Increased Use of the Emergency Department After Health Care Reform in Massachusetts

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**Study objective:** With implementation of the Patient Protection and Affordable Care Act, 30 million individuals are predicted to gain access to health insurance. The experience in Massachusetts, which implemented a similar reform beginning in 2006, should provide important lessons about the effect of health care reform on emergency department (ED) utilization. Our objective is to understand the extent to which Massachusetts health care reform was associated with changes in ED utilization.

**Methods:** We compared changes in ED utilization at the population level for individuals from areas of the state that were affected minimally by health care reform with those from areas that were affected the most, as well as for those younger than 65 years and aged 65 years or older. We used a difference-in-differences identification strategy to compare rates of ED visits in the prereform period, during the reform, and in the postreform period. Because we did not have population-level data on insurance status, we estimated area-level insurance rates by using the percentage of actual visits made during each period by individuals with insurance.

**Results:** We studied 13.3 million ED visits during 2004 to 2009. Increasing insurance coverage in Massachusetts was associated with increasing use of the ED; these results were consistent across all specifications, including the younger than 65 years versus aged 65 years or older comparison. Depending on the model used, the implementation of health care reform was estimated to result in an increase in ED visits per year of between 0.2% and 1.2% within reform and 0.2% and 2.2% postreform compared with the prereform period.

**Conclusion:** The implementation of health care reform in Massachusetts was associated with a small but consistent increase in the use of the ED across the state. Whether this was due to the elimination of financial barriers to seeking care in the ED, a persistent shortage in access to primary care for those with insurance, or some other cause is not entirely clear and will need to be addressed in future research. [Ann Emerg Med. 2014;64:107-115.]

Please see page 108 for the Editor’s Capsule Summary of this article.
reform on ED visits in Massachusetts have revealed conflicting results.4-6

Goals of This Investigation

In this study, we examine changes in ED use that resulted from the implementation of Massachusetts health care reform, using data from a statewide database capturing all ED visits, including those that resulted in hospital admissions or observation stays. Our study design takes advantage of the differential effect of health care reform across the state by comparing changes in ED care at the population level for individuals from areas of the state that were affected the most by health care reform with those from areas that were affected the least. Thus, our method allows us to make stronger inferences about the effect of health care reform on use as opposed to simply tracking use trends over time or making comparisons with states that might differ in other fundamental ways. In addition, we examine changes in use for the population aged 65 years and older, which, because of Medicare coverage, should not have been affected by Massachusetts health care reform. Our major limitation is the use of the frequency of ED visits by the uninsured as an estimate of the true frequency of uninsured individuals in an area. We use this estimate because we did not have access to population-level data on the percentage of individuals without insurance. We compensated for this by using several different modeling strategies to test the robustness of our results. Because attaining insurance typically is associated with increased use of services and because of constraints on access to alternative sites of care outside of the ED, we hypothesized that health care reform would be associated with increased ED use.

MATERIALS AND METHODS

In 2006, an act providing access to affordable, quality, accountable health care put in place in Massachusetts a series of Medicaid expansions, subsidized insurance offerings, insurance market reforms, safety net alterations, and individual and employer mandates to purchase or provide health insurance. The various components of the reform, implemented in stages between 2006 and 2008, have been previously described in detail4 and are depicted in Figure 1. More details can be found in Appendix E1 (available online at http://www.annemergmed.com). We analyzed data from 3 periods: prereform (October 1, 2004, through September 30, 2006), within reform (October 1, 2006, through September 30, 2007), and postreform (October 1, 2007, through September 30, 2009). Although the postreform period technically includes the last quarter before the implementation of the full individual penalty, we used this structure to maintain consistent seasons in each group.

Data Collection and Processing

We obtained data from the state of Massachusetts that included all patients treated and discharged from the ED (ED discharge database), as well as databases on observation and full hospital admissions that could be used to identify those admissions that came from the ED. Thus, across the 3 data sources, we captured information on all ED visits in the state during the period spanning October 1, 2004, to September 30, 2009, that are submitted annually from 69 acute care hospitals, accounting for approximately 2 million annual outpatient ED visits, 850,000 inpatient admissions, and 150,000 observation stays. Each of the 3 databases includes deidentified detailed information on the demographic characteristics of the patient (including age, sex, and race/ethnicity), payer type, and 5-digit zip code of residence. We included patients of all ages in the study.

