IMPACT OF TELADOC USE ON AVERAGE PER BENEFICIARY PER MONTH RESOURCE UTILIZATION AND HEALTH SPENDING

Prepared by:
Niteesh K. Choudhry, MD, PhD
Arnie Milstein, MD, MPH
Joshua Gagne, PharmD, ScD
on behalf of Veracity Healthcare Analytics

Veracity HEALTHCARE ANALYTICS

February 2015

1.0 EXECUTIVE SUMMARY

This report examines the impact on health spending and resource use of Teladoc's services among beneficiaries of the nation's largest home improvement retailer (hereafter referred to as "the employer").

The analysis was conducted using healthcare utilization data and employed two basic analytic approaches:

- A "**per member per month**" analysis that evaluated average resource use and spending among all beneficiaries of the employer after, as compared to before, Teladoc began offering services in May 2012. These analyses provide an overall assessment of the impact of Teladoc on population-wide per capita health spending regardless of whether or not an enrollee actually had a Teladoc encounter.
- An "**episode-based**" analysis that evaluated short-term spending and resource use by the employer's beneficiaries who used Teladoc as compared to similar beneficiaries who instead received care for the same conditions in physician offices or emergency departments. These analyses provide an assessment of the implications of using Teladoc for individuals that actually did, independent of the uptake of services among the entire population of beneficiaries.

Per member per month analyses

The impact of Teladoc on average per member per month spending for the employer's beneficiaries is presented in **Table 1.1**. The introduction of Teladoc was associated with a significant reduction in the slope (or trend) of per member per month spending (by an average of $1.16 per month). The level of spending, which represents the immediate impact of offering Teladoc services, was also reduced (by $9.68 per beneficiary) although this change was not statistically significant at the typical level of p=0.05. When these change are expressed as a single number, the introduction of Teladoc by the employer was associated with a significant reduction of $21.30 (p<0.01) in per member per month spending, as a result of reductions in rates of office visits, emergency room visits and hospitalizations.

TABLE 1.1: Changes in per member per month spending after the introduction of Teladoc for the employer's beneficiaries

STATISTICAL MODEL	Impact on per member per month spending* (p value)
Time-series model	
Immediate impact ("Level change")	-$9.68 (0.09)
Trend ("Slope change")	-$1.16 (0.03)
Difference in average observed and average expected spending	-$21.30 (p<0.01)

*negative numbers represent reductions in spending

Episode-based analyses

Spending on the employer's beneficiaries who used Teladoc as compared to matched individuals who instead received care for the same conditions in other settings, 30-days after the initial encounter, is summarized in **Table 1.2**.

TABLE 1.2: Average 30-day spending differences between patients calling Teladoc compared to patients receiving care in other settings (negative numbers represent cost savings)

Alternative site of care	Savings
Office visit	-$191**
Emergency room	-$2661**
Combined office visit or emergency room	-$1157**

**p<0.01

When comparing Teladoc users to similar individuals receiving care for the same conditions in an office setting, the savings difference from the initial encounter ($134) grew over the subsequent month because of a small but statistically significant reduction in the rate of hospitalization for Teladoc users. When compared to matched individuals who received care in an emergency room, the lower spending for Teladoc users resulted from the lower cost of the initial encounter and lower rates of subsequent medical utilization (physician office visit, emergency room visits and hospitalizations). The results were very similar in sensitivity analyses that truncated outliers.

Interpretation

The introduction of Teladoc was associated with reductions in average per member per month spending for the employers beneficiaries. Because the employer began offering Teladoc in the middle of a benefits year (May 2012) rather than at the beginning of one, the analysis is likely to have isolated the specific impact of Teladoc without confounding by concurrent changes in benefit design or without the concurrent introduction of other quality improvement programs. The per member per month savings likely reflect the significantly lower resource utilization and spending by individuals who used Teladoc instead of receiving care for the same conditions in physician offices or emergency rooms.

2.0 ANALYTIC STRATEGY

This report examines the impact on health spending and resource use of Teladoc's services by beneficiaries of the nation's largest home improvement retailer. The analysis used two basic analytic approaches:

- A "**per member per month**" analysis that evaluated average resource use and spending among all beneficiaries after, as compared to before, Teladoc began offering services to the employer's beneficiaries in May 2012. These analyses provide an overall assessment of the impact of Teladoc on population-wide per capita health spending in the 1.5 years after services began to be offered.
- An "**episode-based**" analysis that evaluated short-term spending and resource use by the employer's beneficiaries who used Teladoc as compared to similar beneficiaries who instead received care for the same conditions in physician offices or emergency departments. These analyses provide an assessment of the implications of using Teladoc for individuals that actually did, independent of the uptake of services among the entire population of beneficiaries.

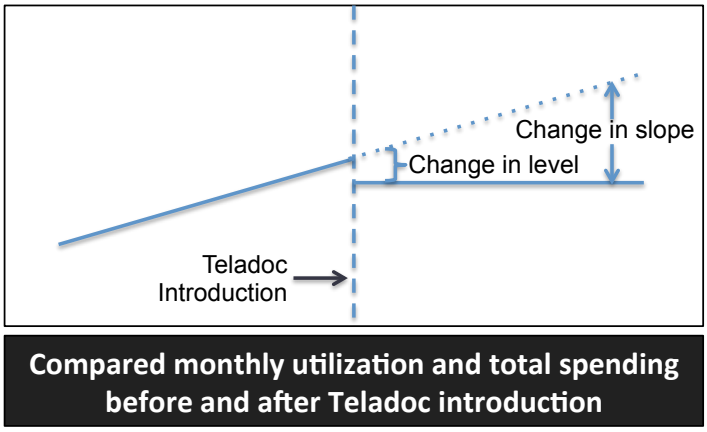
Historically, evaluations of acute care delivery innovations have estimated savings to health insurance plans by assuming that patients would have used more expensive conventional in-person medical care provided in physician offices, emergency rooms, or other settings analogous to the approach we take in the "episode-based" analyses. These evaluations have been criticized on the grounds that more easily accessible services may in some instances add to health spending by replacing zero-cost self-care. To address this valid concern, the per-member-per-month analysis examined the impact of Teladoc for acute medical conditions on population-wide per capita health spending, independent of whether an enrollee actually used these services or not.

