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Massachusetts Reform and Disparities in Inpatient Care Utilization

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Abstract

Background—The 2006 Massachusetts health reform substantially decreased uninsurance rates. Yet, little is known about the reform's impact on actual healthcare utilization among poor and minority populations, particularly for receipt of inpatient surgical procedures that are commonly initiated by outpatient physician referral.

Methods—Using discharge data on MA hospitalizations for 21 months preceding and following health reform implementation (7/1/2006 – 12/31/2007), we identified all non-obstetrical major therapeutic procedures for patients aged 40 and for which 70 percent of hospitalizations were initiated by outpatient physician referral. Stratifying by race/ethnicity and patient residential zip code median (area) income, we estimated pre- and post-reform procedure rates, and their changes, for those aged 40–64 (non-elderly), adjusting for secular changes unrelated to reform by

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comparing to corresponding procedure rate changes for those aged ≥ 70 (elderly), whose coverage (Medicare) was not affected by reform.

Results—Overall increases in procedure rates (among 17 procedures identified) between pre- and post-reform periods were higher for non-elderly low area income (8%, $p=0.04$) and medium area income (8%, $p<0.001$) cohorts than for the high area income cohort (4%); and for Hispanics and Blacks (23% and 21% respectively; p values <0.001) than for Whites (7%). Adjusting for secular changes unrelated to reform, post-reform increases in procedure utilization among non-elderly were: by area income, low=13% (95% CI=[9%, 17%]), medium=15% ([6%, 24%]) and high=2% ([−3%, 8%]), and by race/ethnicity, Hispanics=22% ([5%, 38%]), Blacks=5% ([−20%, 30%]) and Whites=7% ([5%, 10%]).

Conclusions—Post-reform use of major inpatient procedures increased more among non-elderly lower and medium area income populations, Hispanics, and whites, suggesting potential improvements in access to outpatient care for these vulnerable subpopulations.

A central policy assumption in the U.S. is that expanding health insurance coverage will improve access to health care and outcomes, and make each more equitable for all Americans.(1) Massachusetts (MA) is the site of a key policy-relevant natural experiment; (2–8) recent legislation has resulted in nearly all (96.5%) of the state's residents obtaining health insurance.(9) However, little is known about MA reform's impact on health care utilization, particularly among poor and minority populations, whose access to care the reform sought to increase.

The number of uninsured MA residents fell sharply after the reform was implemented.(10) Among adults aged 18 to 64, the population targeted by the reform, uninsurance rates declined from 8.4% (2006) to 3.4% (2009) overall, but from 18% to 9% among the poorest population quintile, from 15% to 5% among Blacks and 20% to 13% among Hispanics. (9, 11, 12) However, the limited evidence of the reform's impact on access to and use of health care, based largely on population surveys, provides a mixed picture. Self-reported rates of a usual source of care and of preventive care visits improved post-reform; however, lower income respondents and Hispanics with limited English proficiency reported higher rates of unmet need due to difficulty in finding a health care provider or due to unaffordable cost. (12–14) While evidence of the impact of health reform on emergency department (ED) use is mixed, hospitalizations for conditions preventable by appropriate outpatient care decreased.(15–18)

There have not yet been reports on the use of inpatient surgical procedures whose receipt is sensitive to outpatient physician referral. Changes in receipt of such surgical procedures following MA health reform could be a measure of access to outpatient care that may improve with expanded insurance coverage.(19) Thus, we focused on the use of such procedures among vulnerable subpopulations – those living in low-income areas and racial/ethnic minorities. These groups are known to underutilize elective inpatient care, (20–22) and were specifically targeted for larger gains in coverage expansion from the MA health reform.(23) We hypothesized that the entire reform package, including increased population rates of insurance coverage, would be associated with increased rates of receipt of surgical procedures most commonly initiated through outpatient physician referral, and that such gains would be greater among vulnerable populations.

