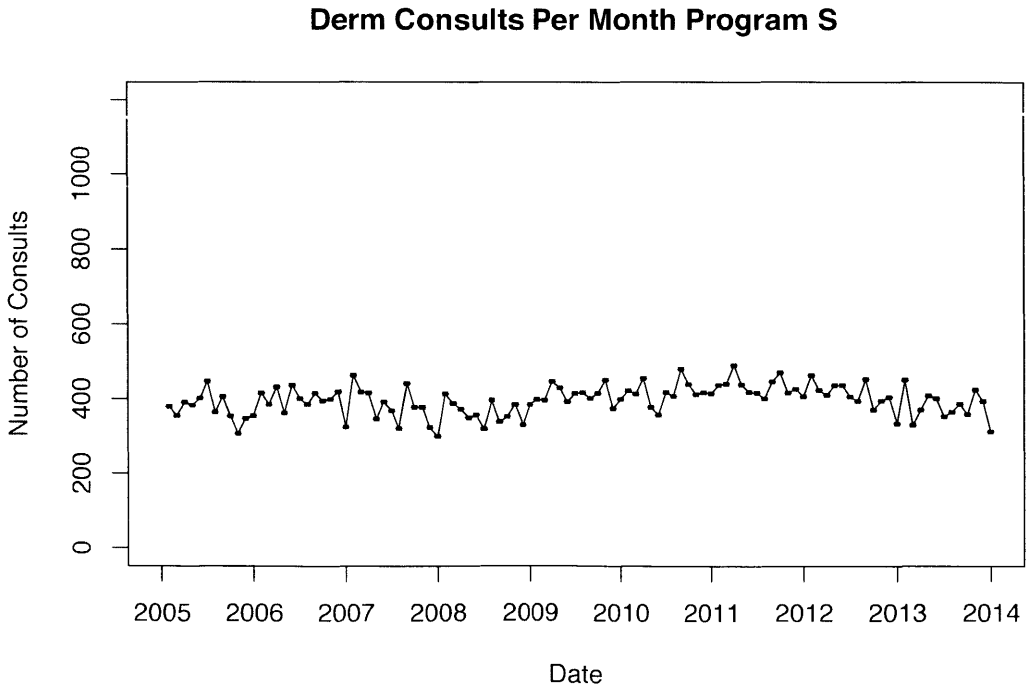


Figure H-19. Monthly consults to dermatology, Program S

Table H-1. Coefficient values for linear regression models

Program	Number of Independent Variables	Coefficient For:	Estimate	*p*-value
A	1	(Intercept)	208.00	<0.01
		PCP	0.29	<0.01
	2	(Intercept)	293.88	<0.01
		PCP	0.09	0.07
		TeleDerm	0.96	<0.01
C	1	(Intercept)	-118.31	0.09
		PCP	2.39	<0.01
	2	(Intercept)	18.67	0.75
		PCP	1.73	<0.01
		TeleDerm	1.19	<0.01
F	1	(Intercept)	87.77	0.05
		PCP	1.06	<0.01
	2	(Intercept)	200.13	<0.01
		PCP	0.49	<0.01
		TeleDerm	2.20	<0.01
G	1	(Intercept)	-125.98	<0.01
		PCP	1.35	<0.01
	2	(Intercept)	59.40	0.04
		PCP	0.70	<0.01
		TeleDerm	1.04	<0.01
H	1	(Intercept)	24.55	0.41
		PCP	0.89	<0.01
	2	(Intercept)	95.75	<0.01
		PCP	0.45	<0.01
		TeleDerm	0.97	<0.01
I	1	(Intercept)	159.60	<0.01
		PCP	0.82	<0.01
	2	(Intercept)	265.97	<0.01
		PCP	0.46	<0.01
		TeleDerm	0.88	<0.01
J	1	(Intercept)	152.12	0.06
		PCP	0.88	<0.01
	2	(Intercept)	364.08	<0.01
		PCP	0.54	<0.01
		TeleDerm	1.05	<0.01
K	1	(Intercept)	123.59	<0.01
		PCP	0.71	<0.01
	2	(Intercept)	149.32	<0.01
		PCP	0.48	<0.01
		TeleDerm	0.40	<0.01

Program	Number of Independent Variables	Coefficient For:	Estimate	*p*-value
M	1	(Intercept	91.02	<0.01
		PCP	0.74	<0.01
	2	(Intercept)	174.87	<0.01
		PCP	0.38	<0.01
		TeleDerm	0.78	<0.01
N	1	(Intercept)	81.69	<0.01
		PCP	0.11	0.22
	2	(Intercept)	90.01	<0.01
		PCP	0.04	0.62
		TeleDerm	1.50	<0.01
O	1	(Intercept)	198.92	<0.01
		PCP	0.38	<0.01
	2	(Intercept)	220.12	<0.01
		PCP	0.33	<0.01
		TeleDerm	0.84	<0.01
Q	1	(Intercept)	-28.37	0.41
		PCP	1.15	<0.01
	2	(Intercept)	66.70	<0.01
		PCP	0.69	<0.01
		TeleDerm	0.72	<0.01
S	1	(Intercept)	366.30	<0.01
		PCP	0.15	0.31
	2	(Intercept)	372.58	<0.01
		PCP	0.08	0.59
		TeleDerm	0.14	0.07

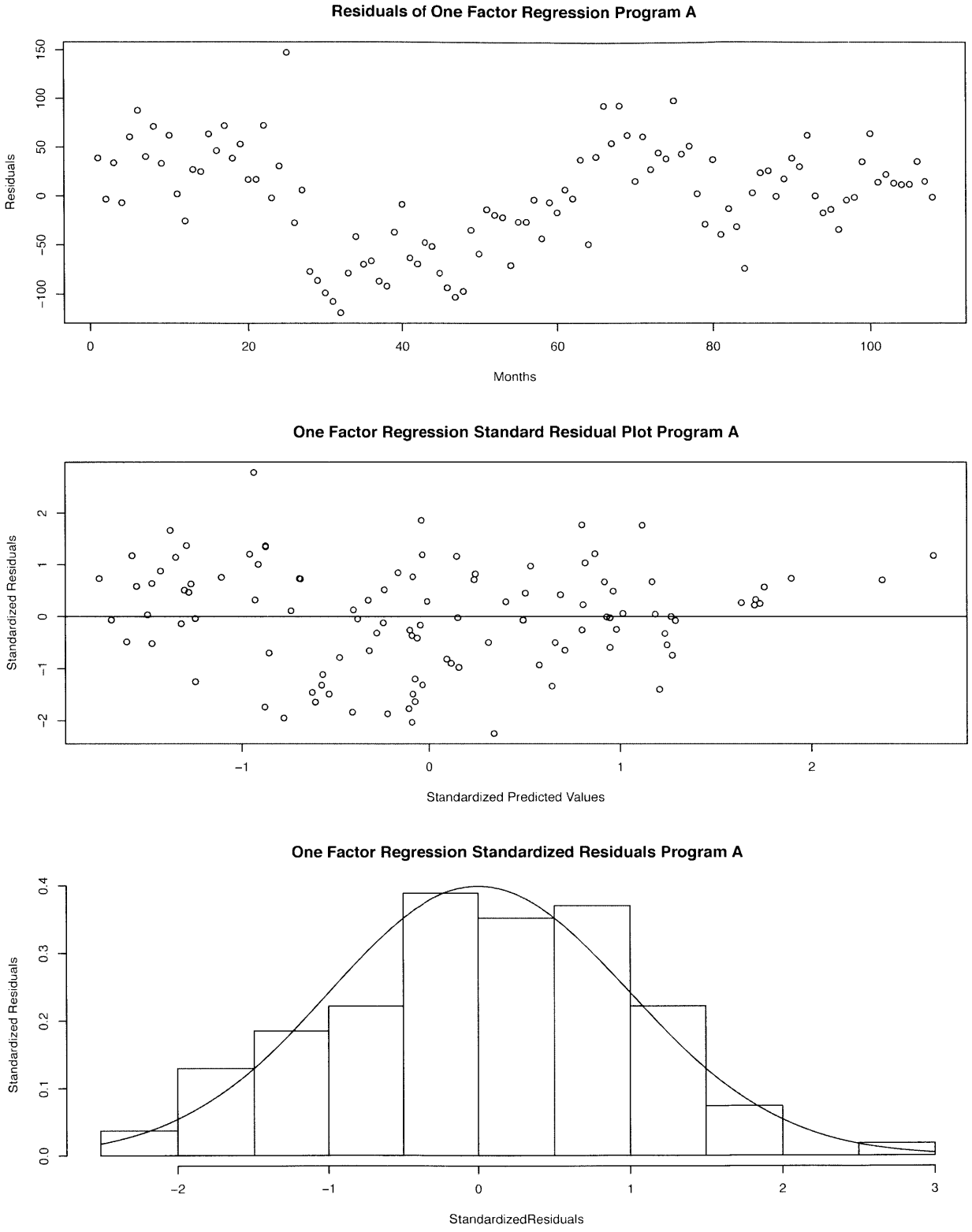
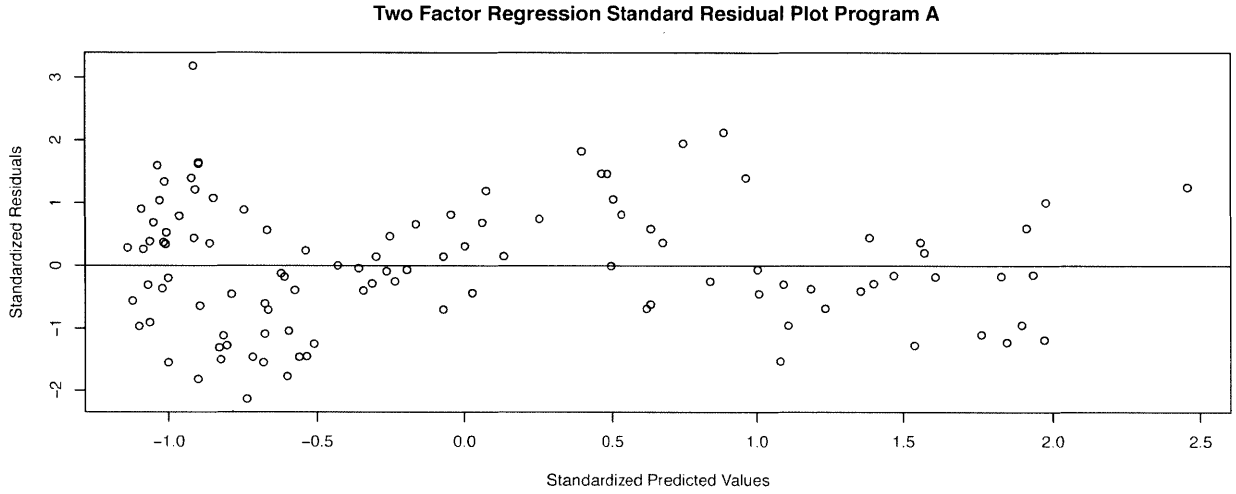


Figure H-20. Graphs of linear regression residuals for Program A with one independent variable



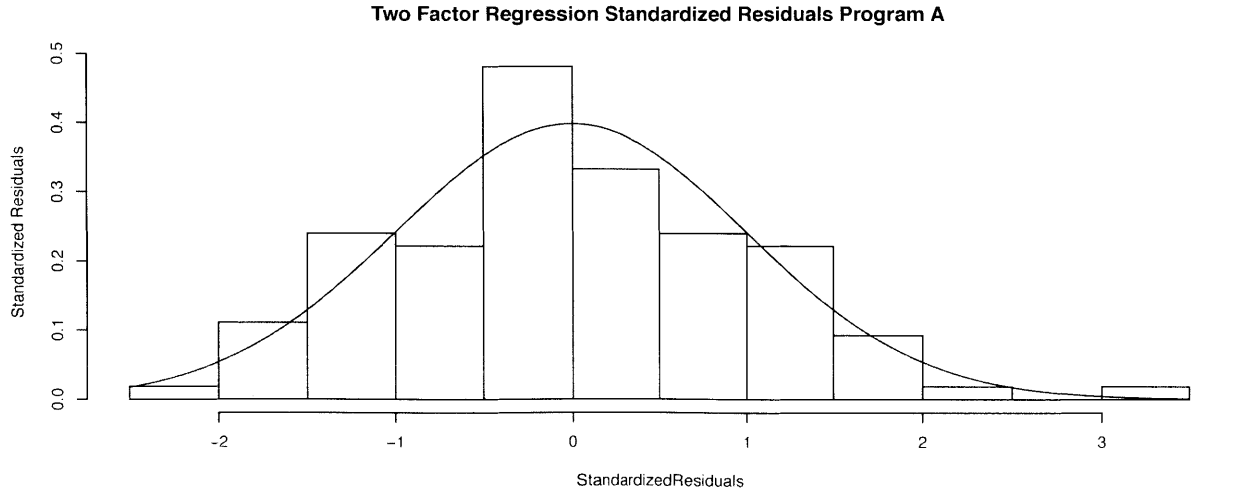


Figure H-21. Graphs of linear regression residuals for Program A with two independent variables