The analyses were conducted with de-identified health insurance datasets, which contained information about medical health care utilization (e.g. physician office visits, hospitalizations, emergency department admissions, and outpatient radiology) and prescription drug use.

2.1 PER-MEMBER-PER-MONTH (PMPM) ANALYSES

The overall approach for the PMPM time-series analyses is summarized in **Figure 2.1**.

FIGURE 2.1: Analytic design for the per-member per-month analyses



The time series approach compares PMPM utilization and spending before and after Teladoc's introduction, while accounting for background trends in these outcomes. The method produces estimates of both the immediate change in the "level" and the trend ("slope") of resource use and spending in 1.5 years following its implementation.

(a) Subjects

This analysis included all of the employer's beneficiaries with coverage in each analysis month, regardless of whether they used Teladoc or other medical services. The analyses included monthly averages of 131,576 beneficiaries of whom 506 (0.4%) had a Teladoc encounter each month.

(b) Outcomes

In each month before and after the introduction of Teladoc services we evaluated:

- office visit utilization rates
- ER utilization rates
- hospitalization rates
- healthcare spending

Medical service utilization rates are expressed as the number of visits per 1,000 beneficiaries in a month. Spending estimates were based upon the allowed amounts in the claims data. These include the cost for each Teladoc encounter. We had access to both medical and prescription drug utilization and thus the spending estimates represent the impact of Teladoc on the total cost of care.

(c) Statistical considerations

We used segmented linear regression models to perform our analyses. The effect of Teladoc was estimated by comparing outcomes after with those before the introduction of Teladoc. The models assess whether Teladoc's introduction was associated with a change in the trend of a given outcome. Such changes could have occurred immediately (i.e., an abrupt change in the level of the trend) and/or over the longer term (i.e., a change in the slope of the trend). We used generalized estimating equations to account for the correlation resulting from the evaluation of repeated outcome measures for each patient.

In order to generate a single number to summarize the average impact of Teladoc's introduction on per member per month spending (in contrast to evaluating its impact using both a level and a slope estimate), we also conducted a pre-post comparison in which we compared the mean observed outcome rate in the post-Teladoc period to the mean predicted value for the post-period generated by extrapolating the pre-Teladoc outcome trend into the post-Teladoc period.

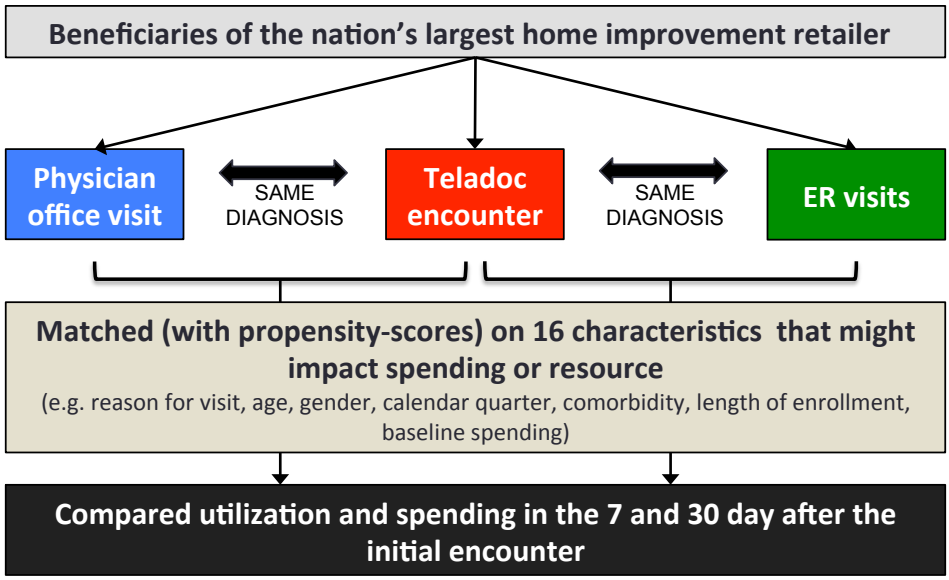
(d) Sensitivity analyses

To estimate the total expenditure for Teladoc, we repeated our analyses after adding in the per-member-per-month Teladoc fee.

2.2 EPISODE-BASED ANALYSES

The analytic approach used to evaluate the impact of Teladoc's services on short-term "episode-based" health spending and resource use is summarized in **Figure 2.2**.

FIGURE 2.2: Analytic design for the episode-based analysis



(a) Subjects

We identified individuals who used Teladoc for the first time as well two groups of comparators who did not use Teladoc but who instead had their first physician office visit or emergency room (ER) visit for the same diagnoses during the same period of time (see **Table 2.1**). The analyses focused on first-time users to clearly define the exposure groups and to ensure that eligible encounters were not the result of follow-up care related to prior care.