METHODS

Overview

We estimated longitudinal population rates of receipt of referral-dependent procedures by combining comprehensive state-level inpatient administrative data with census population

data. We estimated pre- and post-reform rates of procedure use among non-elderly subpopulations stratified by cohorts defined by race/ethnicity and income of the area of patient residence. To isolate the impact of health reform from secular trends, we contrasted post-reform change among the non-elderly with changes among the elderly. We chose this control group because most elderly residents were covered by Medicare both pre- and post-reform, and therefore the change in their procedure use reflects secular changes unrelated to health reform.

Pre- and Post-Reform Periods

The MA health reform was multifaceted and included measures to expand insurance coverage, such as individual and employer mandates, establishment of an insurance exchange, income-related premium subsidies for newly created private insurance and loosened eligibility criteria for Medicaid coverage.(2) Implementation of MA health reform began on 7/1/2006 with expansion of Medicaid to cover previously “enrollment capped” low income populations, culminating in a penalty-enforced mandate of individual insurance coverage effective 1/1/2008.(24) We examined inpatient procedure use for 21 months (1/1/2008 to 9/30/2009) following this mandate (“post-reform” period) and contrasted it with data for 21 months (10/1/2004 to 6/30/2006) preceding reform (“pre-reform” period), excluding the middle, transition period.

Data Sources and High Referral Rate Procedures

We focused on hospitalizations for surgical procedures that are predominantly scheduled by outpatient referral, that we term “high referral rate procedures”. While similar to the previously defined concept of “referral-sensitive procedures”,(19) we found that for some referral-sensitive procedures (e.g., coronary artery bypass graft) the proportion arising from outpatient referral was no higher than 50 percent (see Appendix). Using all hospitalizations with discharges during the pre- and post-reform periods as raw data (MA Inpatient Discharge Data for 2004–09)(25), we included MA-residing patients aged 40 or older (those with significant risk for the procedures examined) undergoing a major therapeutic surgical procedure (using AHRQ Procedure Classes system; CCS), as illustrated by Figure 1.(26) These procedures’ ICD-9-CM diagnosis codes were classified into the 231-category AHRQ CCS.(27) To minimize chance misclassification we only included procedures with aggregate volume ≥ 500. We excluded obstetrical procedures as their usage has been universally covered in MA.

Based on the “source of admission” field, we defined high referral rate (HRR) procedures as those with an outpatient physician referral rate ≥ 70 percent, reasoning that this threshold would represent a large majority of procedures. We excluded some non-specific HRR procedures – for instance, “Other operations of the ovary” – that captured a broad range of procedures. To minimize chance fluctuations in procedure use, we grouped the HRR CCS procedures into ICD-9-CM procedure categories(27) and excluded those with < 200 surgeries for each area income or race/ethnicity cohort.

Information on patient race/ethnicity was part of the discharge data submitted by each hospital; as such identification is likely based on multiple sources, including, patient self-report and administrative records. We found longitudinal consistency in the reporting patterns over years, not only for the main racial/ethnic groups (Whites, Blacks and Hispanics), but also for proportion with missing race/ethnicity; the proportion of all discharges in a year with race/ethnicity missing or “Other” (i.e., not White, Black or Hispanic) ranged between a low of 5.32% (2004) to 6.06% (2006) of the study period years (2004–2006, 2008–2009).

Analytic Data Structure

To estimate pre- and post-reform procedure use we produced two analytic datasets, one for performing comparisons by race and ethnicity and another for comparisons by area income. The first dataset was obtained by stratifying the state population into cohorts stratified by race/ethnicity, age, sex, county and time period (i.e., pre/post-reform). We stratified patients by the three largest race/ethnic cohorts: Hispanics, non-Hispanic Whites and non-Hispanic Blacks (see Appendix). Categorizing patient age (in years) into ten five-year age groups aged 40–84 (e.g., 40–44), we excluded the 65–69 age group; as the post-reform study period lasts 21 months, inclusion of both 60–64 and 65–69 age cohorts may over-estimate reform effect on procedure use if those initially aged 63 or 64 then age into the 65–69 age group and became eligible for Medicare before the end of the 21st month. Excluding this age group also eliminates the sharp increases in procedure use previously noted for new Medicare age-65 enrollees.(28, 29) To adjust for geographic heterogeneity across MA in factors determining procedure use, we stratified the state into 11 county-based areas, as this is the finest sub-state level for which annual census population counts are available.(30) This allowed us to perform a finer grained analysis than that at the larger state level. With each county stratified into 54 cohorts (based on sex, nine age groups and three racial/ethnic groups), there were a total of 594 observations each for the pre- and post-reform periods (N=1,188).