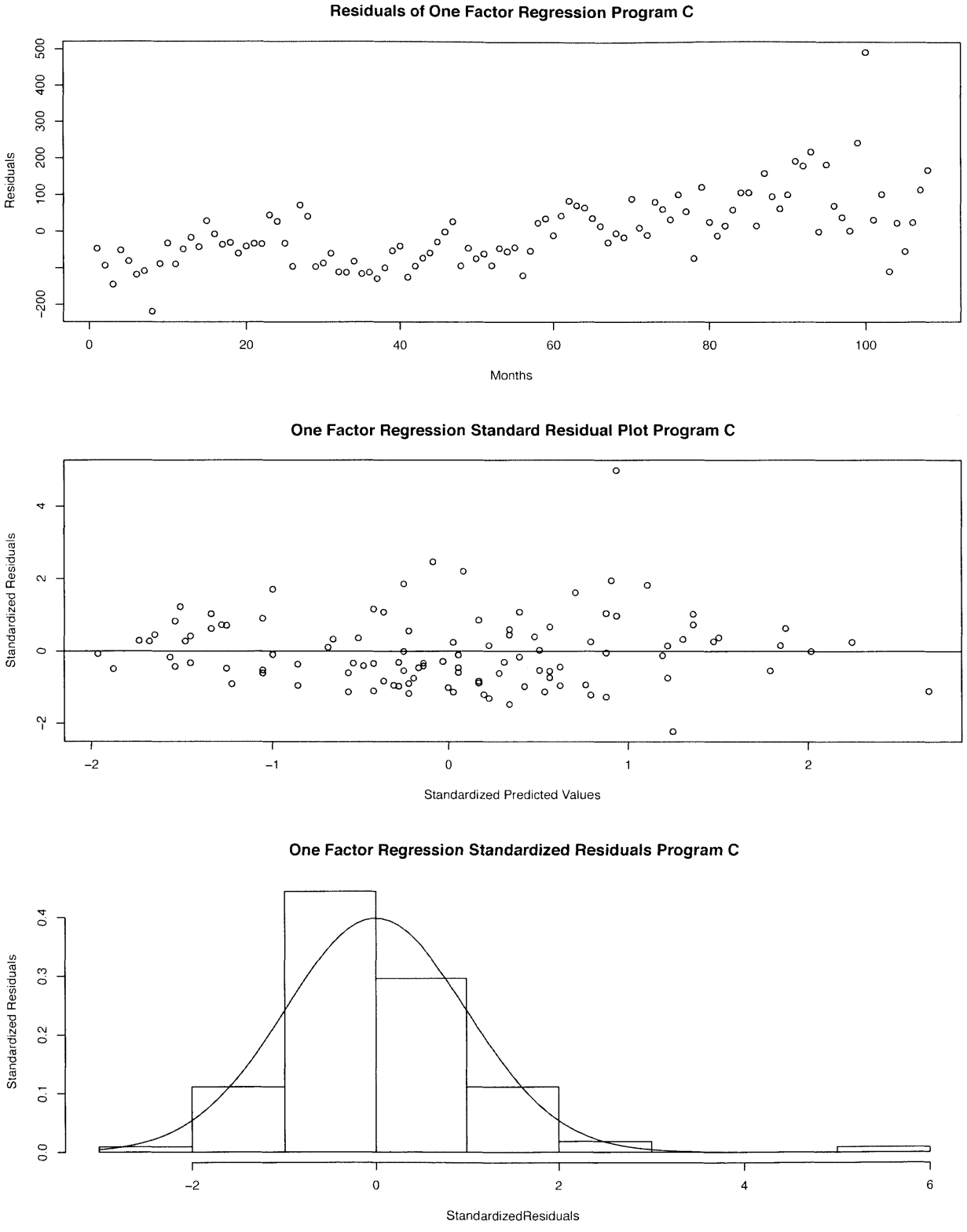
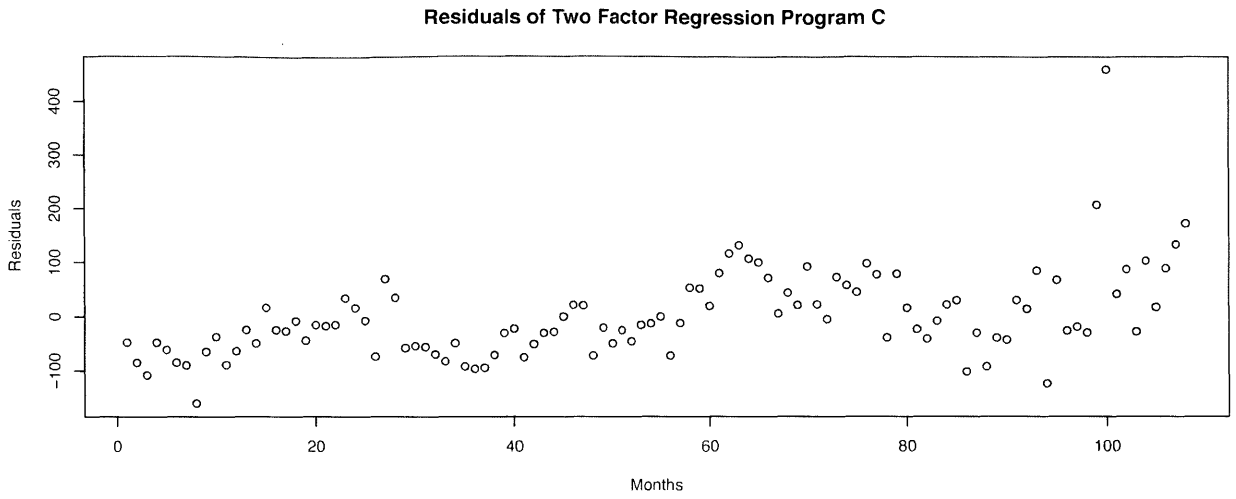
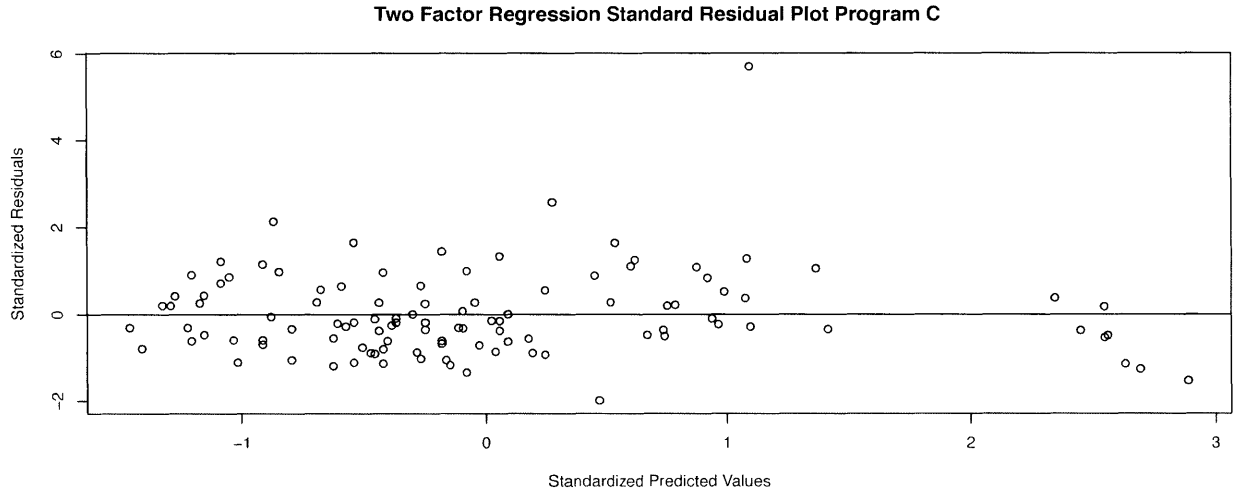


Figure H-22. Graphs of linear regression residuals for Program C with one independent variable





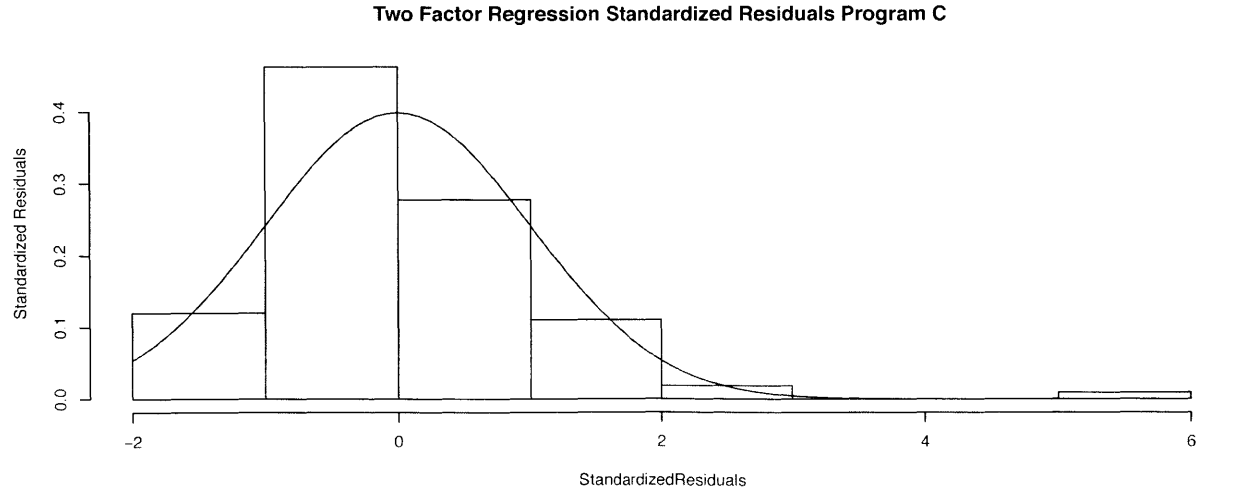


Figure H-23. Graphs of linear regression residuals for Program C with two independent variables

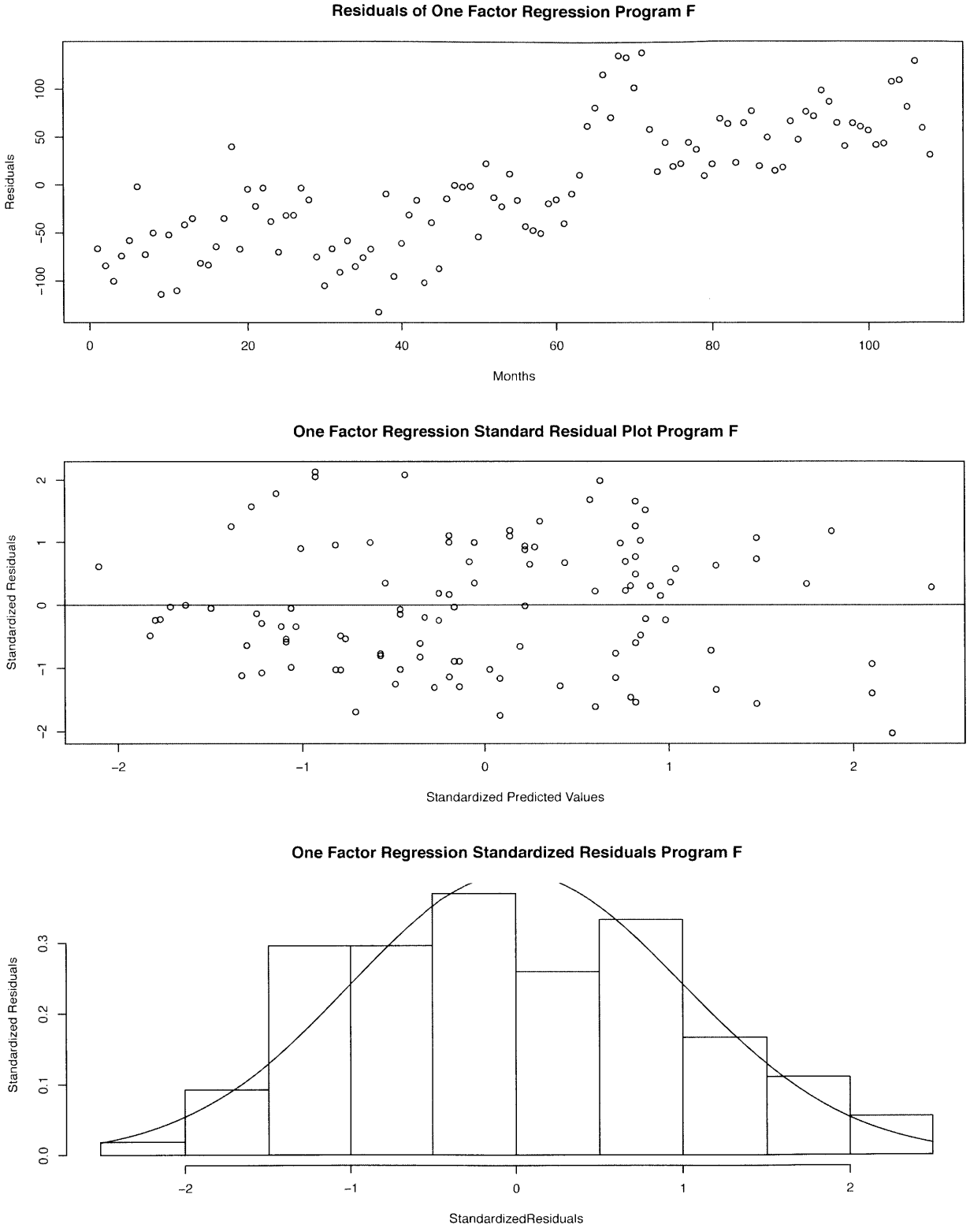


Figure H-24. Graphs of linear regression residuals for Program F with one independent variable

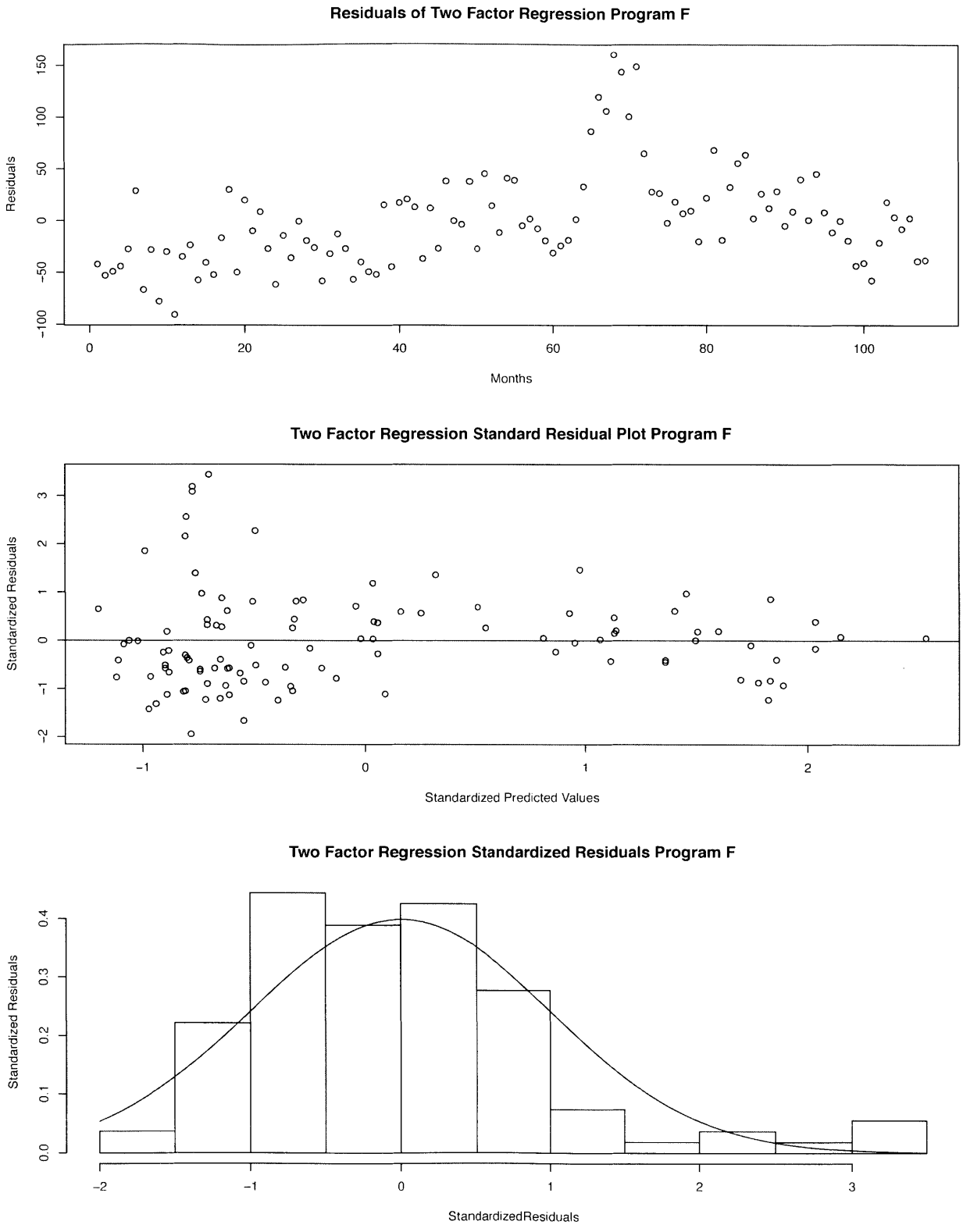


Figure H-25. Graphs of linear regression residuals for Program F with two independent variables