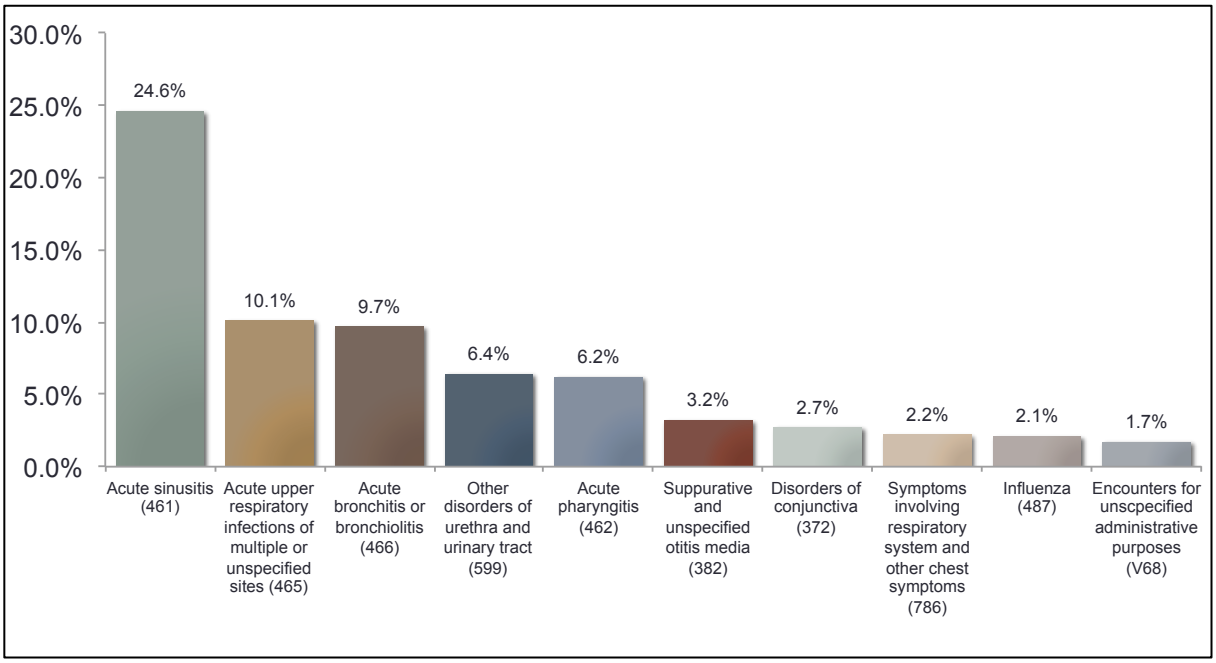
TABLE 2.1: Potentially-eligible individuals for episode-based analyses

Teladoc users	5,877
Comparison groups*	
Office visit	111,755
Emergency department	26,888

* see text for details about how controls were selected; analyses were conducted after propensity-score matching (described in greater detail below)

As shown in **Figure 2.3**, the most common reasons for calls to Teladoc were acute sinusitis (25%), acute upper respiratory infections of multiple or unspecified sites (10%), and acute bronchitis or bronchiolitis (10%).

FIGURE 2.3: Top 10 reasons for calls to Teladoc, May 2012-December 2013



(b) Matching procedures

Analogous to a randomized controlled trial, we sought to create comparison groups that were as equivalent as possible using "propensity scores" (**see Appendix A**) to match Teladoc and office visit and emergency department comparators. The propensity score models contained 16 characteristics, generated from the claims data that might impact spending or resource use:

- reason for visit or Teladoc call, based on 3-digit International Classification of Disease (ICD) code
- age
- gender
- calendar quarter
- length of enrollment
- baseline spending
- number of prior hospitalizations
- number of prior outpatient visits
- number of prior emergency room visits
- comorbidity score
- pulmonary disorder
- cancer
- congestive heart failure
- diabetes
- hypertension
- renal disease
- HIV/AIDS

We also performed a combined analysis in which Teladoc users were matched to either office visit or emergency room users, in a ratio proportional to which these sources of care were used. As a result, this

analysis examined the impact of using Teladoc as compared to using either an office visit or going to the ER in proportion to the frequency with which patients sought care in these two settings.

Matches

Characteristics of the employer's beneficiaries prior to matching are shown in **Appendix A**. After matching, we found office visit matches and emergency room matches for 5,531 (94%) and 3,370 (57%) Teladoc users, respectively. After matching, the groups were very similar (**Table 2.2**).

TABLE 2.2: Baseline characteristics of Teladoc and comparison groups after matching

Variable	Office visit comparison		ER comparison	
	Teladoc users (n = 5,531)	Office users (n = 5,531)	Teladoc users (n = 3,370)	ER users (n = 3,370)
Demographics				
Age, mean	37.8	38.7	36.1	35.8
Female, %	58%	57%	56%	56%
Prior resource utilization				
Prior hospitalizations, mean	0.1	0.1	0.2	0.2
Prior outpatient visits, mean	1.7	1.6	2.0	1.9
Prior ER visits, mean	0.5	0.5	0.6	0.6
Comorbidity				
Comorbidity score, mean	0.3	0.3	0.4	0.4
Congestive heart failure, %	2%	2%	2%	2%
Diabetes, %	7%	7%	8%	8%
Hypertension, %	19%	19%	21%	21%
Pulmonary disorders, %	10%	10%	11%	11%
Renal disease, %	2%	2%	2%	1%
HIV/AIDS, %	<1%	<1%	<1%	<1%
Index encounter primary diagnosis, top 15				
Acute sinusitis, %	23%	24%	3%	3%
Acute upper resp. infection, %	11%	10%	8%	10%
Acute bronchitis/bronchiolitis, %	10%	10%	10%	10%
Disorder of urethra/urinary tract, %	7%	7%	10%	10%
Acute pharyngitis, %	7%	6%	7%	8%
Suppurative otitis media, %	4%	3%	5%	4%
Respiratory/chest symptoms, %	2%	3%	4%	4%
Disorders of conjunctiva, %	3%	3%	3%	3%
Influenza, %	2%	2%	3%	3%
Streptococcal sore throat, %	2%	2%	2%	2%
Symptoms involving skin, %	1%	1%	2%	2%
Viral and chlamydial infection, %	1%	1%	2%	2%
Contact dermatitis/eczema, %	1%	1%	2%	2%
Others disorders of back, %	1%	1%	2%	2%
Disorders of external ear, %	1%	1%	2%	2%

(c) Outcomes

Within the propensity score-match cohorts, we compared "all-cause" resource utilization (office visits, ER visits, and hospitalizations) and spending for the initial ("index") visit and in the 7- and 30-day periods after the initial encounter. Costs were based upon the allowed amounts in the insurance claims data and no restriction was made based on the diagnosis associated with these services. Costs include total cost of care (i.e. both medical and prescription drug spending).