There is no extant data source that can be used to measure the insurance status of every resident of the state. In place of a direct measure, we estimated area-level rates of insurance for each zip code during each period (first by quarter and then for each of the 3 periods of study) by calculating the percentage of visits by the insured for actual visits during the relevant period in each of the zip codes in the state (there are technically 566 zip codes but only 502 with a population greater than zero) and then calculated the change in insurance coverage from the first to the last period. We included 500 of these zip codes in our analyses because a few of them had such small populations that no ED visits originated from these areas.

We categorized patients as being self-pay, “free care” (in the uncompensated care pool or health safety net), Commonwealth Care, Medicaid, Medicare, or commercial insurance. We then created 2 larger groupings of coverage as “uninsured” for the self-pay category, and “insured” for all else because free care patients have coverage for services even though only at an individual hospital or community health center. Because we estimated the “rate” of uninsured in each zip code from the actual percentage of uninsured visiting the ED, our calculations of
changes in the percentage of insurance coverage in an area could have been confounded by changes in use that might have resulted from health care reform. Because visits over time might thus be endogenous with insurance status in an area, we separately calculated the baseline percentage of insurance, using ED visits from the prereform period as a sensitivity analysis because this measure would not be affected by changes in use over time that might have resulted from health care reform.

We categorized patients throughout all the years as white, black, Asian, or other and calculated the proportions in each category for each zip code for each year of the study. Unfortunately, the inconsistent coding practices for race made it difficult to accurately report the percentage of Hispanic patients with ED visits over time.

Primary Data Analysis

We used 2 specifications based on a difference-in-differences identification strategy to directly examine the influence of health care reform on ED utilization. A difference-in-differences approach is meant to compare differences between the before and after periods (“differences”) for treatment and control groups, as opposed to simply measuring the difference in one group before and after an intervention or between different groups after an intervention. This approach assumes that the differences in the proportion of ED visits by the insured across the different study periods is due to the health care reform and not other reasons, which are differentiated by the inclusion of contemporaneous control areas within the state that were less affected by health care reform.

Our first approach regresses the number of visits per zip code (measured quarterly) on the change in insurance rate from the first to the last period within the zip code (and separately using the baseline prereform percentage of visits by the insured), controlling for patient demographics and time of year. The key coefficients are the interaction effects between the change in insurance (or baseline insurance as a sensitivity analysis) and period, which represent the extent to which the increase in the number of visits in the within-reform and postreform periods was greater in zip codes that experienced larger increases in insurance, or in the case of the sensitivity analysis, to which any change in visits is related to a higher percentage of visits by the uninsured in the prereform period.

The second difference-in-differences specification tests whether ED utilization for the population younger than 65 years in the state was differentially affected across the periods of health care reform compared with the population aged 65 years or older, almost all of whom were covered by Medicare throughout the study period.

Finally, as a robustness check, we evaluated the extent that visits increased within a zip code as a function of changes in the insurance rate over time. We accounted for common variation in the number of visits across time (eg, seasonal effects, secular trends) through the inclusion of month dummies. This model tests whether changes in the insurance rate that resulted from health care reform (ignoring the period of health care reform) are related to changes in the rate of visits within a zip code.

A more detailed discussion of the approach to our statistical models is presented in Appendix E2 (available online at http://www.annemergmed.com). All models assume that unmeasured characteristics of the population in different geographic areas of the state remained relatively constant over time and, more
important, that there were no shifts in places of residence as a
direct result of health care reform. The expected number of ED
visits was modeled with a Poisson distribution. Additionally, we
include fixed effects for zip code and quarter to account for time-
invariant confounders and the general population trend over
time. Our quarterly time-trend dummies account for year effects,
seasonal effects, and their interaction.

In all our models, we incorporated data from 500 of the 566
zip codes in the state; we removed zip codes where no ED visits
originated from that area. Because we use a Poisson regression
model, the model automatically weights the contribution of each
zip code such that larger zip codes (those with a higher expected
number of visits) contribute more to the fitted regression model
than smaller ones.

All analyses were performed with SAS (version 9.1.3; SAS
Institute, Inc., Cary, NC). The study was approved by the
institutional review board at Beth Israel Deaconess Medical Center.