For the second analytic dataset, we followed a similar process but replaced race/ethnicity strata by area income strata. In the absence of individual income, we followed previous work and used the median income (2000 census) for each patient's residence zip code, to stratify all patients into three area income groups: lowest quartile (i.e., all residents of zip codes in the poorest quartile, henceforth referred to as "low area income" population), second lowest quartile ("medium area income") and top two quartiles combined ("high area income").(22, 31–33) As the number of area income cohorts (N=3) is the same as that number of race/ethnicity cohorts, the second analytic dataset has the same number of observational units (N=1,188).

Procedure Rates

Our primary outcome measure was a **procedure rate** for each cohort of interest, derived from the ratio of (1) the number of HRR procedures for each cohort in the inpatient discharge data, and (2) the census population of this cohort, and then multiplying this ratio by 10,000 so as to obtain the procedure rate per 10,000 census population.

Analysis

We estimated pre- and post-reform procedure rates for all HRR procedures combined and for each individual procedure category, for subpopulations by area income or race/ethnicity; we adjusted for compositional differences in sex and age by direct standardization.(34) These adjusted rates were estimated separately for non-elderly and elderly cohorts. We first measured overall change (%) in procedure use – the percentage change between pre- and post-reform procedure rates. To estimate net change (%) associated with health reform, we adjusted for secular changes using the elderly as the comparison cohort ("difference-in-difference" estimation).(35, 36) We used a count regression (Poisson) model with procedure count as the outcome measure and census population count as the population at risk. We specified a county-level fixed effects regression structure (with clustering-adjusted standard errors) to capture nesting of cohorts within county. (35, 37) Regression covariates included indicators of age, sex, race/ethnicity or area income, time period (pre/post-reform) and interaction between the elderly/non-elderly indicator and time period (to estimate the net change). Statistical significance was assessed at the level of $p < 0.05$. All estimation was performed using Stata Version 11.1.(37) We performed several sensitivity analyses to assess

the robustness of findings to a) inclusion of 65–69 age group, b) alternative count regression (i.e., negative binomial) specification, and c) state-level aggregated unit of analysis (i.e., without county-level stratification). To address potential bias from regression to the mean or differential changes in the characteristics of the study over time, we also estimated an alternative model based on segmented time-series specification of post-reform effects that allowed for level and trend effects. This study was approved by the Boston University Medical Campus Institutional Review Board.

Note that the comparison groups were based on age, not whether the patient held Medicare coverage, so dual eligibles were included with their respective age groups. Our estimates are based on change in procedure rate (say, among non-elderly or elderly patients) between the pre- and post-reform period. It may well be that the subgroup of, say, elderly with dual-eligibility may have different procedure rates than their counterparts without dual-eligibility; however, to the extent that prevalence of dual-eligibility remained similar in the pre- and post-reform periods, it does not impact the net estimates that we have estimated.

RESULTS

We identified 17 HRR procedures, in five clinical categories, with an aggregate volume of 201,907 surgeries during the pre- and post-reform periods (Table 1). The overall referral rate for all procedures was 90%.

Table 2 summarizes the number of people undergoing HRR procedures, the number of people in the population at risk, and each group's socio-demographic composition pre- and post-reform. Whereas the non-elderly accounted for 60% of pre-reform surgeries, their share increased to 64% in the post-reform period; however, the non-elderly share of the population at risk remained at 78%. The share of Blacks and Hispanics increased both among procedure recipients (6.4% to 8.2%) and the population at risk (9.0% to 9.8%); share by area income cohorts did not change.