(d) Statistical considerations

We used generalized linear models to estimate relative and absolute differences in each outcome. Models assumed Poisson-distributed outcomes and used log link functions for estimating relative differences and identity link functions for estimating absolute differences. Poisson distributions are typically used for modeling count data, such as counts of medical counters, and have the benefit of including zero-value outcomes when modeling cost data (i.e., $0), which are common when examining short-term (e.g., 7- and 30-day) costs. In addition to overall 7- and 30-day costs, we also segmented cost difference into the following components: office visit costs, ER costs, hospitalization costs, and other medical resource costs. Because we used regression models to generate valid inferences of the impact of Teladoc on outcomes, the modeled estimates may not always exactly equal simple arithmetic differences between the groups.

(e) Sensitivity analyses

Sensitivity analyses were conducted to assess the robustness of our findings. Because a few people with extremely high levels of resource use and spending could influence average estimates, we repeated our analyses after truncating extreme expenditures in the ER comparison. Specifically, in separate analyses, we capped 7- and 30-day spending at the 99th and 95th percentiles.

2.3 METHODOLOGICAL NOTES

Several methodological issues should be kept in mind when evaluating the results of our analyses.

The "per member per month" evaluation used a methodology called "interrupted time series" analysis. The results depend heavily on the uptake of Teladoc services, which is both a strength and a weakness of the approach. That is, while the analyses produce valid estimates of average resource use for all beneficiaries of a given employer, there must have been sufficient utilization of Teladoc for it to have impacted overall medical resource utilization and medical costs for an entire beneficiary population.

Although time series analysis is considered the strong quasi-experimental approach for evaluating time-delimited interventions, it is potentially influenced by other factors, such as changes in coverage policies or quality improvement interventions, that are implemented at approximately the same time as the introduction of Teladoc. In other words, if there was more than one program introduced simultaneously it is impossible to disentangle the effects of each. In addition, because we did not have access to data for an external control group, we are unable to exclude the influence of temporal trends in outcomes. Because the employer began offering Teladoc in the middle of a benefits year (May 2012) rather than at the beginning of one, the analysis is likely to have isolated the specific impact of Teladoc without confounding by concurrent changes in benefit design or without the concurrent introduction of other quality improvement programs.

Finally, in order to estimate immediate changes in the "level" of resource utilization, the interrupted time series model assumes an abrupt, widespread intervention whereas Teladoc utilization increased gradually over time in the employer's population. Thus, the estimates of slope change are likely more meaningful in these analyses.

For the "episode-based" analyses, we used propensity scores to match on characteristics that might affect medical resource utilization and spending, and thereby effectively created the observational research analogue of a randomized controlled trial. While this approach has been widely validated, it is not possible to guarantee that if users had not called Teladoc that they would have sought care in a physician's office or an ER. It is also possible that, despite matching, there are unaccounted for differences between individuals in the Teladoc group and those in the comparison groups with regard to patient characteristics or illness severity, especially related to the index encounter itself.

For both the episode-based and per member per month analyses, our findings may not apply to other employers with different characteristics and/or Teladoc utilization rates.

3.0 FINDINGS: PMPM ANALYSES

3.1 PRIMARY RESULTS

Figure 3.1 shows the rates (per 1,000 enrollees per month) of office visits, ER visits, and hospitalizations for before and after the introduction of Teladoc. The dotted line represents a regression line fit to the pre-Teladoc period. In the post-Teladoc period, the line represents the predicted rate of the outcome had the pre-Teladoc trend continued. Rates of office visits and ER visits were lower than the predicted rates after the introduction of Teladoc services.

FIGURE 3.1: Rates of resource utilization, January 2011 to December 2013 (per 1,000 enrollees per month)