RESULTS

For the population younger than 65 years, we studied 4.3
million visits in the 2 years before health care reform, 2.2 million
visits during the health care reform period, and 4.5 million
visits during the post–health care reform period (Table 1). The

Table 1. Characteristics of visits for each period of health care reform.*

<table>
<thead>
<tr>
<th>Characteristics, Health Care Reform Period</th>
<th>&lt;65 Years</th>
<th>≥65 Years</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Baseline (2 Years)</td>
<td>During Reform (1 Year)</td>
</tr>
<tr>
<td>Total visits</td>
<td>921,311</td>
<td>444,180</td>
</tr>
<tr>
<td>Insured</td>
<td>3,910,524</td>
<td>2,001,535</td>
</tr>
<tr>
<td>Uninsured</td>
<td>372,678</td>
<td>147,769</td>
</tr>
<tr>
<td>Visits by uninsured</td>
<td>9.5</td>
<td>7.4</td>
</tr>
<tr>
<td>Visit disposition</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Discharged</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Insured</td>
<td>90.2</td>
<td>91.1</td>
</tr>
<tr>
<td>Uninsured</td>
<td>96.6</td>
<td>97.1</td>
</tr>
<tr>
<td>Observation</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Insured</td>
<td>2.3</td>
<td>2.3</td>
</tr>
<tr>
<td>Uninsured</td>
<td>0.7</td>
<td>0.8</td>
</tr>
<tr>
<td>Admitted</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Insured</td>
<td>7.5</td>
<td>6.6</td>
</tr>
<tr>
<td>Uninsured</td>
<td>2.7</td>
<td>2.2</td>
</tr>
<tr>
<td>Median age (IQR), y</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Insured</td>
<td>31 (28)</td>
<td>31 (28)</td>
</tr>
<tr>
<td>Uninsured</td>
<td>28 (18)</td>
<td>28 (17)</td>
</tr>
<tr>
<td>Women</td>
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<td></td>
</tr>
<tr>
<td>Insured</td>
<td>41.3</td>
<td>44.0</td>
</tr>
<tr>
<td>Uninsured</td>
<td>52.1</td>
<td>52.4</td>
</tr>
<tr>
<td>Race</td>
<td></td>
<td></td>
</tr>
<tr>
<td>White</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Insured</td>
<td>62.7</td>
<td>59.9</td>
</tr>
<tr>
<td>Uninsured</td>
<td>76.7</td>
<td>73.9</td>
</tr>
<tr>
<td>Black</td>
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<td></td>
</tr>
<tr>
<td>Insured</td>
<td>12.0</td>
<td>12.1</td>
</tr>
<tr>
<td>Uninsured</td>
<td>11.0</td>
<td>11.2</td>
</tr>
<tr>
<td>Asian</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Insured</td>
<td>1.4</td>
<td>1.2</td>
</tr>
<tr>
<td>Uninsured</td>
<td>1.7</td>
<td>1.7</td>
</tr>
<tr>
<td>Hispanic/other</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Insured</td>
<td>23.9</td>
<td>26.9</td>
</tr>
<tr>
<td>Uninsured</td>
<td>18.6</td>
<td>21.7</td>
</tr>
<tr>
<td>Primary insurance type</td>
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<tr>
<td>Commercial</td>
<td>54.0</td>
<td>51.6</td>
</tr>
<tr>
<td>Medicare</td>
<td>7.0</td>
<td>7.4</td>
</tr>
<tr>
<td>Medicaid</td>
<td>23.6</td>
<td>27.6</td>
</tr>
<tr>
<td>uncompensated care pool/health safety net</td>
<td>6.7</td>
<td>6.5</td>
</tr>
<tr>
<td>Commonwealth Care</td>
<td>0</td>
<td>0.1</td>
</tr>
<tr>
<td>Missing</td>
<td>0.01</td>
<td>0.02</td>
</tr>
<tr>
<td>Uninsured</td>
<td>8.7</td>
<td>6.9</td>
</tr>
</tbody>
</table>

*Data are percentage unless otherwise indicated.
Table 2. Percentage of ED visits by the uninsured.

<table>
<thead>
<tr>
<th>Quartile</th>
<th>Pre</th>
<th>During</th>
<th>Post</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>9.25</td>
<td>7.03</td>
<td>4.86</td>
</tr>
<tr>
<td>2</td>
<td>7.11</td>
<td>5.59</td>
<td>4.52</td>
</tr>
<tr>
<td>3</td>
<td>5.9</td>
<td>4.8</td>
<td>4.17</td>
</tr>
<tr>
<td>4</td>
<td>5.15</td>
<td>4.53</td>
<td>4.37</td>
</tr>
</tbody>
</table>

population aged 65 years and older included an additional 921,311 visits in the prereform period, 444,180 visits during health care reform, and 919,667 visits in the postreform period. Overall ED visits by the uninsured younger than 65 years decreased from 9.5% of overall visits before health care reform to 5.7% of visits afterward, whereas the percentage of ED visits by the uninsured for the population aged 65 years and older remained steady, at about 1%. Free care visits for the population younger than 65 years decreased from 6.7% before reform to 3.8% after. Five hundred zip codes were included in our analysis. From the prereform to within-reform periods, 462 zip codes experienced a decrease in the percentage of visits by the uninsured and 38 zip codes experienced an increase. From the prereform to postreform periods, 484 zip codes experienced a decrease in the percentage of visits by the uninsured and 16 zip codes experienced an increase.