Procedure Rates & Overall Post-reform Change by Area Income

Pre-reform use of HRR procedures was similar among non-elderly area income subgroups (Table 3). After reform, overall increases in procedure rates were higher for low area income (8%, $p=0.04$) and medium area income (10%, $p<0.001$) cohorts compared to that for their high area income counterparts (4%). Adjusting for secular changes, the impact of health reform for the non-elderly income cohorts (or the net change in procedure rate) was: 13% (low area income, 95% CI=[9%, 17%]), 15% (medium area income, 95% CI=[6%, 24%]) and 2% (high area income, 95% CI=[-3%, 8%]).

Procedure Rates & Overall Post-reform Change by Race/Ethnicity

Pre-reform use of all HRR procedures was significantly lower among non-elderly Hispanics (118 procedures per 10,000 population; $p<0.001$) and Blacks (149; $p=0.05$) compared to Whites (157). After reform, overall change in procedure rates among the non-elderly was greater among Hispanics (23%, $p<0.001$) and Blacks (21%, $p<0.001$) compared to that among Whites (7%). Adjusting for secular trends, the net change in procedure rate was 22% (95% CI=[5%, 38%]) for Hispanics, 5% for Blacks (95% CI=[-20%, 30%]) and 7% for Whites (95% CI=[5%, 10%]).

Post-reform Change by Procedure Categories

Table 4 presents analogous findings for each procedure category by area income and race/ethnicity. There is considerable variation in overall and net changes across categories, with some indicating secular decrease in procedure rates, but statistical precision of estimates is

also reduced due to relatively smaller volumes within individual procedure categories. For musculoskeletal and urinary/genital procedures, both low and medium area income cohorts experienced significant increase in overall post-reform procedure rates. Although not statistically significant, we find that compared to the high area income group, the estimated net increase (%) was larger or net decrease smaller for all five procedure categories among the lowest area income cohort and for four procedure categories among the medium area income cohort. Comparisons by race/ethnicity indicate that compared to Whites, the estimated net change (%) was greater for three of the procedure types (musculoskeletal, urinary/genital and nervous) among Hispanics, but only for digestive procedures among Blacks – and statistically significant only for nervous system procedures among Hispanics.

Sensitivity analyses indicate that all main findings reported are robust to a) inclusion of those aged 65–69, b) alternative count regression specification to permit overdispersion, and c) aggregation of procedure counts to state instead of county level (see Appendix). Segmented time-series Poisson model indicated similar patterns in post-reform change, with no significant transition period effects for any of the cohorts (see Appendix).

DISCUSSION

We compared pre- and post-reform utilization of major therapeutic inpatient surgical procedures predominantly scheduled by outpatient referrals among non-elderly MA adults, and found greater overall increases for lower area income cohorts compared to the highest area income cohort, and for Hispanics compared to Whites. Prior to reform, both Blacks and Hispanics had lower rates of these procedures compared to Whites. We estimated the net change in procedure use associated with health reform among the non-elderly accounting for secular trends, finding significant increases for lower area income groups and Hispanics and Whites but not among Blacks or the highest area income group. As 90 percent of all surgeries came from outpatient physician referral, these findings suggest a meaningful improvement in access to outpatient care for the surgeries studied, especially those living in lower income areas, Hispanics and Whites.

Our findings of greater net increases in procedure use among lower area income groups and Hispanics are consistent with previous randomized(38, 39) and natural experiments of expanded public insurance programs or similar policy changes; however, few prior studies have explicitly examined whether increased insurance coverage reduces income or racial/ethnic disparities in access to or use of care.(36, 40) A recent study of Oregon's lottery-selected expansion of Medicaid to uninsured low-income non-elderly adults in 2008 found that hospital admissions increased by 30 percent in one year; this effect is nearly identical to that found in the RAND randomized study in the 1970s.(38, 39) More relevant to our study is the finding from Oregon that the increase in inpatient admissions was “disproportionately concentrated” among admissions “that do not originate in the emergency room”; we note that these primarily include admissions based on outpatient physician referral, including those for HRR procedures examined here.(39)