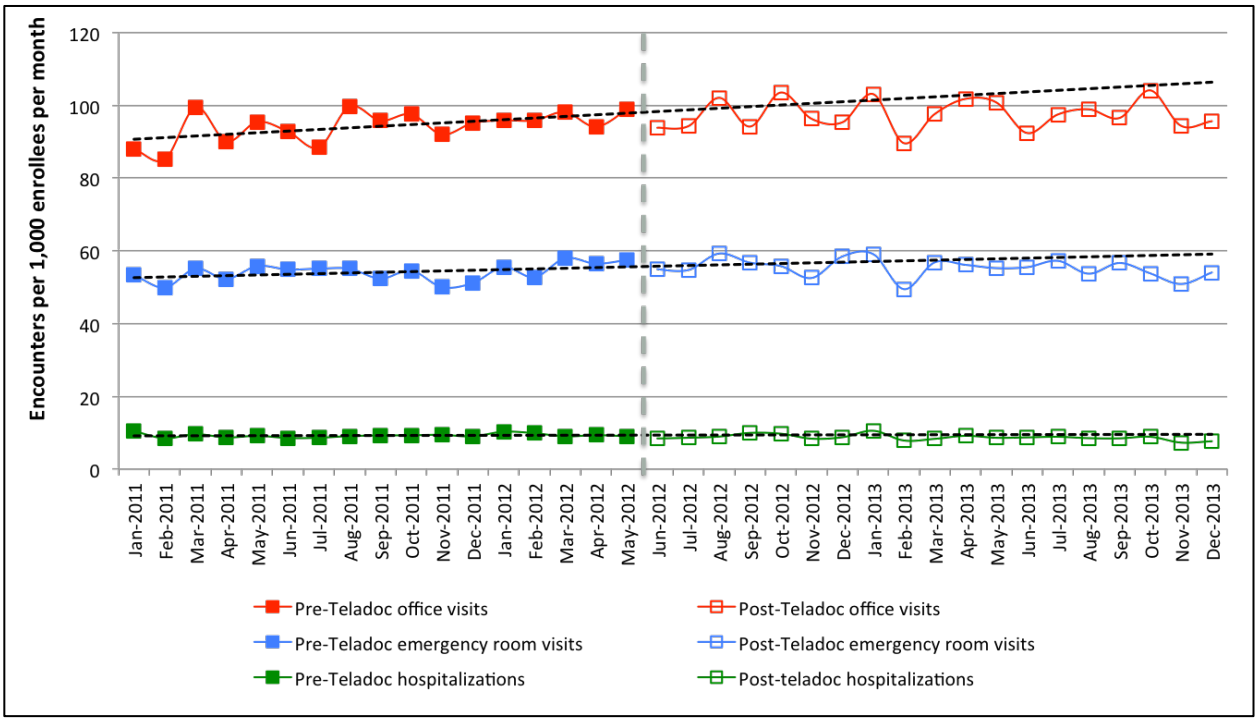
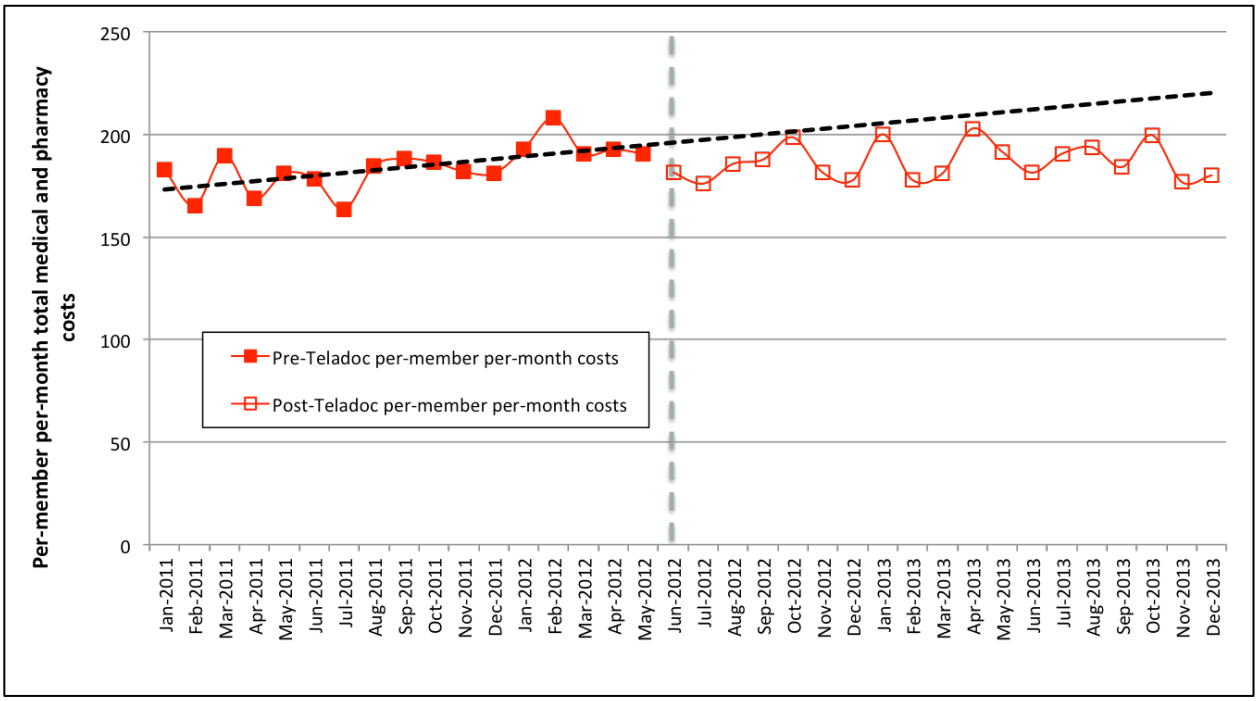


Figure 3.2 shows the per-member per-month total medical and pharmacy spending before and after the introduction of Teladoc service. The dotted line represents a regression line fit to the pre-Teladoc period. In the post-Teladoc period, the line represents the predicted PMPM cost had the pre-Teladoc trend continued. PMPM medical and pharmacy costs were lower than predicted costs after the introduction of Teladoc.

FIGURE 3.2: PMPM total spending, January 2011 to December 2013



The formal interrupted time series analysis confirmed statistically significant decreases in the ER visit and cost slopes (**Table 3.3**).

TABLE 3.1: Estimates of the impact of Teladoc's introduction on the level and slope of resource utilization and total spending.

Outcome	Level change (*p*-value)	Slope change (*p*-value)
Total spending (per member per month)	-$9.68 (0.09)	-$1.16 (0.03)
Office visits (per 1,000 members per month)	-0.83 (0.74)	-0.41 (0.10)
Emergency room visits (per 1,000 members per month)	1.11 (0.47)	-0.32 (0.03)
Hospitalizations (per 1,000 members per month)	-0.03 (0.95)	-0.07 (0.08)

A pre-post comparison suggested that the mean observed rates for office visits, ER visits, hospitalizations, and total medical and pharmacy costs were lower in the post-Teladoc period as compared to the mean predicted values for the post-period (**Table 3.2**).