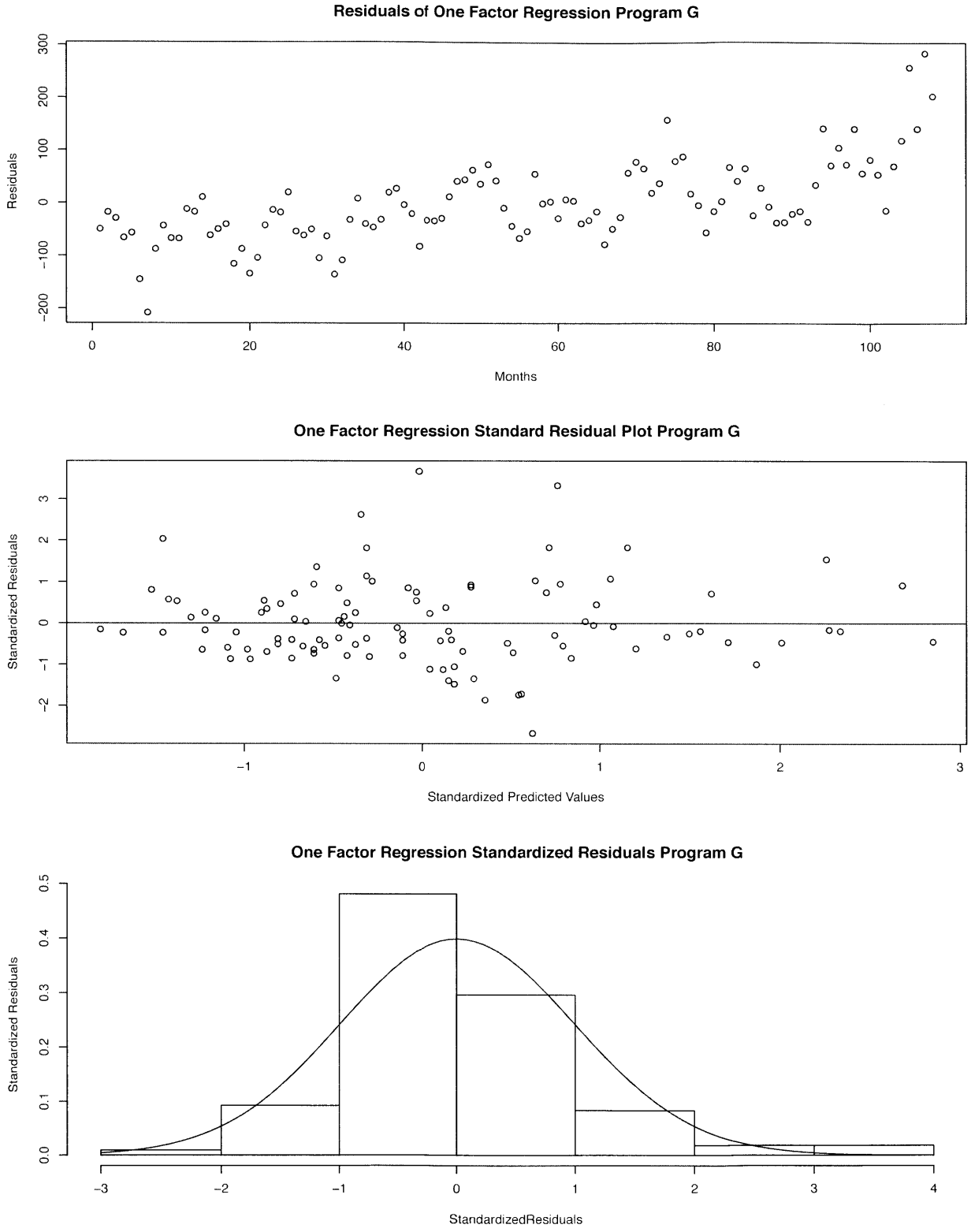
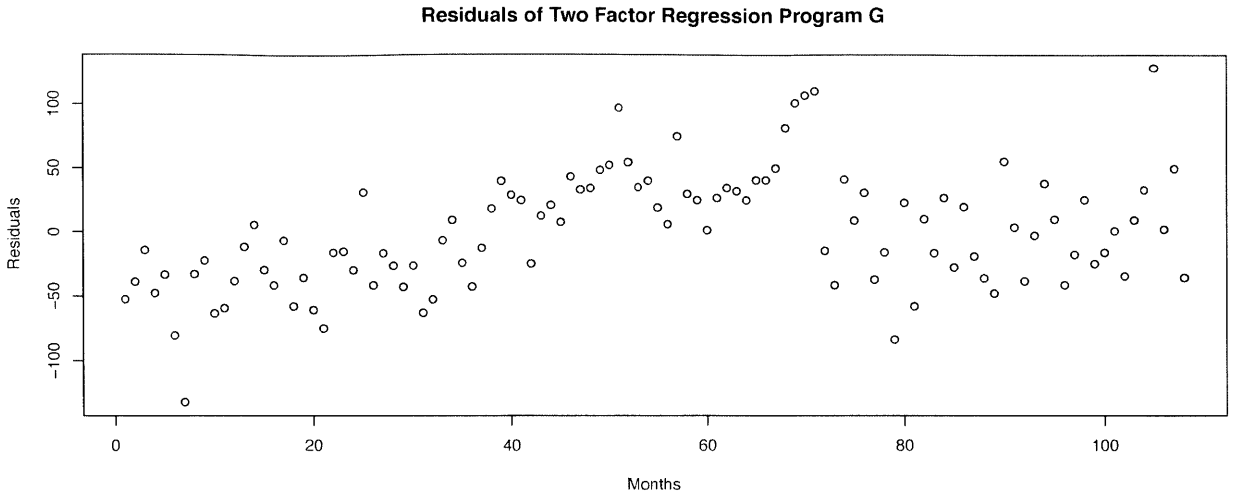
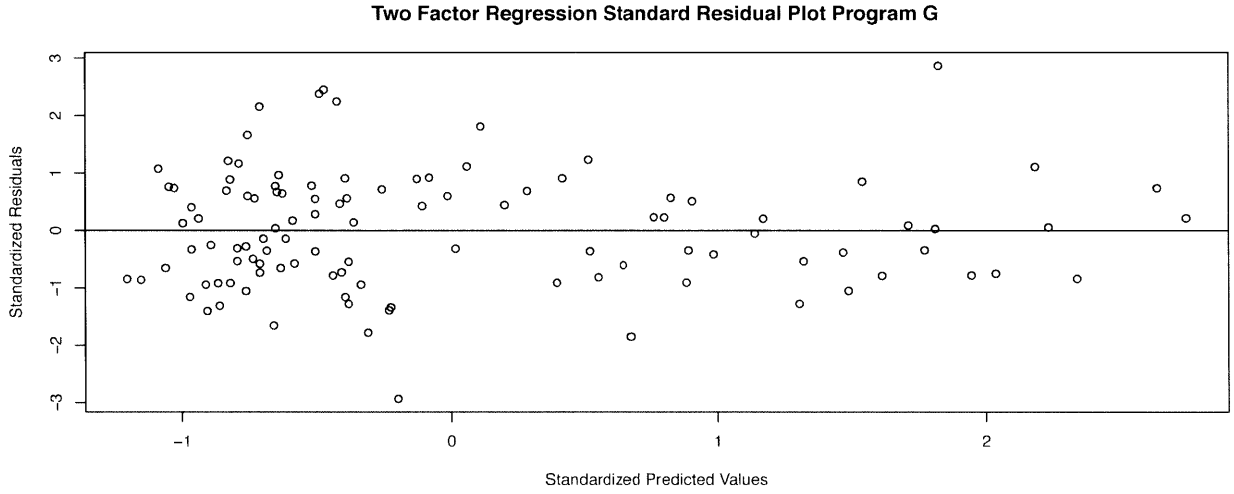


Figure H-26. Graphs of linear regression residuals for Program G with one independent variable





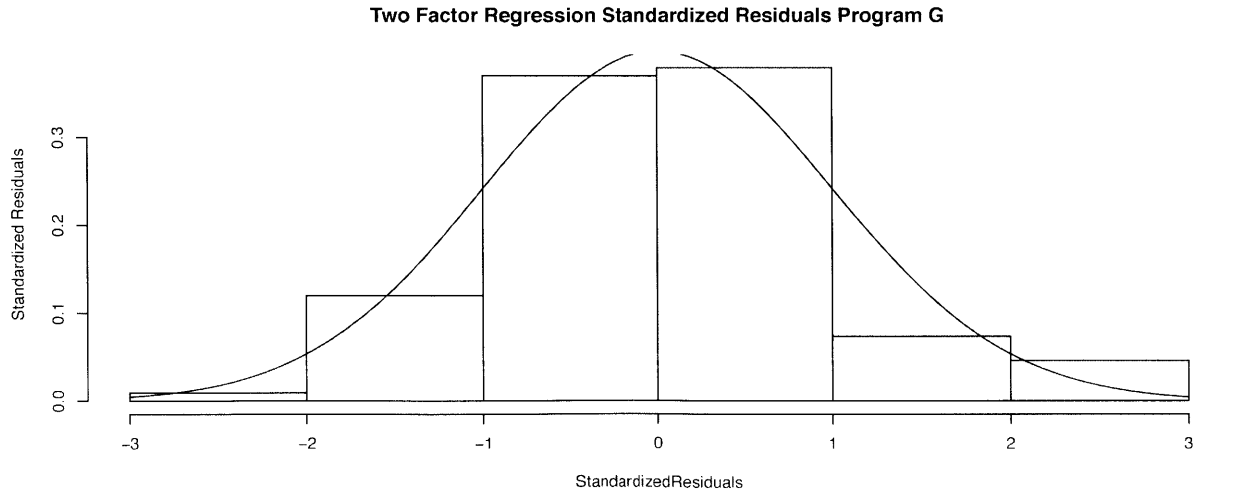


Figure H-27. Graphs of linear regression residuals for Program G with two independent variables

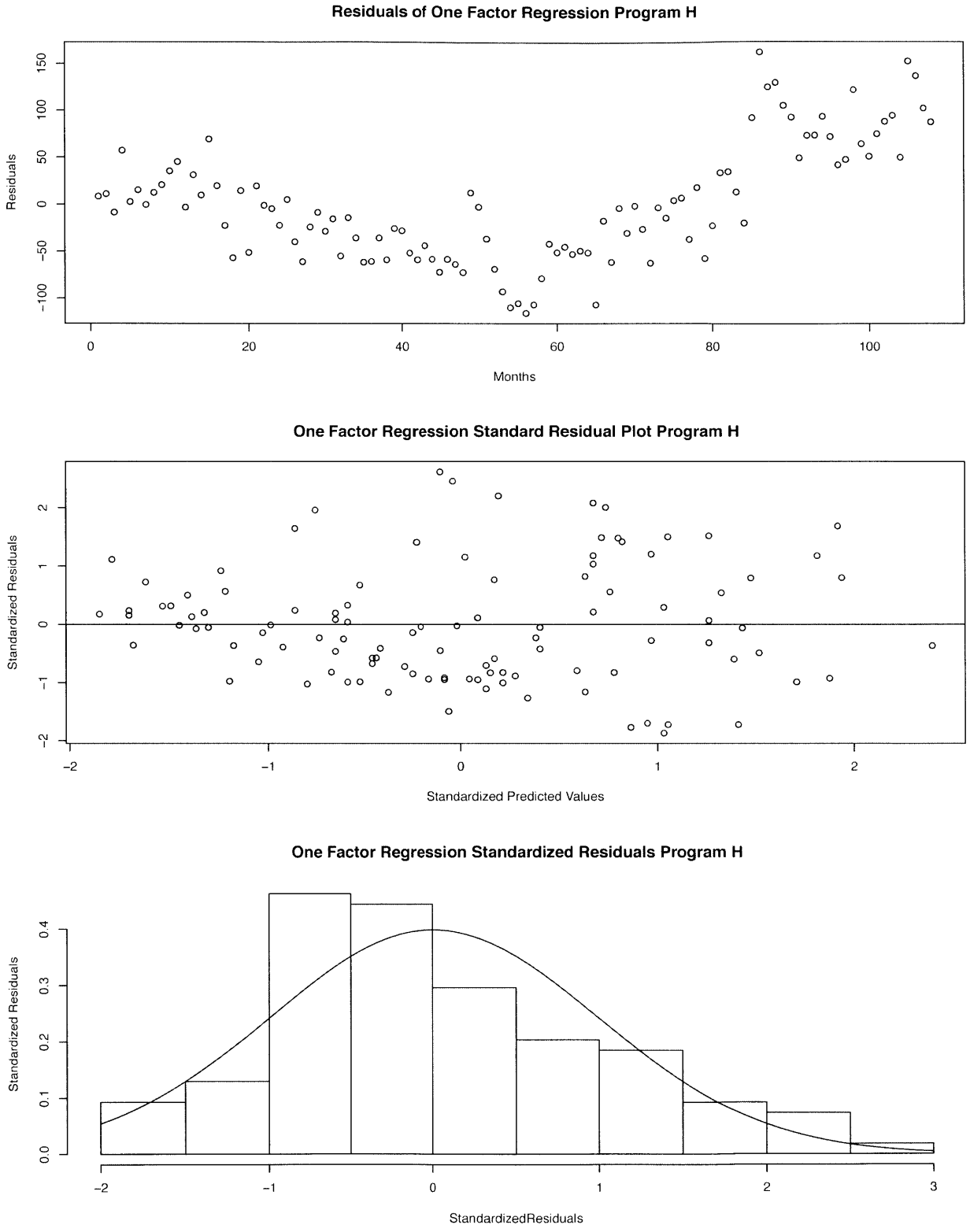


Figure H-28. Graphs of linear regression residuals for Program H with one independent variable