Table 2 shows the demographic characteristics of the population, as well as visits for each type of ED visit (admission, observation, and discharge) across the periods of health care reform. The median age of patients younger than 65 years was 31 years, and approximately half were women across all study years. The demographic characteristics of those visiting the ED remained substantively unchanged over time. Unfortunately, changes in coding practices for race made it difficult to properly report the percentage of Hispanic patients with ED visits over time. Table 1 also demonstrates a breakdown of visits for all 3 periods of the study by type of insurance. This table in particular illustrates the visits by individuals covered by the new publicly subsidized insurance product referred to as Commonwealth Care, in addition to visits related to the expansion of Medicaid.

Table 2 is presented to demonstrate the percentage of ED visits by the uninsured for each of the 4 quartiles of change in insurance during the 3 periods of health care reform. Results for the modeling estimation strategies are presented in Table 3. Our difference-in-differences analyses based on the change in insurance rate reveal a positive effect on ED utilization both during and after reform (within-reform estimate 0.32, \( P<.03 \); postreform estimate 0.57, \( P=.008 \)), suggesting that areas of the state with greater increases in insurance as a result of health care reform had greater increases in ED utilization. This translates to a 1.2% increase (95% confidence interval [CI] 0.2% to 2.3%) in visits per year during the within-reform period and a 2.2% increase (95% CI 0.6% to 3.8%) during the postreform period.

The analysis comparing use for the populations younger than 65 years versus aged 65 years and older also revealed a positive effect of health care reform on overall ED utilization among the population younger than 65 years for both the within-reform (estimate 0.05; \( P<.001 \)) and postreform periods (estimate 0.04; \( P<.001 \)). This would result in a 0.2% increase (95% CI 0.1% to 0.2%) in visits per year during the within-reform period and a 0.2% increase (95% CI 0.1% to 0.2%) in the postreform period. The results of the fixed-effect models and the sensitivity analysis (Table 3) also are consistent with the results of the primary difference-in-differences models.

Figure 2 demonstrates the average number of visits across all zip codes, using the raw data, adjusted only for season. This figure must be interpreted with caution because it does not examine the change in visits in areas according to area changes in the percentage of visits by the uninsured. Figure 3 shows ED

Table 3. Results of the primary model of ED utilization and sensitivity analyses.*

<table>
<thead>
<tr>
<th>Modeling Approach</th>
<th>Results</th>
<th>( \text{Estimate (Regression Coefficient)} )</th>
<th>( \text{P Value} )</th>
<th>Increase in Additional Visits per Year From Health Care Reform (95% CI), %</th>
</tr>
</thead>
<tbody>
<tr>
<td>Model based on changes in the percentage of insurance coverage over time across zip codes (comparing prereform to during reform and postreform periods)</td>
<td>( \text{During reform: 0.32} ) ( \text{Postreform: 0.57} ) ( \text{During reform: .03} ) ( \text{Postreform: .008} )</td>
<td>( \text{During reform: 1.2 (0.2–2.3)} ) ( \text{Postreform: 2.2 (0.6–3.8)} )</td>
<td>( \text{During reform: 1.0 (0.5–1.6)} ) ( \text{Postreform: 1.7 (0.9–2.5)} ) ( \text{During reform: 0.2 (0.1–0.2)} ) ( \text{Postreform: 0.2 (0.1–0.2)} ) Increase of 2.0 (1.0–3.0)</td>
<td></td>
</tr>
<tr>
<td>Same as above but using baseline percentage of visits by individuals with insurance</td>
<td>( \text{During reform: 0.27} ) ( \text{Postreform: 0.45} ) ( \text{During reform: &lt;.001} ) ( \text{Postreform: &lt;.001} )</td>
<td>( \text{During reform: 1.0 (0.5–1.6)} ) ( \text{Postreform: 1.7 (0.9–2.5)} ) ( \text{During reform: 0.2 (0.1–0.2)} ) ( \text{Postreform: 0.2 (0.1–0.2)} ) Increase of 2.0 (1.0–3.0)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Model comparing visits for the &lt;65 y and ( \geq 65 ) y over time (comparing prereform to during reform, and postreform periods)</td>
<td>( \text{During reform: 0.05} ) ( \text{Postreform: 0.04} ) ( \text{During reform: &lt;.001} ) ( \text{Postreform: &lt;.001} )</td>
<td>( \text{During reform: 1.0 (0.5–1.6)} ) ( \text{Postreform: 1.7 (0.9–2.5)} ) ( \text{During reform: 0.2 (0.1–0.2)} ) ( \text{Postreform: 0.2 (0.1–0.2)} ) Increase of 2.0 (1.0–3.0)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*Controls for person and place characteristics.
†Compared as percentage change=\( \text{100} \times (\text{EXP} (\text{Estimate} \times 0.038) - 1) \), where 3.8% is the absolute increase in the percentage of visits by individuals with insurance from the prereform to postreform periods. The resulting quantity is the percentage change in ED visits given a 3.8% change in the corresponding predictor.
‡Model accounts for common variation in the number of visits across time (eg, seasonal effects, secular trends) through the inclusion of month dummies and includes fixed effects for zip code to account for time-invariant features of each zip code. Tests whether changes in the percentage of insurance coverage that resulted from health care reform (ignoring the period of health care reform) are related to the number of visits in a zip code. Model also controls for patient and place characteristics measured at the zip code level.
visits over time (by quarter) for the 4 quartiles of zip codes, ranging from the quartile that was most affected by health care reform to the quartile of zip codes that showed the least change in insurance coverage. Visually, it is apparent that the quartile including the zip codes with the largest change in insurance had a relative increase in visits compared with the quartile with the least change in insurance. On the other hand, there is no clear pattern of increase for the population older than 65 years.