More appropriate for comparison to our study are findings of quasi-experimental expansions of public health insurance.(28, 40–42) Studies examining the impact of Medicare enrollment at age 65 have noted increased use of inpatient and outpatient care among the previously uninsured(29) and also the previously insured (due to the relative “generosity” of Medicare) (28, 40). One study documented a 10 percent increase in hospitalizations in the year following Medicare enrollment, with larger increases in use of “elective” procedures such as bypass surgery and joint replacement.(28) This suggests that our finding of increased procedure use may reflect a combination of pent-up unmet need and need arising from new diagnoses following increased access to outpatient care.

While the 17 surgical procedures examined represent a broad spectrum of inpatient procedures our main focus here was on their role as markers of access to care. In combining these procedures for evaluating the differential impact of health reform in access to care across subpopulations, we recognize heterogeneity in the procedures in other respects, including acuity of conditions targeted, impact on quality of life and value in terms of clinical benefit per dollar. Reflecting this heterogeneity, we found considerable differences in post-reform changes in rates, with several categories of procedures experiencing decrease in utilization while some others had sharp increases (≥ 25 percent). As estimates of net increases by individual procedure categories had wide confidence intervals due largely to small numbers, we cannot rule out potentially large differences among subpopulations. Nevertheless, statistically significant net increases associated with health reform were found for musculoskeletal and urinary/genital procedures among lower area income cohorts and Whites, and for urinary/genital procedures among Hispanics.

For Hispanics, the overall post-reform increase in procedure use among the non-elderly was considerably higher than that for their elderly counterparts, particularly for musculoskeletal, urinary/genital and nervous system procedures. For Blacks, whereas the changes for both groups were similar for musculoskeletal and urinary/genital procedures, the magnitude of the change is large and comparable to that for the non-elderly Hispanics. Therefore, it is the similar increase in the use of these procedures among the elderly Blacks that leads to the results of no significant net change (for non-elderly) attributable to the reform. Reasons for the similar increase among all Blacks (elderly and non-elderly) are unclear and merit further examination.

There is considerable debate on whether more medical care leads to better health.(43) However, most studies of natural experimental policy changes have found that expansions of health insurance result in health improvements for individual health measures or subpopulations.(36) Given the natural experimental setting of MA reform, we instead examined disparities in healthcare utilization and focused on vulnerable subpopulations and selected inpatient procedure categories for which underutilization of care is known to be associated with uninsurance or underinsurance. Research has documented higher rates of clinically unmet need among minorities and lower income patients for many inpatient procedures, including those for cardiac,(44) cancer(45, 46) and musculoskeletal(22) care. Our findings are among the first to show that expanded insurance coverage on a population level is associated with increase in use by such vulnerable populations.

Our study has several important limitations. First, we cannot differentiate overuse of procedures from clinically appropriate use. We suspect that our findings of increased procedure use among minorities do not reflect overuse, as Dartmouth Atlas comparisons of regional differences for Medicare beneficiaries for 12 common inpatient surgeries found MA procedure rates were below average for 6, near average for 5 and above average for only one procedure.(47) Second, since our data is observational, the possibility of potential confounding from unobserved factors remains. However, since we adjust for changes among the elderly, our estimates are robust to unobserved factors (including practice pattern changes) that affect all age groups. Also, comparison of non-elderly and elderly rates of use may not be clinically meaningful for some procedures. However, our findings do include same-age group comparisons by race/ethnicity and area income cohorts. Further, we did not include individual level data on insurance status, because of the inability to infer population rates of insurance status by the subgroups of interest from our data on health care users only. Identification of patient race/ethnicity is not necessarily based on patient self-report and may vary across hospitals; however, as this is likely to affect both non-elderly and elderly patients in each hospital, our methodology of contrasting changes among non-elderly patients with those for elderly patients provides robustness of findings to the potential

heterogeneity in race/ethnicity identification. Also, in the absence of data on individual income, we have used zip code –level income as the measure of socioeconomic status; however, this approach has been used in numerous previous studies.(31–33) Finally, our focus on the use of inpatient procedures may underestimate use of procedures performed in outpatient settings.