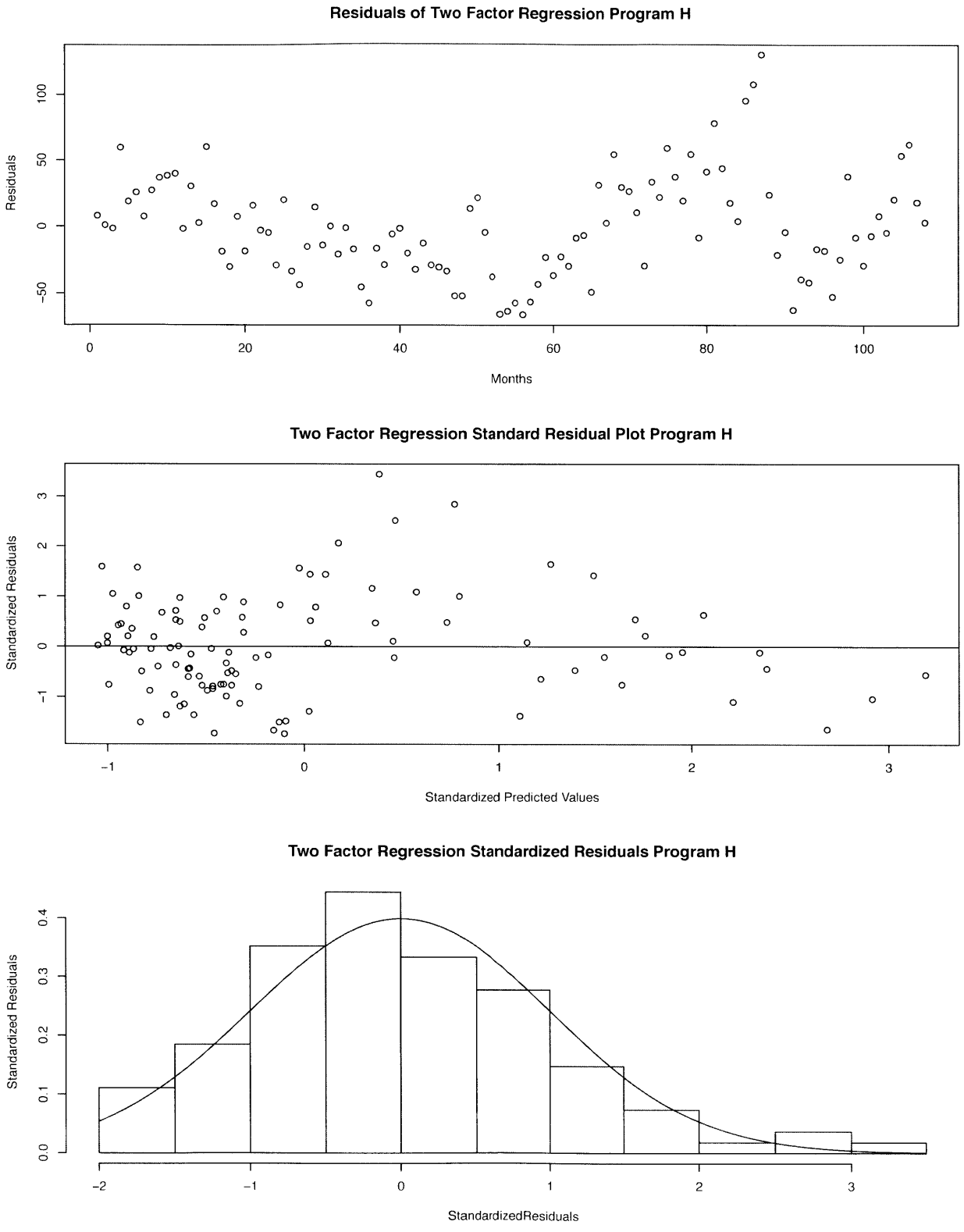


Figure H-29. Graphs of linear regression residuals for Program H with two independent variables

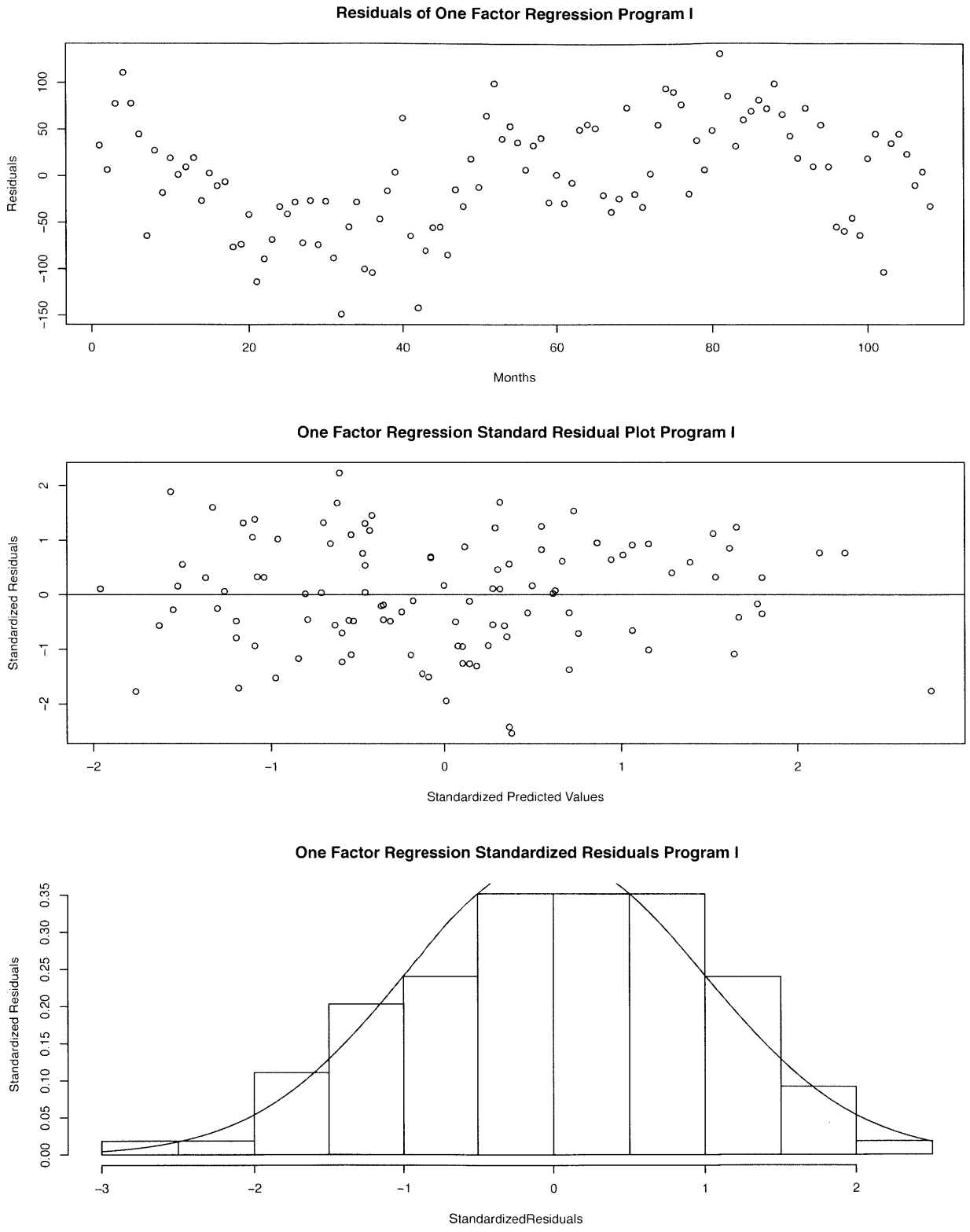


Figure H-30. Graphs of linear regression residuals for Program I with one independent variable

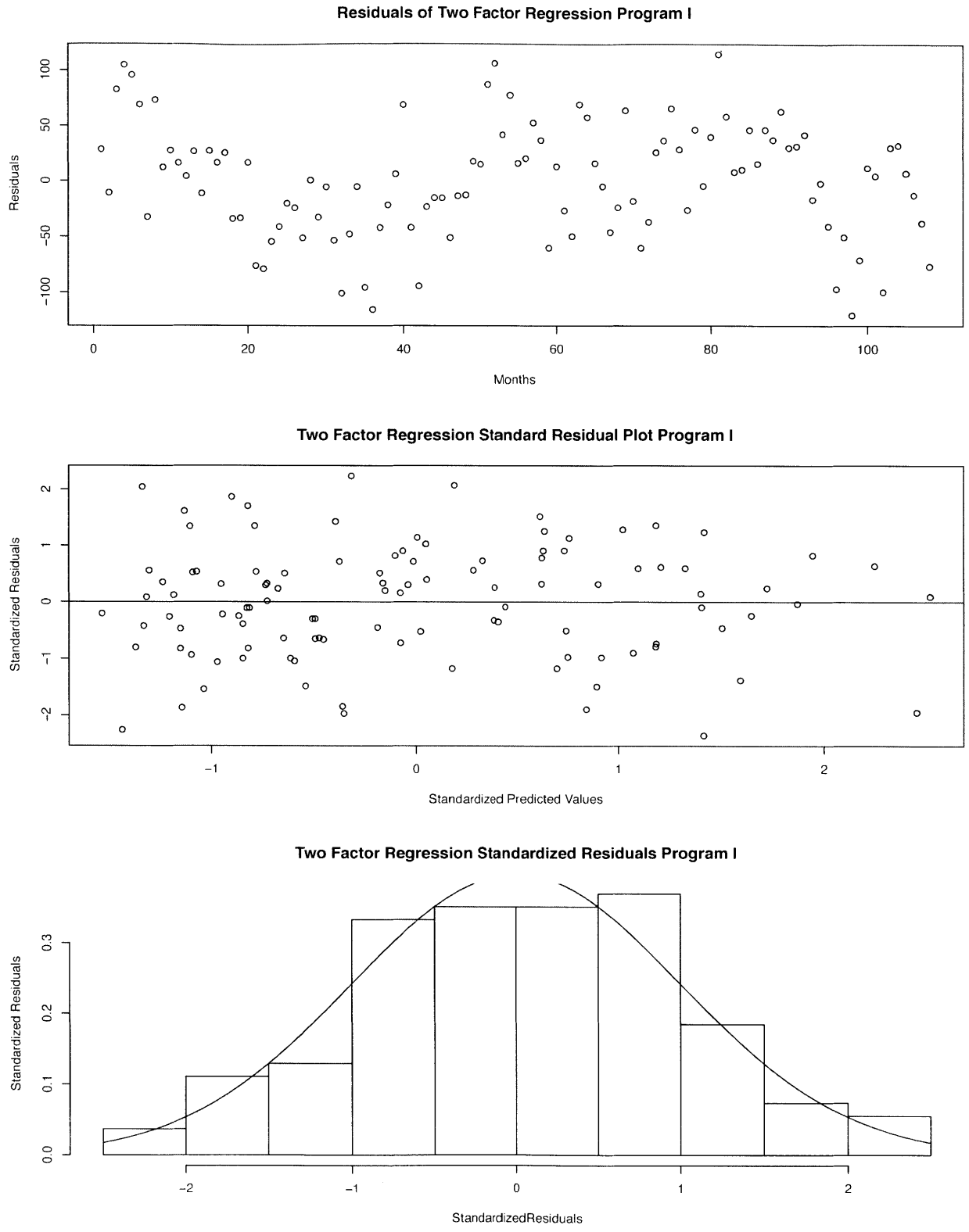


Figure H-31. Graphs of linear regression residuals for Program I with two independent variables

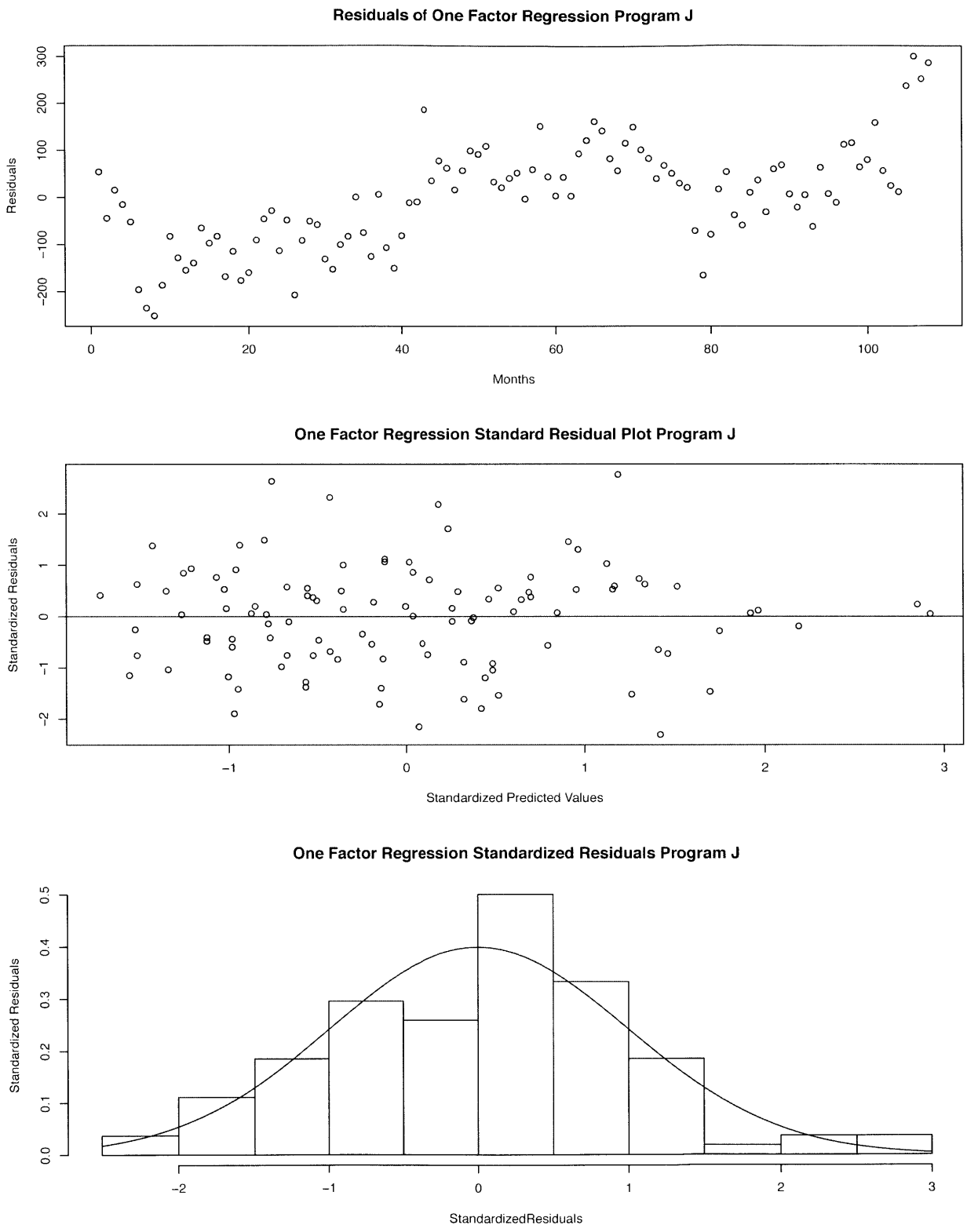


Figure H-32. Graphs of linear regression residuals for Program J with one independent variable