**LIMITATIONS**

There are several limitations to our analyses. The ideal way to study this issue outside the context of a randomized controlled trial would be to obtain insurance coverage data on a defined cohort of patients and compare those who obtain health insurance with those who either did not obtain health insurance or already had health insurance, using a difference-in-differences approach. Such data, however, are unavailable. The statewide...
data set of ED visits that we used is a next best approximation. A major limitation of this approach is the use of the frequency of ED visits by the uninsured as an estimate of the overall percentage of uninsured in the overall area population. We used this estimate because there is no extant source of population-level data on the percentage of individuals without insurance. This potentially means that our calculations of changes in rates of insurance coverage in an area could have been confounded by changes in use that might have resulted from health care reform. We compensated for this by using several different modeling strategies. In addition, we found consistent results in models by using the baseline insurance rates, which would not have the same limitation. Furthermore, the difference-in-difference analysis using the population older than 65 years as a control group had similar results.

An additional limitation is the use of a visit-based analysis (deidentified data not accounting for individual person or repeated visits) rather than a person-based analysis. Using ED visits as opposed to individual persons may introduce the potential bias of determining population-based insurance rates based on those with frequent use of the ED. Our sensitivity analysis based on the prereform uninsurance rate, however, addresses this concern and demonstrated similar results.

We also could not explicitly control for population-level factors in each zip code, other than by relying on information from patients who used the ED. However, it is unlikely that migration patterns within the state would have been driven by health care reform, or that any migration patterns would explain our results. Although the rate of increase of the Massachusetts population between 2005 (6,398,743) and 2010 (6,646,144) of 3.8% slightly exceeds the growth in ED visits observed in our study, there would have to be substantial growth centered specifically in the areas of increased insurance for population growth to solely explain our findings. Furthermore, as mentioned above, the consistency in results of our 3 models is reassuring in that our results are not explained by trends in population growth.

We also did not focus specifically on use by individuals with Medicaid, which has been studied extensively elsewhere.8-10 Our analyses focus on the larger effect of increasing health insurance coverage—temporally associated with health care reform—on utilization of the ED. However, our results are generally consistent with the most recent results from the Oregon Medicaid experiment, in which gaining insurance was associated with increases in ED utilization.10

Finally, our analyses are likely to underestimate the effect of health care reform nationally because of the baseline high rate of insurance coverage in Massachusetts. Even before health care reform implementation, Massachusetts had a robust safety net system in place, and most patients had health insurance. For instance, our data show that the percentage of insured visits to the ED increased by just 3.8% from the prereform to the postreform period. Thus, the magnitude of the effect on ED visits is no doubt limited.

**DISCUSSION**

To our knowledge, this is the first study using complete data on statewide ED visits to demonstrate that the increase in insurance coverage associated with health care reform in Massachusetts resulted in a small but measurable increase in ED visits across the state. Not unexpectedly, these findings were concentrated in areas of the state that were most affected by health care reform and were not present for the population that was covered by Medicare for the entire study period. Our findings also are robust and consistent across several different specifications. These results carry significant implications for our understanding of the effect of insurance on the use of emergency care and for states planning for the impending effect of national health care reform.