TABLE 3.2: Results of pre-post analysis comparing outcome rates before and after the introduction of Teladoc services

Outcome	Mean predicted value in post period	Mean observed value in post period	Difference (*p*-value)
Total spending (per member per month)	$208.00	$186.70	-$21.30 (<0.01)
Office visits (per 1,000 members per month)	102.3	97.4	-4.9 (<0.01)
Emergency room visits (per 1,000 members per month)	57.4	55.3	-2.1 (0.02)
Hospitalizations (per 1,000 members per month)	9.5	8.7	-0.7 (<0.01)

3.2 SENSITIVITY ANALYSES

Adding the per-member-per-month Teladoc fee had little impact on the spending results (**Table 3.5**). The level change decreased slightly to -$9.03 (*p*-value = 0.11). The slope change increased slightly to -$1.18 (*p*-value = 0.03).

TABLE 3.5: Estimates of the impact of Teladoc on average spending after adding in the monthly per beneficiary Teladoc fee. Numbers are expressed as per member per month.

Outcome	Level change (*p*-value)	Slope change (*p*-value)
Total spending	-$9.03 (0.11)	-$1.18 (0.03)

4.0 FINDINGS: EPISODE-BASED ANALYSES

4.1 PRIMARY RESULTS

(a) Office visit comparison

Total (medical and pharmacy) spending who used Teladoc was $191 lower (p<0.01) over the subsequent 30 days as compared to matched individuals who instead received care in a physician office for the same condition (**Table 4.1**). Teladoc users had more office visits in the 7 days following the index encounter although this difference was no longer statistically significant by 30 days. Rates of hospitalization were also similar although were slightly (and statistically significantly) lower among Teladoc users. As a result, the cost savings from the initial encounter ($135, p<0.01) increased to $191 by 30-days after the initial encounter.

TABLE 4.1: Average resource utilization and spending and estimates of relative and absolute differences between Teladoc and matched office visit users

Outcome	Teladoc users, mean	Office visit users, mean	Relative difference (*p*-value)	Absolute difference (*p*-value)
Spending				
Index encounter	$39	$173	-77% (<0.01)	-$134 (<0.01)
Total 7-day costs	$242	$370	-35% (<0.01)	-$128 (<0.01)
Total 30-day costs	$524	$715	-27% (<0.01)	-$191 (<0.01)
7-day resource utilization				
Office visits	0.18	0.13	38% (<0.01)	0.05 (<0.01)
Hospitalizations	0.00	0.01	-33% (0.18)	0.00 (0.18)
ER visits	0.03	0.02	15% (0.32)	0.00 (0.32)
30-day resource utilization				
Office visits	0.66	0.63	5% (0.15)	0.03 (0.15)
Hospitalizations	0.01	0.01	-38% (0.03)	0.00 (0.04)
ER visits	0.05	0.04	19% (0.11)	0.01 (0.11)

The largest contributor to the 30-day savings was from the cost of the initial encounter (**Table 4.2**).

TABLE 4.2: Breakout of 30-day spend differences between Teladoc and matched office visit users

Outcome	Teladoc users, mean	Office visit users, mean	Relative difference (*p*-value)	Absolute difference (*p*-value)
Index encounter	$39	$173	-77% (<0.01)	-$134 (<0.01)
Office visits	$305	$321	-5% (0.64)	-$16 (0.64)
ER visits	$38	$45	-16% (0.58)	-$7 (0.59)
Hospitalizations	$75	$90	-17% (0.32)	-$15 (0.32)
Other	$67	$86	-22% (0.54)	-$19 (0.52)

(b) ER comparison

Spending on the employer's beneficiaries who used Teladoc instead of receiving care in an emergency department for the same condition was $2,661 lower over the subsequent 30 days (p<0.01) (**Table 4.3**).

This was attributable to savings from the initial encounter and lower medical resource utilization in the following month. Specifically, Teladoc users had significantly lower rates of follow-up office visits, ER visits, and hospitalizations at both 7 and 30 days. As a result, the savings from the initial encounter ($816) increased to $2249 total savings in the 7 days following the index encounter and $2,661 in the 30 days following the index encounter.

TABLE 4.3: Average resource utilization and spending and estimates of relative and absolute differences between Teladoc and matched ER users

Outcome	Teladoc users, mean	ER users, mean	Relative difference (*p*-value)	Absolute difference (*p*-value)
Spending				
Index encounter	$39	$854	-95% (<0.01)	-$816 (<0.01)
Total 7-day costs	$290	$2538	-88% (<0.01)	-$2249 (<0.01)
Total 30-day costs	$616	$3275	-81% (<0.01)	-$2661 (<0.01)
7-day resource utilization				
Office visits	0.20	0.34	-41% (<0.01)	-0.14 (<0.01)
Hospitalizations	0.00	0.06	-93% (<0.01)	-0.05 (<0.01)
ER visits	0.04	0.15	-73% (0.25)	-0.11 (<0.01)
30-day resource utilization				
Office visits	0.71	1.07	-34% (<0.01)	-0.36 (<0.01)
Hospitalizations	0.01	0.07	-90% (<0.01)	-0.06 (<0.01)
ER visits	0.07	0.21	-68% (<0.01)	-0.14 (<0.01)

Breaking out the 30-day spending differences showed savings for Teladoc users in all cost categories as compared to matched individuals receiving care in an ER for the same diagnoses (**Table 4.4**).

TABLE 4.4: Breakout of 30-day spending differences between Teladoc and matched ER users

Outcome	Teladoc users, mean	ER users, mean	Relative difference (*p*-value)	Absolute difference (*p*-value)
Index encounter	$39	$854	-95% (<0.01)	-$816 (<0.01)
Office visits	$341	$1520	-78% (<0.01)	-$1178 (<0.01)
ER visits	$44	$201	-78% (<0.01)	-$157 (<0.01)
Hospitalizations	$90	$406	-78% (0.02)	-$316 (<0.01)
Other	$101	$294	-66% (<0.01)	-$193 (<0.01)

Because the employer's beneficiaries included in our analysis were relatively young and healthy, there was very little spending on prescription drugs in either group.