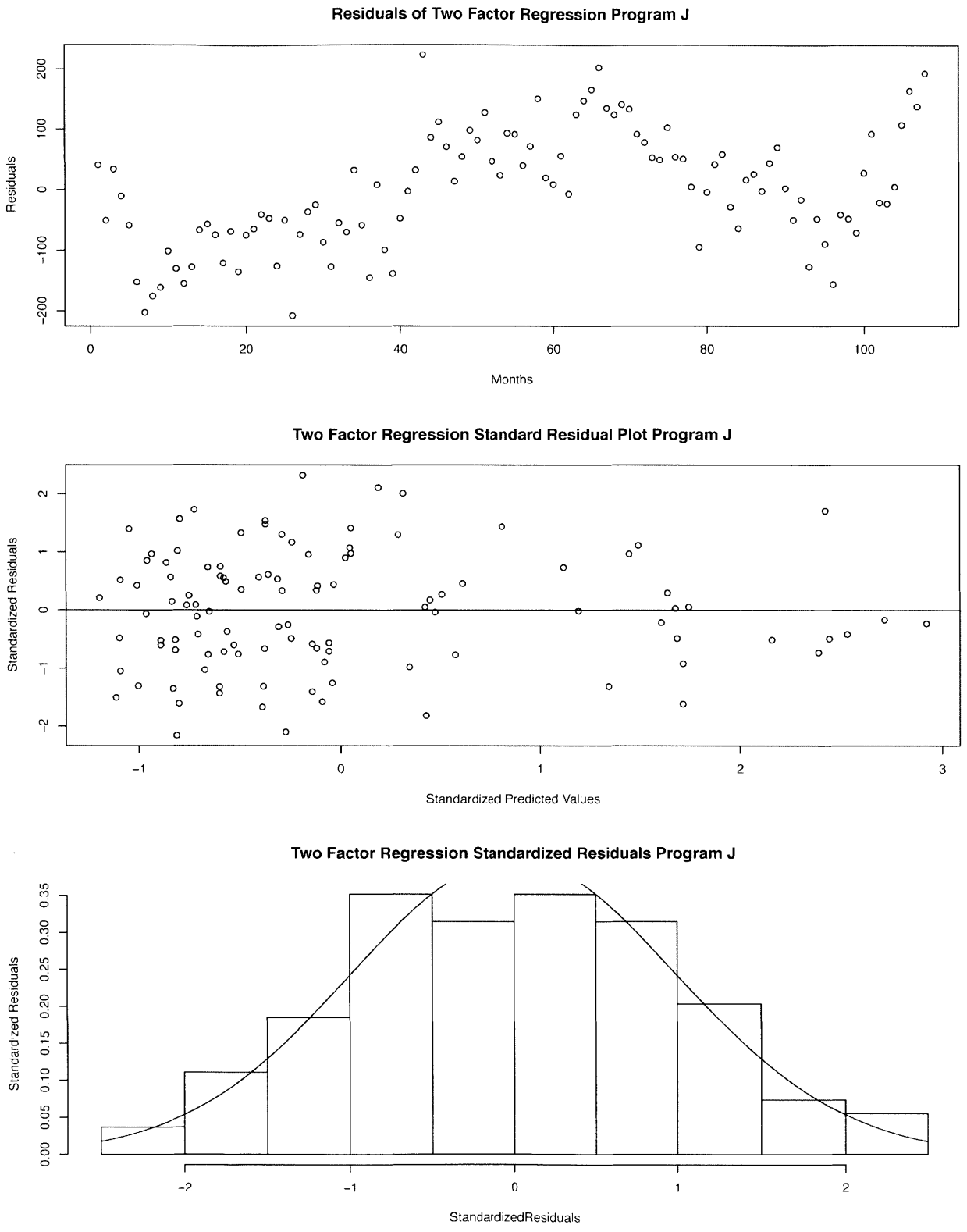


Figure H-33. Graphs of linear regression residuals for Program J with two independent variables

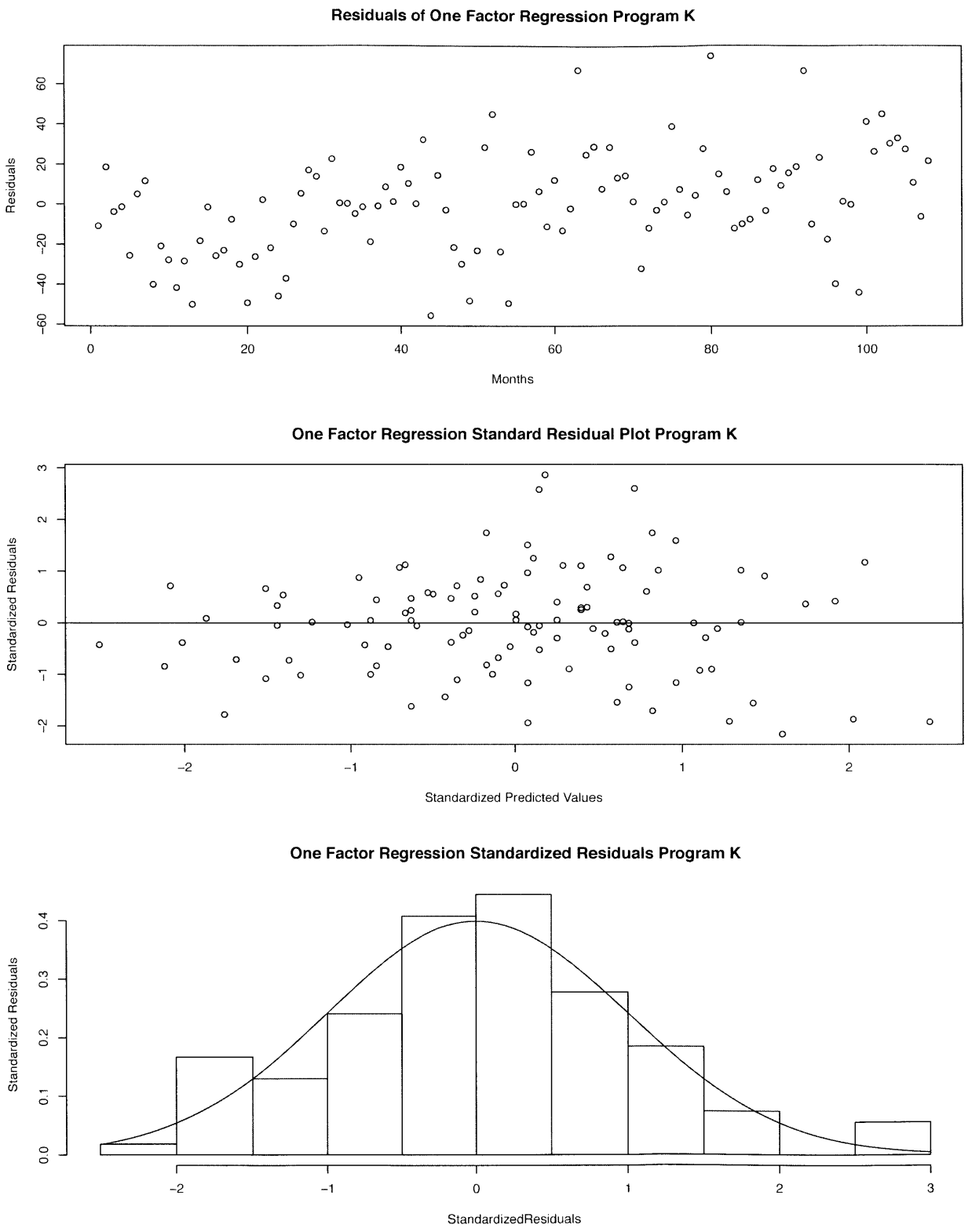
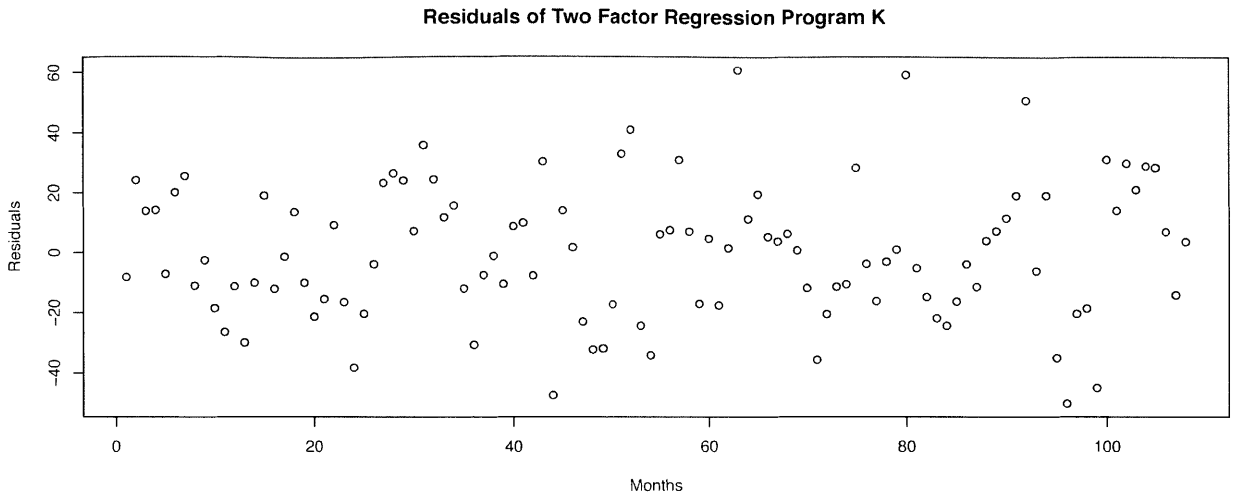
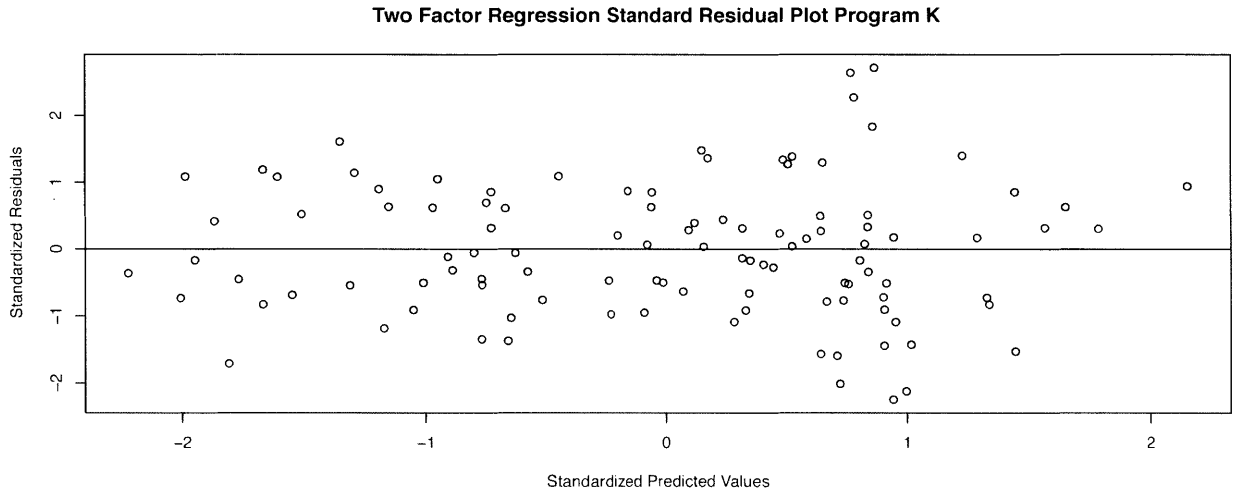


Figure H-34. Graphs of linear regression residuals for Program K with one independent variable





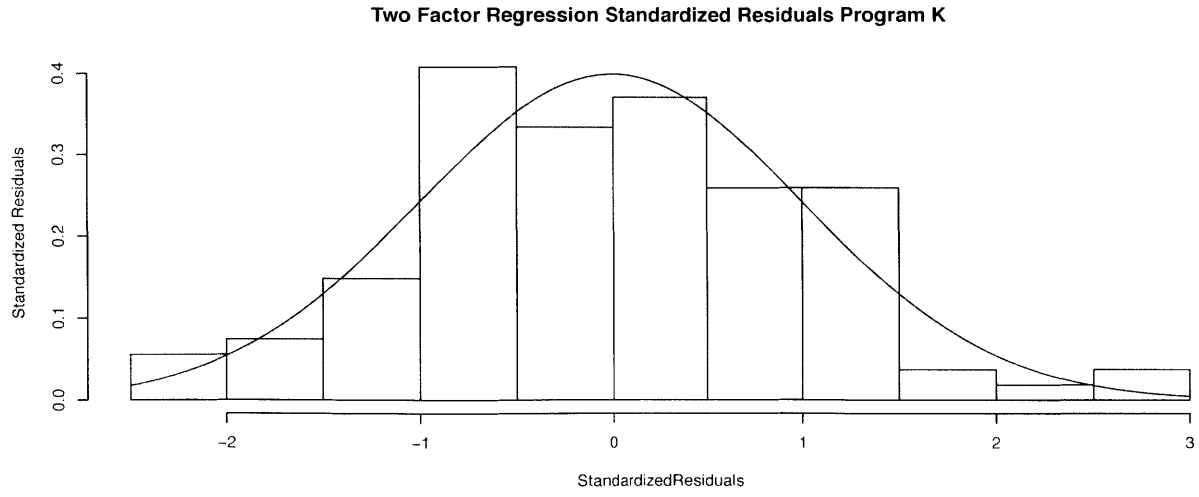


Figure H-35. Graphs of linear regression residuals for Program K with two independent variables