In a previous study using data from selected Massachusetts hospitals, health care reform was associated with a small decrease in low-urgency ED visits but an increase in admissions for ambulatory care–sensitive conditions, perhaps indicating that the effect of health care reform was overshadowed by limitations in access to primary care.8 Chen et al5 recently demonstrated that although the rate of overall ED visits in Massachusetts continued to increase after health care reform, the rate of ED use and admissions from the ED in Massachusetts did not differ substantially from that of nearby states during the same period. That study, however, was underpowered to detect changes of the magnitude we observed and could not account for state-specific policies that might have differentially affected growth rates within a state. In addition, recent survey data from the Urban Institute and the Blue Cross Foundation reported a small decrease in self-reported ED utilization from 2006 to 2010, but these findings are limited by small sample sizes and possible nonresponse bias.11,12 Finally, Miller6 studied the effect of health care reform on all ED discharges (ie, did not include observation visits or admissions) according to county-level prereform uninsurance rates and found a decrease in lower-urgency ED visits. This study has a number of potential limitations, most notably evaluating only ED discharges. Our study improves on these earlier studies by using comprehensive data on all ED visits in the state and by comparing areas or populations within Massachusetts for which we would expect more or less effect from health care reform. As a robustness test, we also examined these same trends using a model comparing use with overall coverage during the 20 quarters, without respect to the phase of health care reform, which also yielded similar results.

Both economic theory and previous empirical evidence suggest that having health insurance may increase use of certain health care resources, including the ED, and, conversely, that greater financial barriers such as increased copayments may result in reduced use of both necessary and unnecessary care.13 Recent evidence from the Oregon Medicaid expansion further supports this link between insurance and greater overall health care use.9,10

The connection between health insurance and ED utilization likely is related to a number of factors, including financial barriers to care, universally available ED care as mandated by the federal Emergency Medical Treatment and Labor Act, and access to
primary care. In this context, our results are as expected: increasing the rate of insurance may have reduced financial barriers to care while minimally affecting barriers to accessing timely care outside of the ED.

Thus, our results are consistent with the view that although extending health insurance through expansions of programs such as Medicaid and Commonwealth Care (publicly subsidized insurance products) may reduce some of the financial barriers to accessing a regular source of care, other nonfinancial barriers continue to limit overall access to care. In addition, access to primary care for individuals who already had insurance might have been affected by the increased number of newly insured, leading to increased use of the ED among this population. The reality is that primary care access remains limited in Massachusetts and across the United States, and in most states the problem is far grimmer than in Massachusetts. Indeed, the past decade has witnessed an increase in the prevalence of barriers to timely primary care and an associated increase in ED utilization in other settings. Consequently, our study suggests that other states should be prepared for equal or greater influxes of patients into the ED after health care reform is fully implemented. Before making any definitive conclusions about the potential effect of health care reform in other states, however, we will need additional data in Massachusetts about primary care and other health care use after health care reform in addition to data from other states as health care reform is implemented.

This study also should further weaken the long-held notion that high use of the ED is being driven mainly by the uninsured. Other recent data confirm that the percentage of ED visits made by the uninsured is proportional to the rate of uninsured in the population, though the reasons for ED visits differ between the insured and uninsured. The drivers of ED use are multifactorial, encompassing enabling factors such as transportation, 24-hour availability, the ability to take time off from work or find suitable child care, distance to the nearest ED or primary care provider, and the perceived efficiency, technologic expertise, and quality of ED care, increasing awareness of emergency conditions, and the increasing commodification of health care that accompanies the diminished role and availability of primary care. Health system reforms will need to be mindful of each of these factors when care systems are designed for the future.

In summary, in this study of health care reform implementation in Massachusetts we find that increases in health insurance coverage were associated with small but consistent increases in overall ED utilization. Additional study after the implementation of the Patient Protection and Affordable Care Act will be important. Although there is no definitive explanation for these findings, previous work suggests there are several potential explanations, including but not limited to pent-up demand before obtaining health insurance coverage, decreased economic barriers to seeking emergency care, the lack of access to primary care, or a combination of these factors.

REFERENCES


APPENDIX E1.
Description of Massachusetts health care reform.