(c) Combined comparison

Spending on the employer's beneficiaries who used Teladoc instead of receiving care in either a physician's office or an emergency department (based on the frequency with which these visits occurred) for the same condition was $1,157 lower over the subsequent 30 days (p<0.01) (**Table 4.5**). This was attributable to savings from the initial encounter and lower utilization of physician office visits, emergency department visits and hospitalizations both in the 7 and 30 days after the initial encounter.

TABLE 4.5: Average resource utilization and spending and estimates of relative and absolute differences between Teladoc and matched office visit and ER users

Outcome	Teladoc users, mean	Office visit and ER users, mean	Relative difference (*p*-value)	Absolute difference (*p*-value)
Spending				
Index encounter	$39	$437	-91% (<0.01)	-$398 (<0.01)
Total 7-day costs	$260	$1175	-78% (<0.01)	-$915 (<0.01)
Total 30-day costs	$560	$1717	-67% (<0.01)	-$1157 (<0.01)
7-day resource utilization				
Office visits	0.20	0.21	-8% (0.05)	-0.02 (0.05)
Hospitalizations	0.00	0.02	-83% (<0.01)	-0.02 (<0.01)
ER visits	0.03	0.07	-56% (<0.01)	-0.04 (<0.01)
30-day resource utilization				
Office visits	0.68	0.77	-12% (<0.01)	-0.09 (<0.01)
Hospitalizations	0.01	0.03	-77% (<0.01)	-0.02 (<0.01)
ER visits	0.06	0.11	-49% (<0.01)	-0.06 (<0.01)

4.2 SENSITIVITY ANALYSES

The results were similar in sensitivity analyses that truncated outliers (see **Appendix B**).

5.0 CONCLUSIONS

The introduction of Teladoc was associated with a significant reduction in the trend (slope) in average per member per month spending and a non-significant immediate change in its level. When expressing the level and slopes changes as a single number, introducing Teladoc resulted in a statistically-significant reduction in per member per month spending of $21.30, attributable to reductions in office visits, emergency room visits and hospitalizations.

When comparing individuals who actually used Teladoc with similar individuals who received care in other settings for the same condition, spending was substantially lower for Teladoc users. The cost differences were particularly large when comparing Teladoc to care provided in an ER (up to $2,661 per episode of care). Overall episode-based spending was $1,157 lower for beneficiaries receiving care through Teladoc as compared to in a physician office or ER, in proportion to the frequency with which care was sought in these two settings. The episode-based results were robust to sensitivity analyses that truncated outliers.

APPENDIX A: EPISODE-BASED ANALYSES SUPPLEMENTAL STATISTICAL INFORMATION

TABLE A.1: Comparison of national comorbidity burden to Teladoc users

Variable	Teladoc users	National average	Age-adjusted national average
Comorbidity score, mean	0.4	0.5	0.3
Pulmonary disorders, %	10%	16%	10%
Diabetes, %	7%	9%	6%
Hypertension, %	21%	29%	18%

A.1 OFFICE VISIT COMPARISON

We identified 111,755 beneficiaries who did not use Teladoc services but who had office visits for the same reasons as the Teladoc calls. As compared to the office visit users, Teladoc users were more likely to be female (59% vs. 51%) before matching; otherwise the two groups were similar with respect to baseline characteristics and health service resource use (**Table A.2**).

TABLE A.2: Baseline characteristics of Teladoc and office visit users before matching

Variable	Teladoc users (n = 5,877)	Office visit users (n = 111,755)
Demographics		
Age, mean	38.4	38.0
Female, %	59%	51%
Prior resource utilization		
Prior hospitalizations, mean	0.1	0.2
Prior outpatient visits, mean	1.8	1.6
Prior ER visits, mean	0.5	0.4
Comorbidity		
Comorbidity score, mean	0.4	0.3
Congestive heart failure, %	2%	2%
Diabetes, %	7%	9%
Hypertension, %	21%	22%
Pulmonary disorders, %	10%	8%
Renal disease, %	2%	2%
HIV/AIDS, %	<1%	<1%
Index encounter primary diagnosis, top 15		
Acute sinusitis, %	25%	3%
Acute upper resp. infection, %	10%	3%
Acute bronchitis/bronchiolitis, %	10%	2%
Disorder of urethra/urinary tract, %	6%	2%
Acute pharyngitis, %	6%	3%
Suppurative otitis media, %	3%	2%
Respiratory/chest symptoms, %	2%	3%
Disorders of conjunctiva, %	3%	1%

Influenza, %	2%	1%
Streptococcal sore throat, %	1%	1%
Symptoms involving skin, %	1%	1%
Viral and chlamydial infection, %	1%	1%
Contact dermatitis/eczema, %	1%	2%
Others disorders of back, %	1%	3%
Disorders of external ear, %	1%	1%

The c-statistic for the propensity score model predicting use of Teladoc services versus office visits was 0.90. After matching, the 5,531 pairs were well balanced on baseline characteristics (**Table 2.2**). The post-matching c-statistic was 0.55. Standardized differences in the matched cohort ranged from 0.00 to 0.05, indicating good balance on all baseline covariates.

A.2 EMERGENCY ROOM COMPARISON

We identified 26,888 beneficiaries who did not use Teladoc services but who had an ER visits for the same reasons as the Teladoc calls. Teladoc users were generally healthier than ER visit users before matching. Teladoc users had lower prevalence of pulmonary disorders (10% vs. 14%), diabetes (7% vs. 12%), and hypertension (21% vs. 29%) (**Table A.3**).