Nonetheless our findings have implications for national health reform (Affordable Care Act, 2010) which shares many key elements with MA health reform.(1) Notably, prior to health reform, MA had lower uninsurance and better safety-net funding compared to other states. (48, 49) Depending on the extent to which similar subpopulations gain from insurance expansion from the national reform, the potential for improved access is considerably larger or smaller, as is the potential for higher costs. Our study only examined utilization in the first two years following the reform, and therefore may include sharp increases in utilization from non-elderly patients with prior unmet need. Whether these increases will taper-off in the longer run is unknown. Actual changes also depend on other factors, including provider supply and practice patterns, which also vary considerably across states.

In conclusion, our findings of significant post-reform expansion in procedure use for Hispanics and lower area income patients are consistent with the relatively larger gains in insurance coverage among these subpopulations. These findings suggest potentially improved access to outpatient care and may reflect demand built up prior to reform when individuals were uninsured. Whether such improved access – a crucially important first step to improving equity in access and outcomes – translates into improved clinical outcomes at a reasonable cost merits further study.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

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Figure 1.
Identification & Grouping of High Referral Rate Procedures

Table 1

High Referral Rate Procedures: Volumes and Referral Rate

Procedure Category	# procedures in study period	Average referral rate, %	# Individual procedures in category	Individual procedures (% share of category volume)
Musculoskeletal	80,688	95%	4	Knee arthroplasty (40%), Spinal fusion (31%), Hip replacement (22%) and Partial excision bone (7%)
Urinary/Genital	51,088	95%	6	Hysterectomy (32%), Oophorectomy (32%), Repair of cystocele and rectocele (12%), Transurethral resection of prostate (12%), Genitourinary incontinence procedures (8%) and Nephrectomy (2%)
Nervous	29,372	88%	1	Laminectomy (100%)
Cardiovascular	20,914	80%	4	Heart valve procedures (34%), Endarterectomy (32%), Peripheral vascular bypass (19%) and Aortic resection (15%)
Digestive	19,845	73%	2	Colorectal resection (98%) and Gastrectomy (2%)
All procedures	201,907	90%	17	

Notes:

1. Procedures are categorized by ICD-9-CM Procedure Chapters. No eye, ear and nose/throat procedures met the high referral rate criteria. Urinary, male genital and female genital system procedures have been combined into one category.
2. Study period comprises pre- and post-reform periods (10/1/2004 – 6/30/2006 and 1/1/2008 – 9/30/2009 respectively)
3. # procedures indicates the state-wide volume performed during hospitalization stays in the pre- and post-reform periods.
4. Average referral rate indicates the % of hospitalizations (during which procedure was performed) based on outpatient referral.

Table 2
Counts of High Referral Rate Procedures and Population at Risk, by Socio-Demographics

Characteristics	Total # Procedures (Pre- and Post-reform periods)	Distribution of Procedures		# Population at Risk, person years (Pre- and Post-reform periods)	Distribution of Population at Risk	
		Pre-reform	Post-reform		Pre-reform	Post-reform
All (age 40+ years)	201,907	100%	100%	10,072,992	100%	100%
Sex						
Women	123,560	60%	62%	5,387,207	54%	53%
Men	78,347	40%	38%	4,685,785	46%	47%
Age (years)						
40 to 64	124,966	60%	64%	7,845,648	78%	78%
70 or older	76,941	40%	36%	2,227,344	22%	22%
Area Income, Zip Code						
Median						
Low	43,880	22%	22%	2,282,028	23%	23%
Medium	50,454	25%	25%	2,494,057	25%	25%
High	107,229	53%	53%	5,296,841	53%	53%
Race/ethnicity						
Hispanics	6,688	2.8%	3.8%	484,209	4.5%	5.1%
Blacks	8,115	3.6%	4.4%	460,728	4.5%	4.7%
Others	6,324	3.4%	2.8%	419,872	3.9%	4.4%
Whites	180,780	90.1%	89.0%	8,708,183	87.1%	85.8%