Overall, approximately 70% of the newly insured in Massachusetts obtained coverage through expansion of MassHealth, the state’s Medicaid program (including an extension of children’s eligibility from 200% to 300% of the federal poverty level), and enrollment in Commonwealth Care, a publicly subsidized option for individuals with low income who do not qualify for Medicaid. On October 1, 2006, Commonwealth Care became available to eligible individuals with incomes under 100% of the federal poverty line. Also, an employer assessment of $295 per employee was put into place for employers with more than 11 employees who failed to offer “fair and reasonable” coverage. Expanded Commonwealth Care with sliding subsidies for individuals with incomes between 100% and 300% of federal poverty line became available on January 1, 2007. Many of the individuals who enrolled in both fully subsidized and partially subsidized Commonwealth Care plans were previously uninsured but covered for services at specified individual hospitals and community health centers through the Uncompensated Care Pool, a system of reimbursement to individual hospitals and community health centers that provided coverage to lower-income and underinsured people, but only at a specific institution. Under health care reform, the Uncompensated Care Pool was replaced with a smaller Health Safety Net Fund providing care mostly to undocumented immigrants and underinsured lower-income individuals for whom insurance was deemed not “affordable.”

In April of 2007, the Commonwealth Connector, a quasi public health insurance exchange, began offering unsubsidized coverage for small businesses and individuals with incomes in excess of 300% of the federal poverty line (Commonwealth Choice plans). The Connector also manages the Commonwealth Care plans offered by 4 existing Medicaid managed care plans. Beginning in July 2007, the individual mandate to purchase went into effect, subjecting individuals without insurance to a penalty initially equal to loss of the personal income tax exemption: about $218 for an individual and $437 for a family. Starting in 2008, the tax penalty increased to half the monthly cost of the lowest available premium for which an individual would have qualified through the connector (equal to $912 in 2008).
APPENDIX E2.
Detailed description of statistical models.

We use 3 general approaches based on a difference-in-differences identification strategy analysis to directly examine the influence of health care reform on ED utilization and 1 repeated-measurements approach to examine the indirect influence of health care reform on ED utilization through the percentage insured. Thus, 4 types of models were estimated.

A crucial assumption of all models is that the size and composition of the population in different geographic areas of the state remained relatively constant over time and, more important, that there were no shifts in places of residence as a direct result of health care reform, which would lead to biased estimates.

In each analysis, we include fixed effects for zip code and quarter to account for variation between zip codes and across time that is unrelated to health care reform. Although we fit fixed-effect models for zip code that incorporate adjustments to the standard errors using generalized estimating equations, when these models have a nonindependent working correlation, the parameter estimates differ from those under the fixed-effect model with no adjustment for clustering. Therefore, as a sensitivity analysis we ran the models with an independent as opposed to an AR(1) or other nonindependence correlation structure to ensure that the assumed correlation structure did not sway the results substantially. Main effects for person and place characteristics (percentage of male patients, percentage in various racial groups, median age, etc) related to use were controlled for to account for differences in patient characteristics across zip codes and across time (see main text). Our quarterly time-trend dummies account for year effects, seasonal effects, and their interaction.

Because the outcome is a count, it is reasonable to assume they are from a Poisson distribution with a mean whose log depends linearly on the predictors. Because ED visits are nested within zip codes, we account for the grouped error structure, using generalized estimating equations with appropriately chosen working correlation matrices.

MODELS RELATING THE NUMBER OF VISITS TO BASELINE OR CHANGE IN INSURANCE

We hypothesized that the effect of health care reform during our 3 periods of study (before, during, and after health care reform) would differentially affect individuals from areas of the state that were most likely to be affected by health care reform (ie, areas of the state with high insurance coverage levels throughout the entire period). We computed the change in percentage visits by the uninsured from the preperiod to the postperiod and the average percentage of visits by the uninsured in the preperiod and for each zip code (which identifies areas of the state most likely to be affected by health care reform). We also defined dummy variables for the within-reform and postreform periods. Under both specifications, we assume an autoregressive correlation structure to account for possible latent correlation proportional to the longitudinal closeness of the observations.

We first fit a marginal Poisson regression model in which the linear predictor or systematic component of the model has the form:

\[
\log(\mu_i) = \lambda_i + \gamma_i + x_i^T \beta_i + \beta_3 \text{PreUnins}_i \text{InHR}_{it} + \beta_4 \text{PostHR}_i,
\]  

(1)

Under (1) the quantities \(\exp(\beta_3)\) and \(\exp(\beta_4)\) represent the effects on the number of visits during the within-reform and postreform periods, respectively, because of a 1-percentage-point increase in the percentage of insured patients from the baseline period to the postperiod. These effects represent the extent to which the increase in the number of visits in the within-reform and postreform periods was greater in zip codes whose percentage insured increased the most.