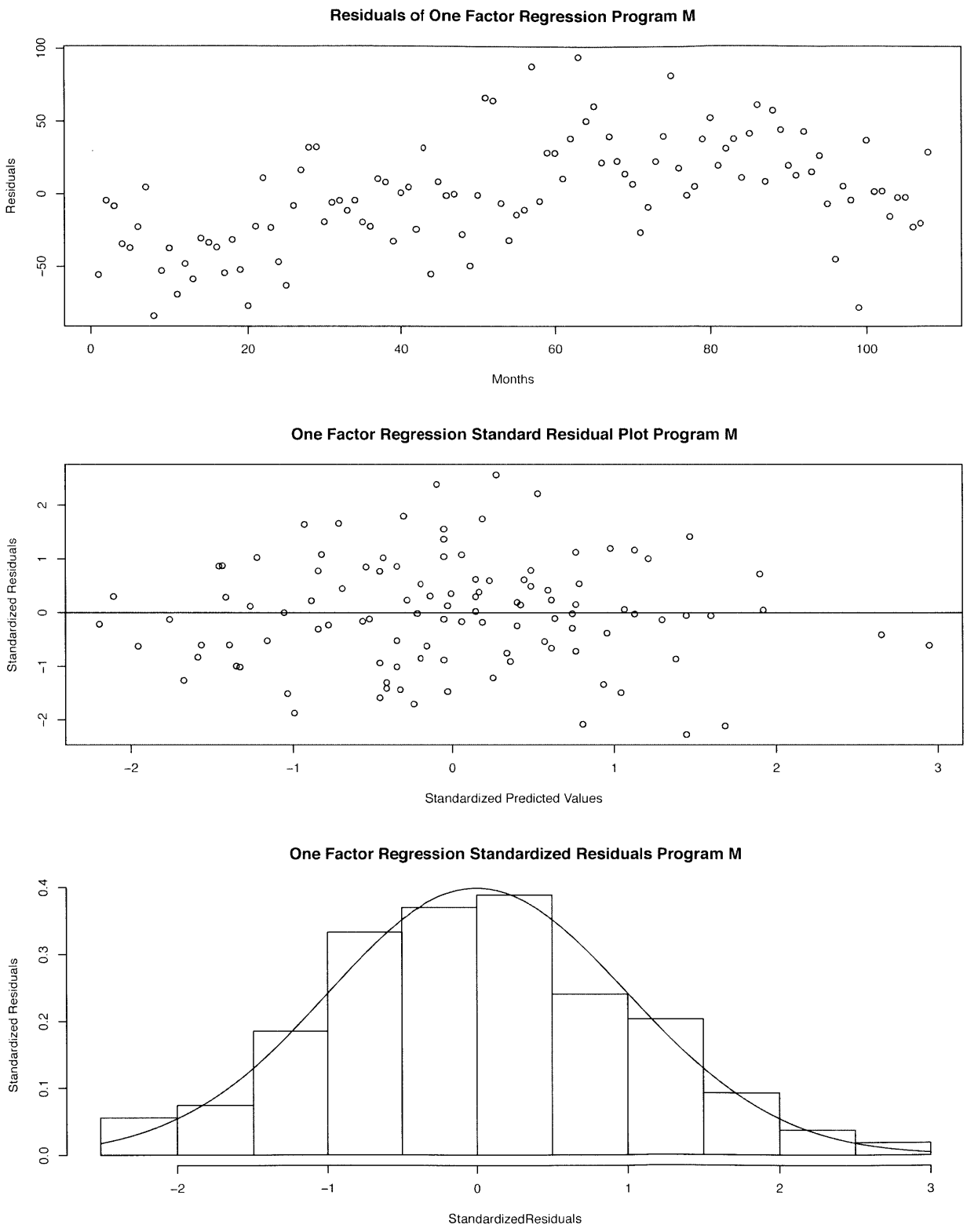
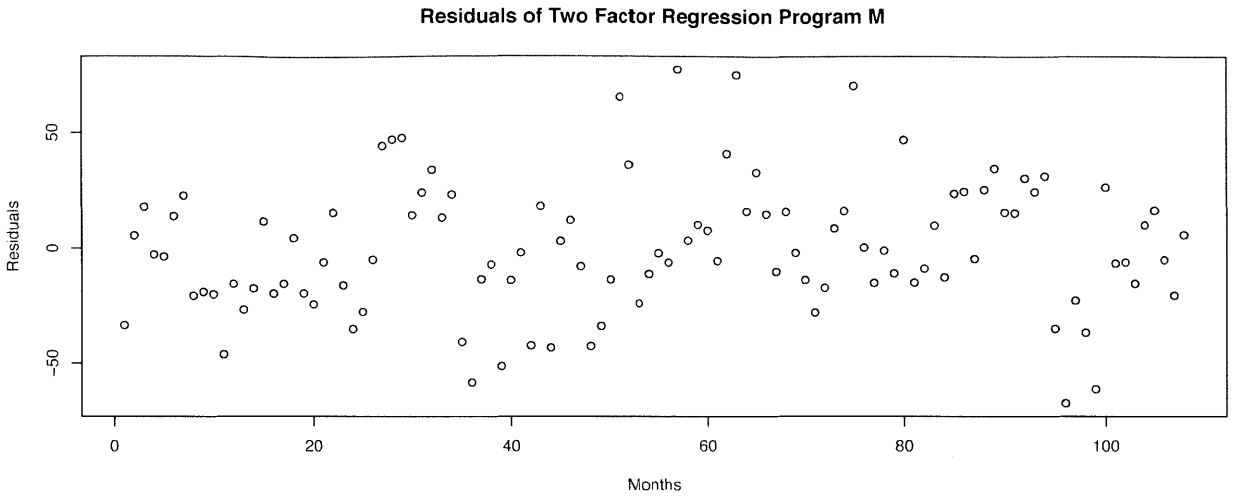
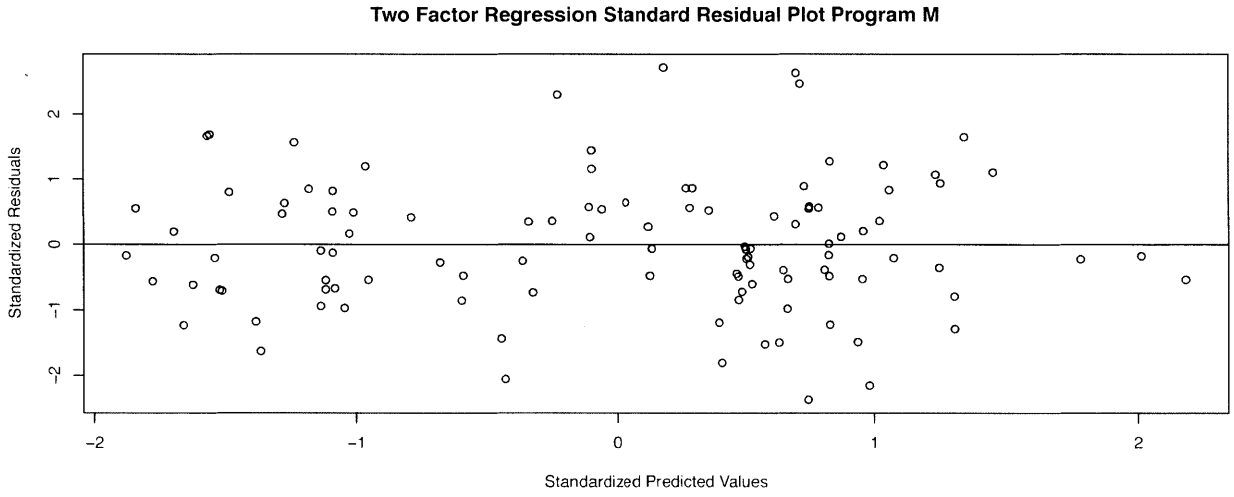


Figure H-36. Graphs of linear regression residuals for Program M with one independent variable





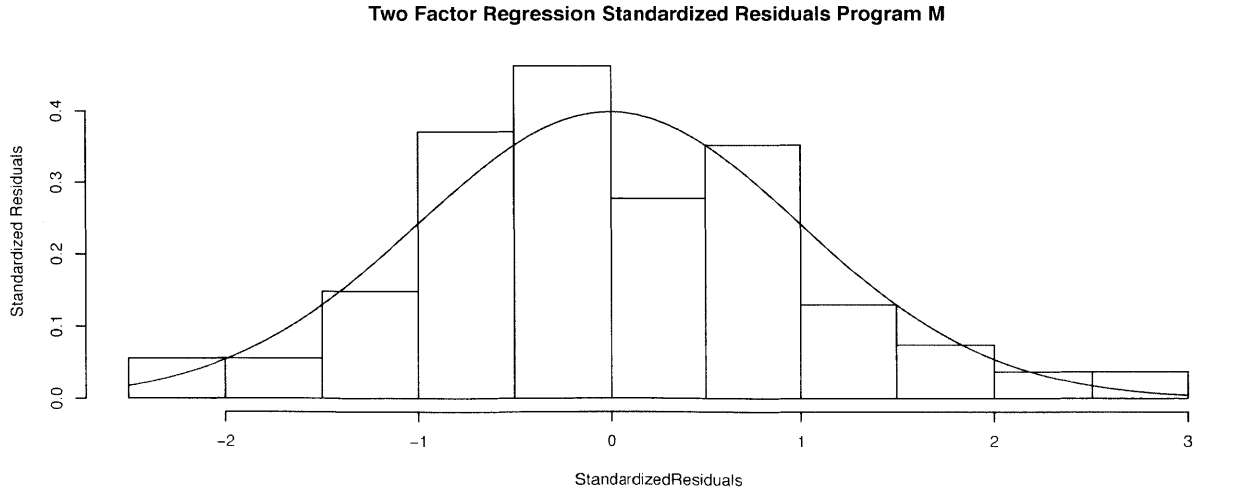


Figure H-37. Graphs of linear regression residuals for Program M with two independent variables

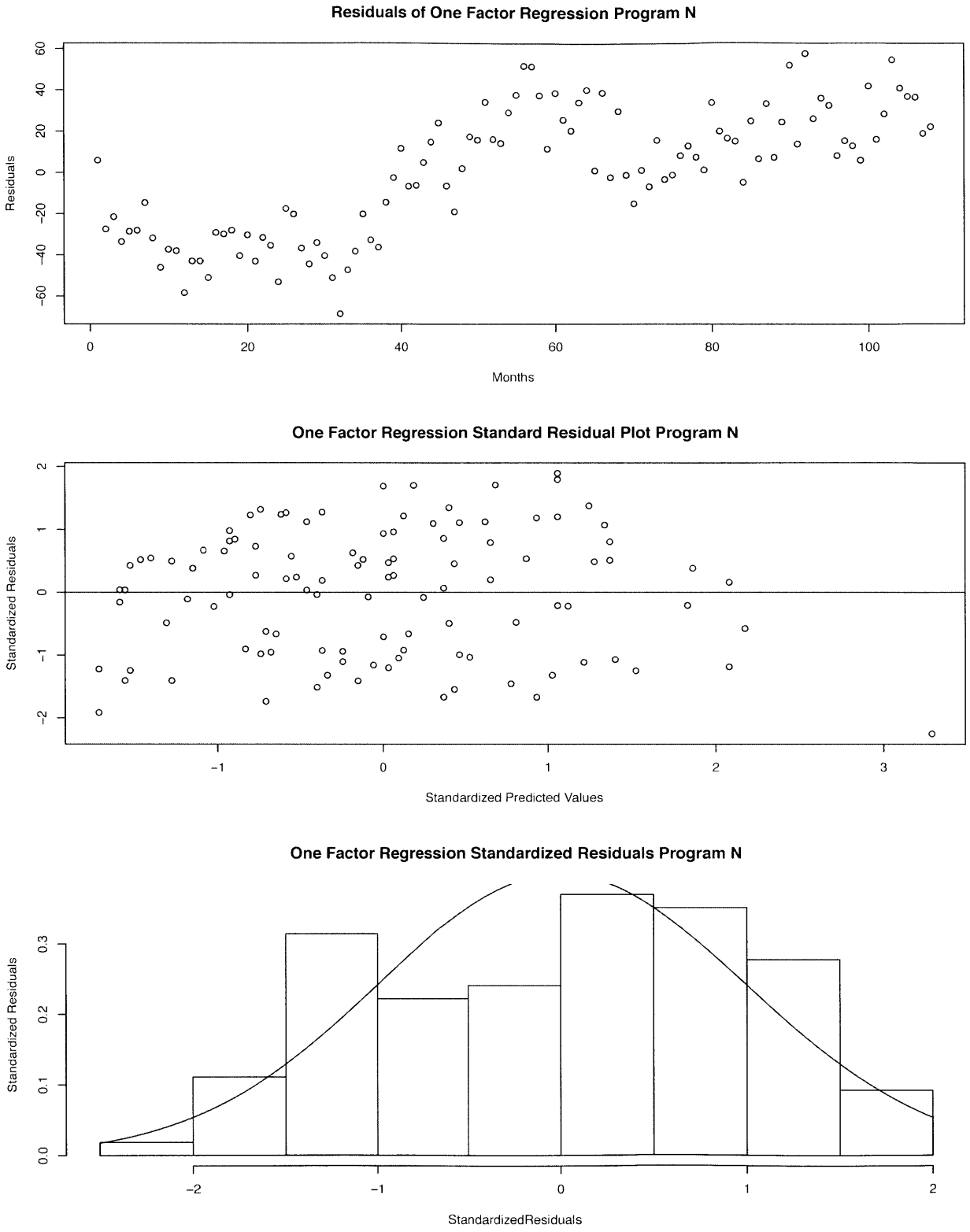


Figure H-38. Graphs of linear regression residuals for Program N with one independent variable