Notes:

1. Study period comprises pre- and post-reform periods (10/1/2004 – 6/30/2006 and 1/1/2008 – 9/30/2009 respectively).
2. Total # Procedures indicates the number of high referral rate procedures performed during hospitalizations in the pre- and post-reform periods.
3. Population at risk indicates the aggregate census population (person-years) during the pre- and post-reform periods.
4. Area Income cohorts are defined as: low=lowest quartile zip codes, medium=second quartile and high=top two quartile

Table 3

Pre- and Post-Reform Use of High Referral Rate Procedure by *Area* Income & Race/Ethnicity Cohorts

Cohort	Pre-reform Procedure Rate			Post-reform Procedure Rate			Overall Post-Reform Change (%) in Procedure Rate			Excess Overall Change among Minorities/Lower Area Income Cohorts			Net Change (%): Post-reform Change (%) in procedure rate among non-elderly due to health reform		
	# procedures /10,000	95% confidence interval	# procedures /10,000	95% confidence interval	Overall Post-Reform Change (%) in Procedure Rate	Difference in % Change between Non-White/White or Lower Area Income/Highest Income	p-value (Difference=0)	% Net Change	95% confidence interval						
By Area Income Cohorts															
Non-elderly (age 40-64 years)															
Low	156	[154, 159]	169	[167, 172]	8%	4%	0.04	13%	[9%, 17%]						
Medium	151	[149, 154]	166	[164, 169]	10%	6%	<0.001	15%	[6%, 24%]						
High	154	[153, 156]	161	[159, 162]	4%	Reference		2%	[−3%, 8%]						
Elderly (age >=70 years)															
Low	302	[295, 308]	284	[278, 291]	−6%	−7%	<0.001								
Medium	354	[347, 361]	340	[333, 346]	−4%	−5%	0.002								
High	365	[360, 370]	369	[365, 374]	1%	Reference									
By Race/Ethnicity Cohorts															
Non-elderly (age 40-64 years)															
Hispanics	118	[113, 123]	146	[141, 151]	23%	16%	<0.001	22%	[5%, 38%]						
Blacks	149	[143, 155]	180	[174, 186]	21%	14%	<0.001	5%	[−20%, 30%]						
Whites	157	[155, 158]	167	[166, 168]	7%	Reference		7%	[5%, 10%]						
Elderly (age >=70 years)															
Hispanics	199	[181, 216]	202	[186, 218]	2%	3%	0.926								
Blacks	234	[218, 251]	268	[251, 285]	14%	15%	0.003								
Whites	355	[352, 359]	353	[349, 356]	−1%	Reference									

Notes:

1. Pre-reform=[Oct 2004, Jun 2006] and post-reform=[Jan 2008, Sept 2009]
2. Procedure rates, adjusted for sex and age differences, are estimated by direct standardization method.
3. Overall change (%) in procedure rate is the simple % change in the pre- and post-reform procedure rates. Difference in overall change by race/ethnicity and *area* income are obtained by comparing overall change.
4. Net change (%) in procedure rate among non-elderly due to health reform are calculated from a separate (county fixed effects) Poisson regression with a difference-in-difference specification using combined non-elderly and elderly cohort data. Confidence intervals are based on bootstrapped standard errors (N=1,000 iterations) to adjust for clustering of observations within county.
5. *Area* Income cohorts are defined as: low=lowest quartile zip codes, medium=second quartile and high=top two quartiles

Impact of Health Reform on Use of High Referral Rate Procedures by *Area* Income, Race/ethnicity & Procedure Category