An alternative form of this model uses the preperiod percentage of insured instead of the change in insurance:

\[
\log(\mu_i) = \lambda_i + \gamma_i + x_i^T \beta_i + \beta_3 \text{PreUnins}_i \text{InHR}_{it} + \beta_4 \text{PreUnins}_i \text{PostHR}_i,
\]  

(2)

where \(Y_{it} = E[Y_{it} | x_i] \) is the expected number of visits, \(Y_{it} \) is the observed number of visits, and \(x_i \) is a vector of aggregate patient covariates (case-mix variables) in zip code \(i \) during quarter \(t \), \(\lambda_i \) is the effect of zip-code \(i \), \(\gamma_i \) is the effect of time period \(t \), PreUnins is the percentage uninsured in the pre–health-reform period in zip code \(i \), and InHR and PostHR are dummy indicator variables for the within-reform and the postreform periods, respectively.

The key coefficients in model (2) are the regression coefficients of the interaction terms, \(\beta_3 \) and \(\beta_4 \). The quantities \(\exp(\beta_3)\) and \(\exp(\beta_4)\) are the relative increases in the number of visits during the within-reform and the postreform periods, respectively, because of a 1-percentage-point increase in the percentage of uninsured patients in the preperiod. (The main effect of percentage insured in the preperiod is absorbed in the zip code fixed effect, so is not explicitly represented.) The rationale is that zip codes with low preinsurance rates should experience the greatest increase in visits because their insured rate is subject to the most change from health care reform.
**DIFFERENCE-IN-DIFFERENCE ANALYSIS EXPLOITING PATIENT AGE GROUP**

The third difference-in-differences approach does not involve frequencies of insurance. Instead, it tests whether the population younger than 65 years was differentially affected compared with the population older than 65 years in the during-reform and postreform periods relative to the prereform period. We hypothesized that health care reform would preferentially affect the population younger than 65 years because almost all residents aged 65 years or older were covered by Medicare throughout the study period. In this analysis, we analyze separate counts of visits for the populations younger and older than 65 years in a single model; that is, we can think of the dependent variable for each zip code quarter as being a bivariate count. Therefore, in this analysis the trend for the population older than 65 years acts as a control across all periods, enabling the difference-in-difference effect of the population younger than 65 years in the within-reform and postreform periods compared with the prereform period to be attributed to health care reform. The model has the general form

\[
\log(\mu_{it}) = \lambda_i + \gamma_t + \beta_1 x_{it} + \beta_2 \text{AgeU65}_i + \beta_3 \text{AgeU65}_i \text{InHR}_{it} + \beta_4 \text{AgeU65}_i \text{PostHR}_{it};
\]

where \(i\) is a binary variable that takes the value 1 for the population younger than 65 years and 0 for the population older than 65 years. Unlike the zip code insurance measures used in models (1) and (2), varies within each zip code and so its main effect is estimable and should be accounted for to extract the modification of its effect because of health care reform.

The effects of interest under (3) are \(\beta_3\) and \(\beta_4\). Their exponentials equal the relative increase in the number of visits during the within-reform and postreform periods among individuals younger than 65 years old compared with those older than 65 years in the same zip code. If the hypothesis that health care reform affects only individuals younger than 65 years is true, then we would expect both \(\beta_3\) and \(\beta_4\) to be positive. Because of the nonoptimal means we have to estimate zip code insurance rate, the model in (3) approach might be viewed as our most robust difference-in-difference approach.

Because separate repeated observations were made on the populations younger and older than 65 years, we treated zip code by patient type (<65 years, >65 years) as the clustering variable. Surprisingly, we encountered difficulties estimating the model with generalized estimating equations with an autoregressive working correlation structure. Therefore, we used an independent working correlation; this enables consistent estimation but by not directly accounting for latent serial correlation may compromise some precision.

**MODEL THAT ESTIMATES DIRECT EFFECT OF HEALTH INSURANCE ON VISITS**

The fourth approach evaluates the extent that more visits occur in the same zip code during quarters of higher insurance compared with quarters of lower insurance. As for models (1) to (3), it accounts for differences in the size of zip codes through the inclusion of zip code dummies (fixed effects) and common variation in the number of visits across time (eg, seasonal effects, secular trends) through the inclusion of month dummies. The systematic component of the model has the general form:

\[
\log(\mu_{it}) = \lambda_i + \gamma_t + \beta_1 x_{it} + \beta_2 \text{Ins}_{it}.
\]

The key predictor in (4) is the quarterly contemporaneous insurance rate, \(\text{Ins}_{it}\); the exponential of its effect, \(\exp(\beta_2)\), is the relative increase in the expected number of visits associated with a 1-percentage-point increase in insurance that quarter. Because zip codes act as their own controls, in (4) \(\hat{\beta}_2\) tests whether percentage insured (considered a consequence of health care reform) is associated with the number of visits. We estimated the model with generalized estimating equations with an autoregressive working correlation matrix.