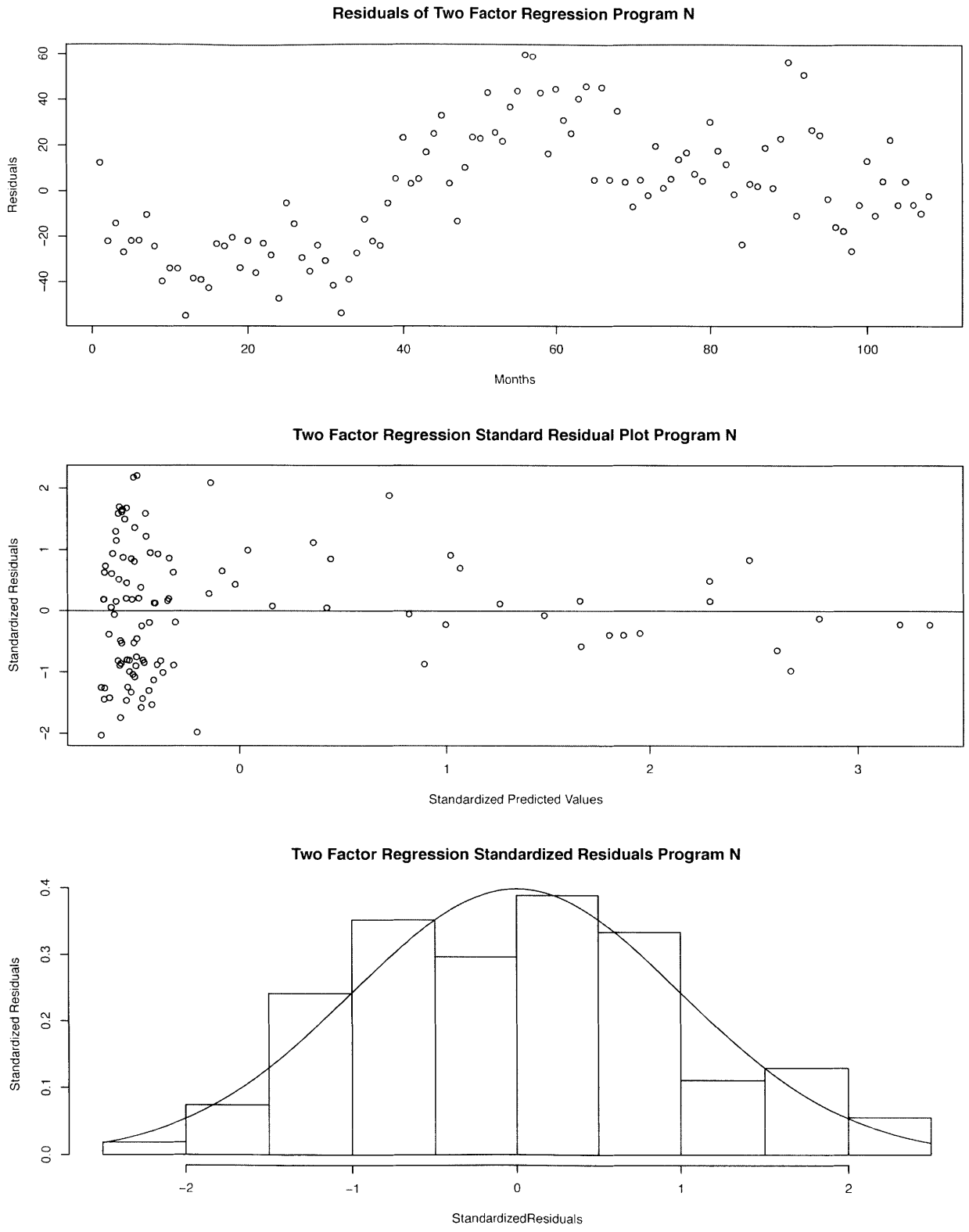


Figure H-39. Graphs of linear regression residuals for Program N with two independent variables

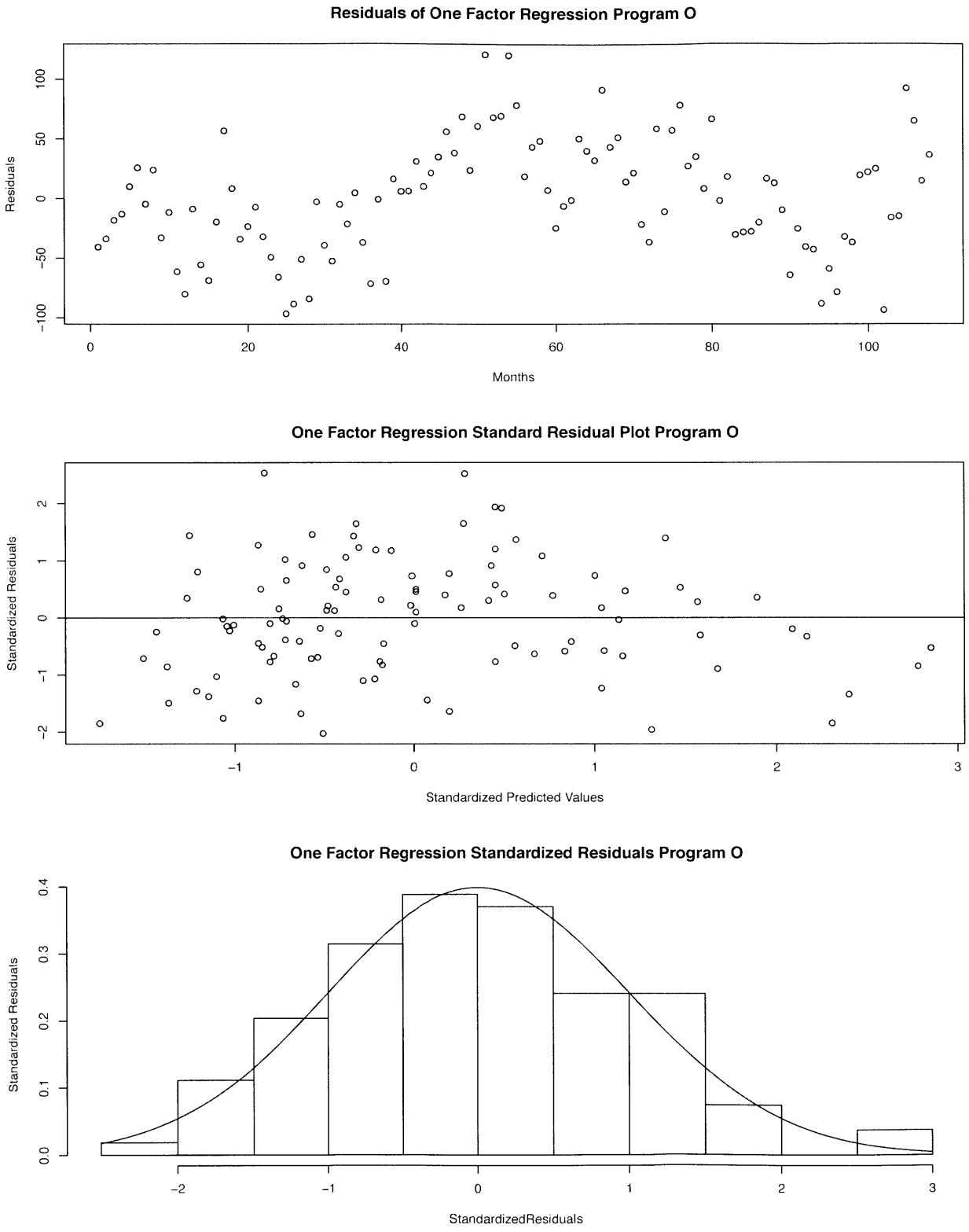


Figure H-40. Graphs of linear regression residuals for Program O with one independent variable

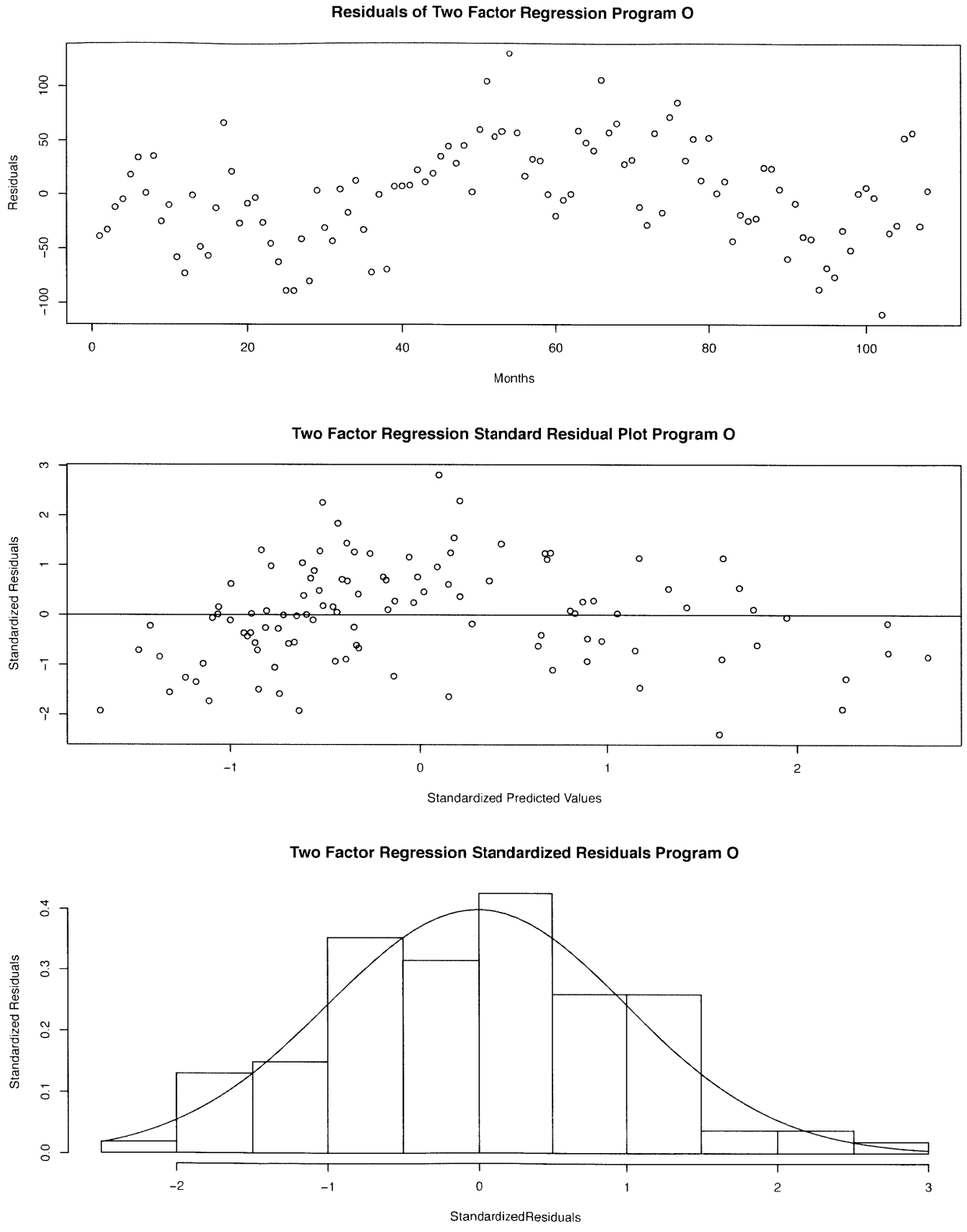


Figure H-41. Graphs of linear regression residuals for Program O with two independent variables

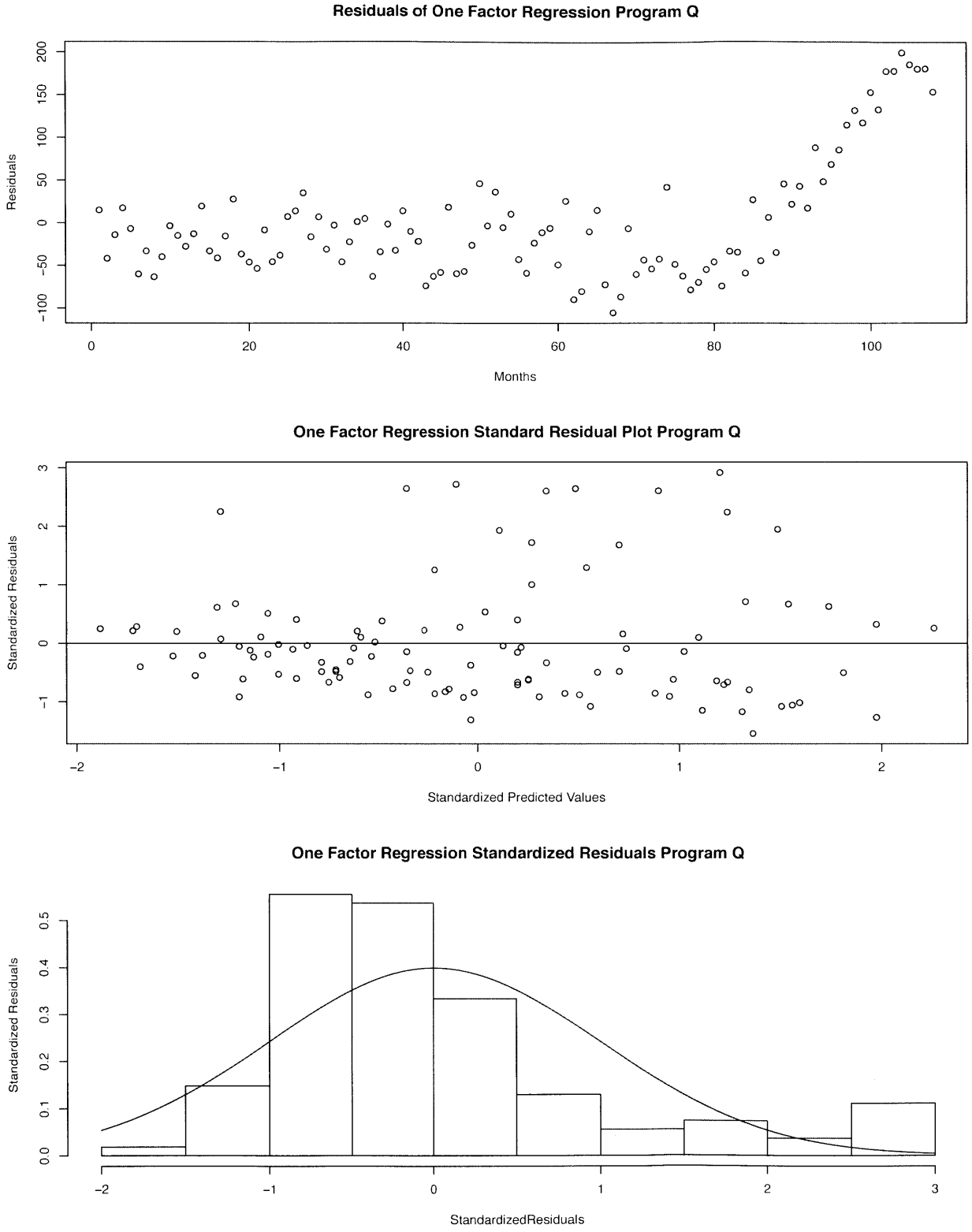


Figure H-42. Graphs of linear regression residuals for Program Q with one independent variable