Table 4

Procedure Category	Cohort (area income)	HRR Procedure Rates Non-elderly (40-64 years)			HRR Procedure Rates Elderly (>=70 years)			Net change (%): Post-reform change in procedure rate among non-elderly due to health reform			HRR Procedure Rates Non-elderly (40- 64 years)			HRR Procedure Rates Elderly (>=70 years)			Net change (%): Post-reform change in procedure rate among non-elderly due to health reform	
		Overall Post- Reform Change (%) in Procedure Rate	p-value (Difference in Lower vs. Highest Area Income Cohorts % Change=0)	Overall Post- Reform Change (%) in Procedure Rate	p-value (Difference in Lower vs. Highest Area Income Cohorts % Change=0)	Net Change (%)	95% confidence interval	Cohort (race/ethnicity)	Overall Post- Reform Change (%) in Procedure Rate	p-value (Difference in Non-White vs. White % Change=0)	Overall Post- Reform Change (%) in Procedure Rate	p-value (Difference in Non-White vs. White % Change=0)	Net Change (%)	95% confidence interval				
Musculoskeletal	Low	20%	<0.001	5%	<0.001	12%	[3%, 22%]	Hispanics	31%	0.017	19%	0.354	8%	[-14%, 31%]				
	Medium	18%	0.001	5%	0.001	12%	[5%, 19%]	Blacks	25%	0.028	20%	0.124	3%	[-12%, 19%]				
	High	9%	Reference	9%	Reference	1%	[-3%, 6%]	Whites	15%	Reference	8%	Reference	6%	[2%, 11%]				
Urinary/Genital	Low	12%	0.595	-11%	0.397	21%	[10%, 31%]	Hispanics	30%	<0.001	-1%	0.846	34%	[1%, 67%]				
	Medium	16%	0.031	-15%	0.024	32%	[21%, 42%]	Blacks	40%	<0.001	42%	<0.001	1%	[-22%, 24%]				
	High	9%	Reference	-7%	Reference	15%	[2%, 28%]	Whites	10%	Reference	-10%	Reference	19%	[11%, 26%]				
Nervous	Low	-6%	0.921	-2%	0.034	-4%	[-16%, 9%]	Hispanics	8%	0.151	-47%	<0.001	71%	[2%, 140%]				
	Medium	-3%	0.32	3%	0.208	-6%	[-20%, 8%]	Blacks	-16%	0.122	43%	0.03	-51%	[-127%, 25%]				
	High	-7%	Reference	10%	Reference	-15%	[-28%, -3%]	Whites	-3%	Reference	7%	Reference	-10%	[-19%, -2%]				
Cardiovascular	Low	-19%	0.312	-10%	0.157	-12%	[-19%, -4%]	Hispanics	-2%	0.265	15%	0.216	-14%	[-52%, 24%]				
	Medium	-15%	0.849	-13%	0.021	5%	[-6%, 16%]	Blacks	2%	0.106	4%	0.5	0%	[-65%, 66%]				
	High	-15%	Reference	-4%	Reference	-16%	[-21%, 11%]	Whites	-17%	Reference	-7%	Reference	-11%	[-15%, -7%]				
Digestive	Low	-5%	0.989	-24%	0.005	23%	[9%, 37%]	Hispanics	8%	0.245	4%	0.508	10%	[-27%, 48%]				
	Medium	-4%	0.865	-9%	0.505	0%	[-10%, 11%]	Blacks	5%	0.375	-30%	0.153	37%	[5%, 69%]				
	High	-5%	Reference	-12%	Reference	10%	[2%, 19%]	Whites	-4%	Reference	-13%	Reference	10%	[5%, 15%]				

Notes:

1. Overall change (%) in procedure rate is the simple % change in the pre- and post-reform procedure rates. Difference in overall change by race/ethnicity and *area* income are obtained by comparing overall change. The figures for the All cohort are identical to those in Table 3.
2. Net change (%) in procedure rate among non-elderly due to health reform are calculated from a separate (county fixed effects) Poisson regression with a difference-in-difference specification using combined non-elderly and elderly cohort data. Confidence intervals are based on bootstrapped standard errors (N=1,000 iterations) to adjust for clustering of observations within county.
3. *Area* Income cohorts are defined as: low=lowest quartile zip codes, medium=second quartile and high=top two quartiles