TABLE A.3: Baseline characteristics of Teladoc and ER users before matching

Variable	Teladoc users (n = 5,877)	ER users (n = 26,888)
Demographics		
Age, mean	38.4	37.7
Female, %	59%	51%
Prior resource utilization		
Prior hospitalizations, mean	0.1	0.4
Prior outpatient visits, mean	1.8	3.3
Prior ER visits, mean	0.5	0.9
Comorbidity		
Comorbidity score, mean	0.4	0.7
Congestive heart failure, %	2%	4%
Diabetes, %	7%	12%
Hypertension, %	21%	29%
Pulmonary disorders, %	10%	14%
Renal disease, %	2%	3%
HIV/AIDS, %	<1%	<1%
Index encounter primary diagnosis, top 15		
Acute sinusitis, %	25%	<1%
Acute upper resp. infection, %	10%	1%
Acute bronchitis/bronchiolitis, %	10%	1%
Disorder of urethra/urinary tract, %	6%	2%
Acute pharyngitis, %	6%	1%
Suppurative otitis media, %	3%	1%

Respiratory/chest symptoms, %	2%	11%
Disorders of conjunctiva, %	3%	1%
Influenza, %	2%	1%
Streptococcal sore throat, %	1%	1%
Symptoms involving skin, %	1%	1%
Viral and chlamydial infection, %	1%	1%
Contact dermatitis/eczema, %	1%	<1%
Others disorders of back, %	1%	3%
Disorders of external ear, %	1%	<1%

The c-statistic for the propensity score model predicting use of Teladoc services versus ER visits was 0.92. After matching, the 3,370 pairs were well balanced on baseline characteristics (**Table 2.2**). The post-matching c-statistic was 0.56. Standardized differences in the matched cohort ranged from 0.00 to 0.06, indicating good balance on all baseline covariates.

APPENDIX B: EPISODE-BASED SENSITIVITY ANALYSES

We conducted sensitivity analyses to assess the robustness of the episode-based results.

B.1 FIRST CALL RESOLUTION RATES

Among the employer's beneficiaries who used Teladoc, 96% did not have office visits, emergency room visits, or hospitalizations for reasons related to the Teladoc call in the 7 days following the call. The resolution rate was 92% in the 30 days following the call.

B.2 TRUNCATION OF OUTLIER ER EXPENDITURE

Truncating expenditures at either the 99th percentile or the 95th percentile had little impact on the results of the ER comparisons (**Tables B.1**). As expected, truncating the extreme expenditures attenuated estimates of absolute savings but still demonstrate substantially lower spending among individuals using Teladoc as compared to matched individuals seeking care in an ER for the same condition.

TABLE B.1: Results of sensitivity analyses truncating extreme expenditures in the episode-based ER comparison

Outcome	Teladoc users, mean	ER users, mean	Relative difference (*p*-value)	Absolute difference (*p*-value)
Costs, truncating at 99th percentile				
Index encounter	$39	$861	-95% (<0.01)	-$816 (<0.01)
Total 7-day costs	$263	$2294	-89% (<0.01)	-$2033 (<0.01)
Total 30-day costs	$530	$2875	-82% (<0.01)	-$2346 (<0.01)
Costs, truncating at 95th percentile				
Index encounter	$39	$861	-95% (<0.01)	-$816 (<0.01)
Total 7-day costs	$224	$1788	-87% (<0.01)	-$1564 (<0.01)
Total 30-day costs	$442	$2249	-80% (<0.01)	-$1807 (<0.01)

ABOUT THE AUTHORS

Niteesh K. Choudhry, MD, PhD is an Associate Professor at Harvard Medical School and Executive Director of the Center for Healthcare Delivery Sciences at Brigham and Women's Hospital, where he also practices inpatient general internal/hospital medicine and is Associate Physician in the Division of Pharmacoepidemiology and Pharmacoeconomics. His research focuses on the design and evaluation of novel strategies to improve health care quality and reduce spending for patients with common chronic conditions. He has extensive collaborations with pubic and private insurers, employers and developers of new technologies and his research is supported by a wide variety of both public and private funders. He has published over 170 scientific papers in leading peer-reviewed medical and policy journals and has been recognized by national and international organizations for his research. Dr. Choudhry, who is Canadian by origin, received his M.D. and completed his residency training in Internal Medicine at the University of Toronto and earned his Ph.D. in Health Policy from Harvard University.

Arnie Milstein, MD, MPH is a Professor of Medicine at Stanford University and directs the Stanford Clinical Excellence Research Center. The Center is a collaboration of the Schools of Medicine, Engineering and Business to design and test new health care delivery models that both lower per capita health care spending and improve clinical outcomes. His career and ongoing research is focused on acceleration of clinical service innovations that improve the societal value of health care. He serves as the Medical Director of the Pacific Business Group on Health (PBGH), the largest regional health care improvement coalition in the U.S. He also guides employer-sponsored clinically-based innovation development for Mercer Health and Benefits and chairs the Steering Committee that directs the largest U.S. physician pay-for-performance program, operated by the Integrated Healthcare Association. Previously he co-founded the Leapfrog Group and Consumer-Purchaser Disclosure Project, and served as a Congressionally-appointed MedPAC Commissioner. He was educated at Harvard (BA-Economics), Tufts (MD) and UC-Berkeley (MPH-Health Services Evaluation and Planning).

Joshua Gagne, PharmD, ScD is an Assistant Professor at Harvard Medical School and the Harvard School of Public Health. He is also an Epidemiologist in the Division of Pharmacoepidemiology and Pharmacoeconomics at Brigham and Women's Hospital. His current research centers on methods for generating post-marketing comparative safety and effectiveness evidence for new medical products. This work is funded by the Agency for Healthcare Research & Quality, the US Food and Drug Administration, the Harvard Catalyst, and the Patient Centered Outcomes Research Institute. He graduated magna cum laude with a Doctor of Pharmacy degree from the University of Rhode Island College of Pharmacy and received his Doctor of Science degree in Epidemiology from the Harvard School of Public Health.

DISCLAIMER

This report was funded by a contract from Teladoc, Inc. to Veracity Healthcare Analytics. The study was designed and the analyses were performed independently by the authors, without input or modification from the funder. The authors of this report are solely responsible for its content.