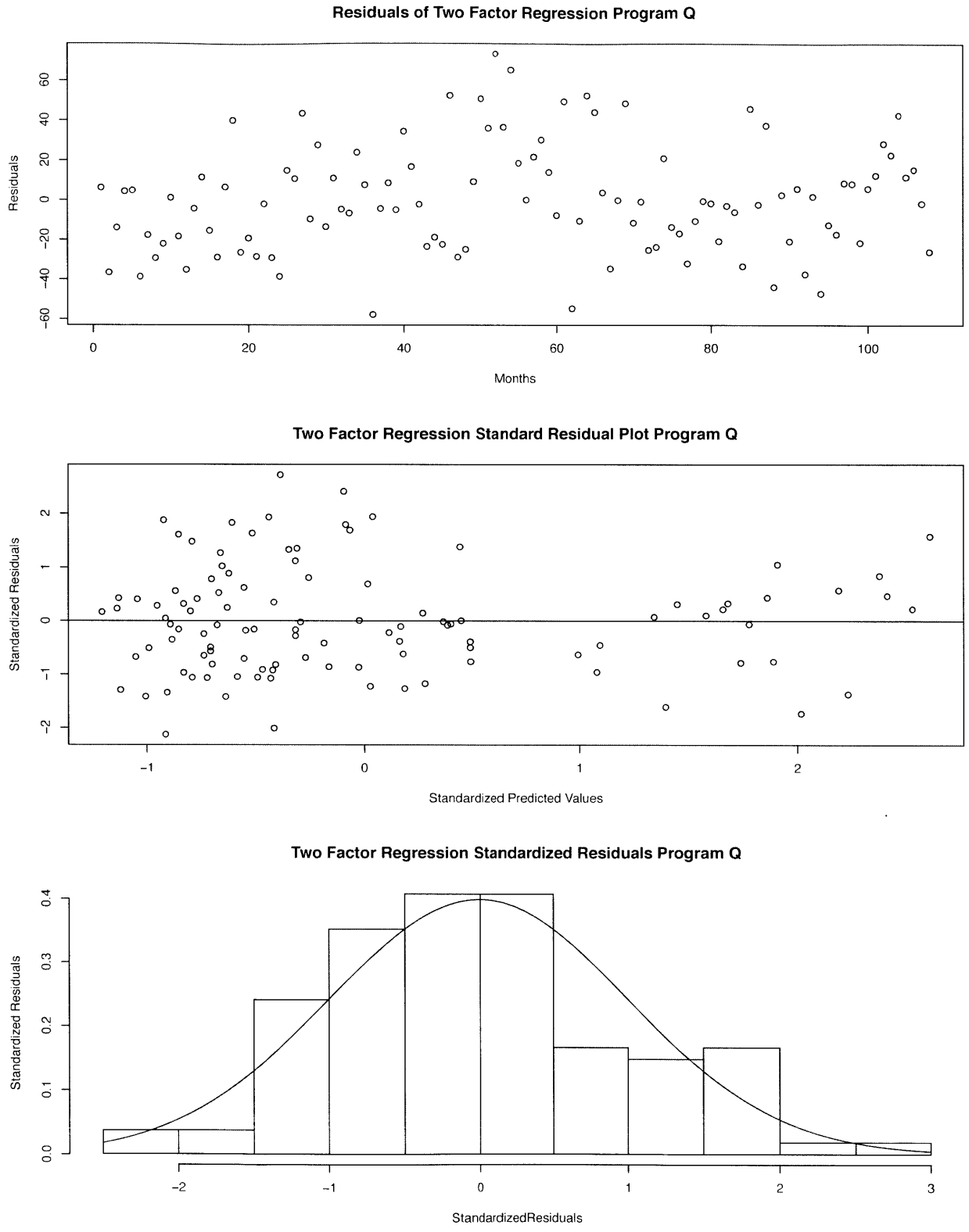


Figure H-43. Graphs of linear regression residuals for Program Q with two independent variables

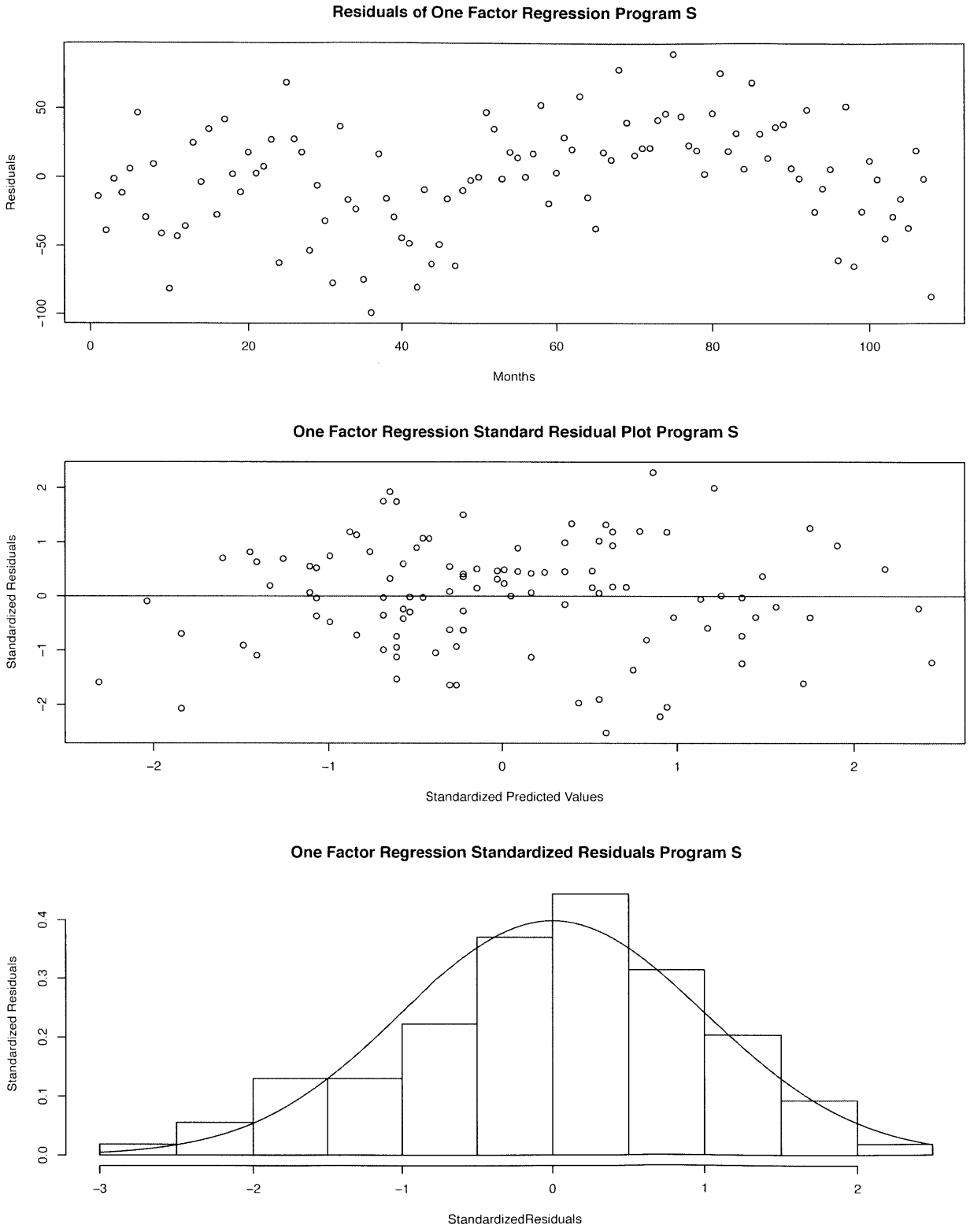
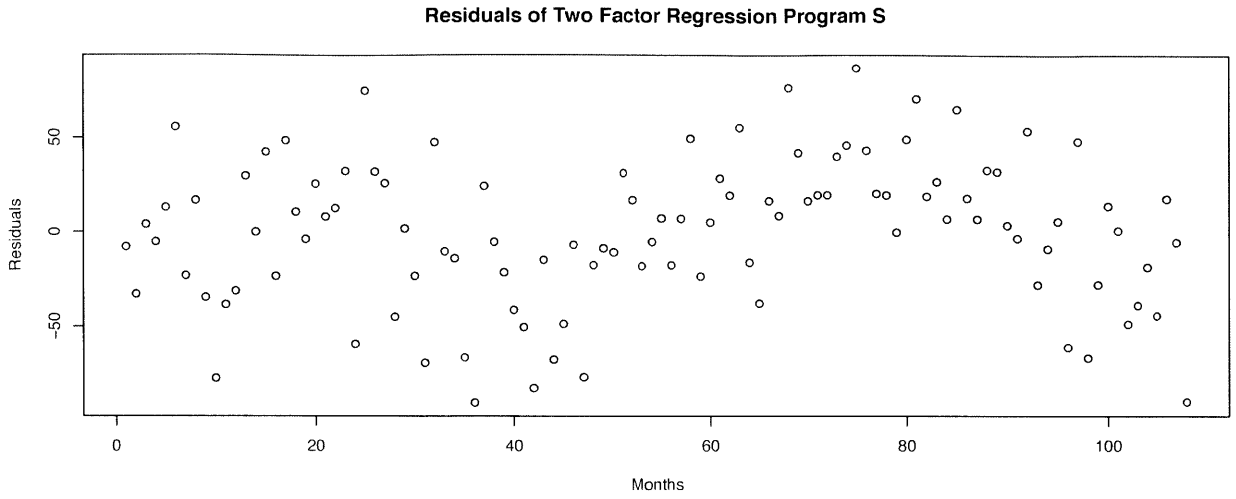
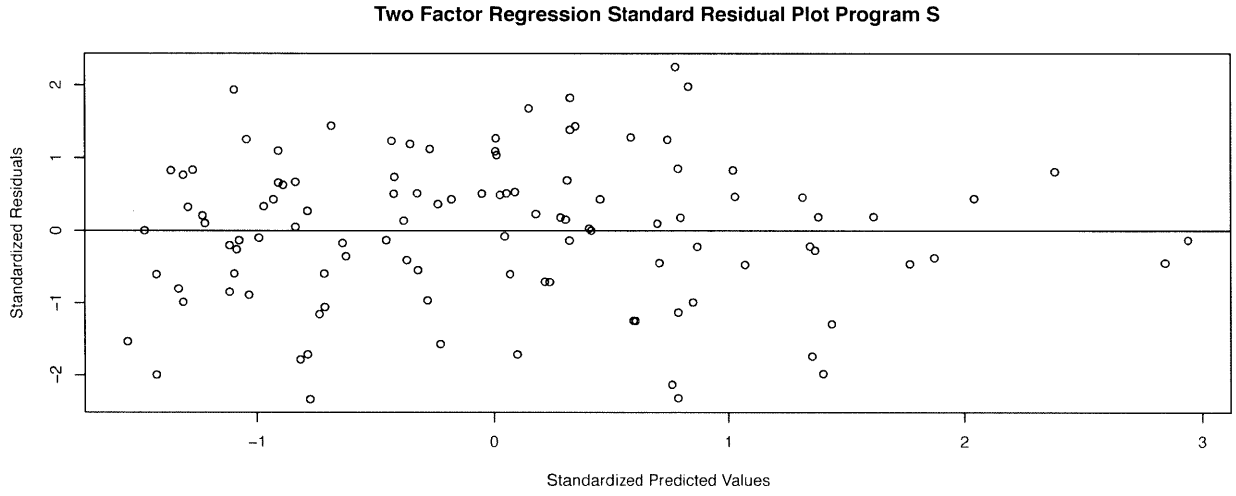


Figure H-44. Graphs of linear regression residuals for Program S with one independent variable





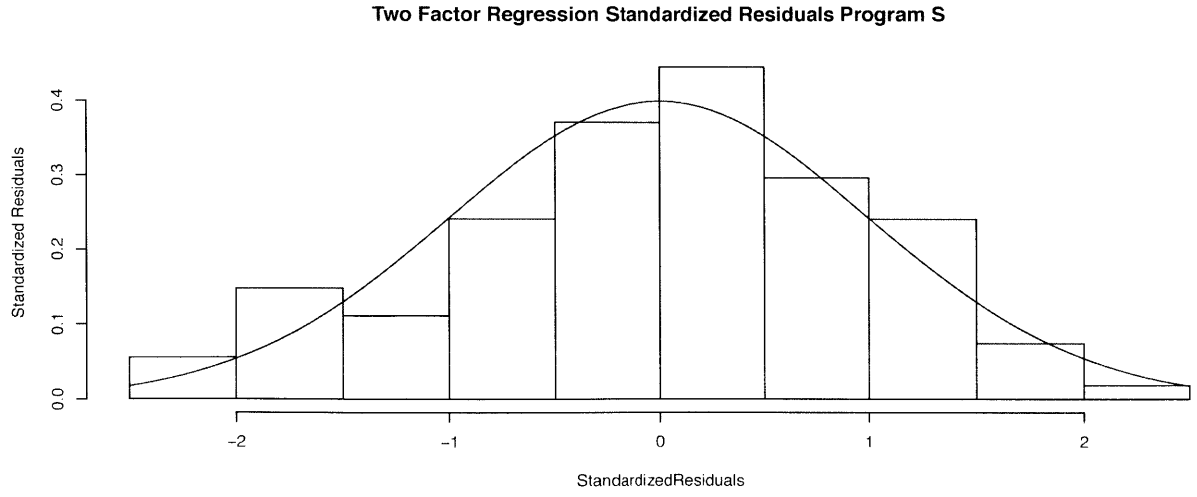


Figure H-45. Graphs of linear regression residuals for Program S with two independent variables

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