# Supplementary Online Content

This supplementary material has been provided by the authors to give readers additional information about their work.

**eFigure 1.** Study Design

**eFigure 2.** Proportion of Patients Receiving Treatment With Osteoporosis Medications by Instrumental Variable Strata
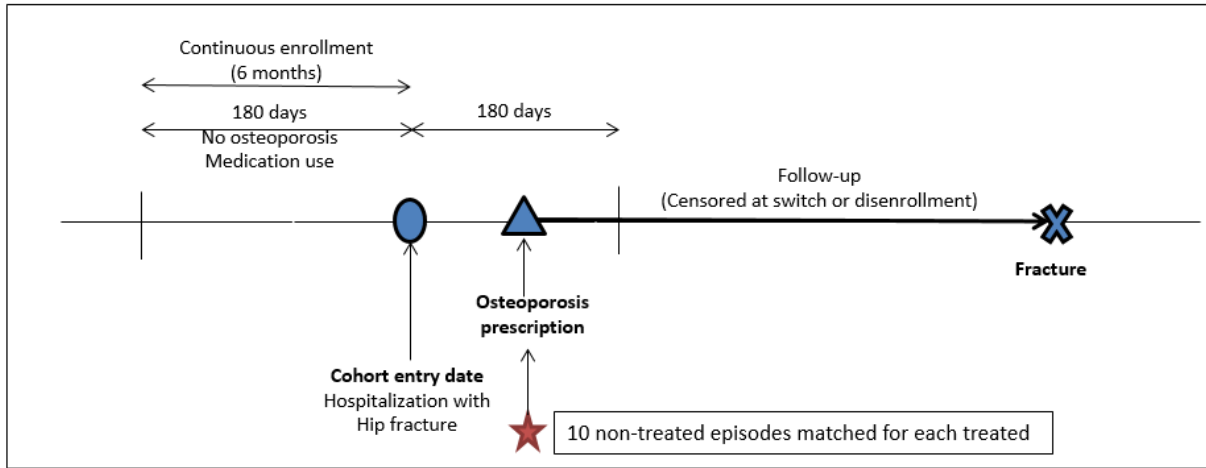
**eFigure 3.** Cumulative Regression Function With Pointwise 95% Confidence Interval for the Treatment Effect Under the Additive Hazard Model
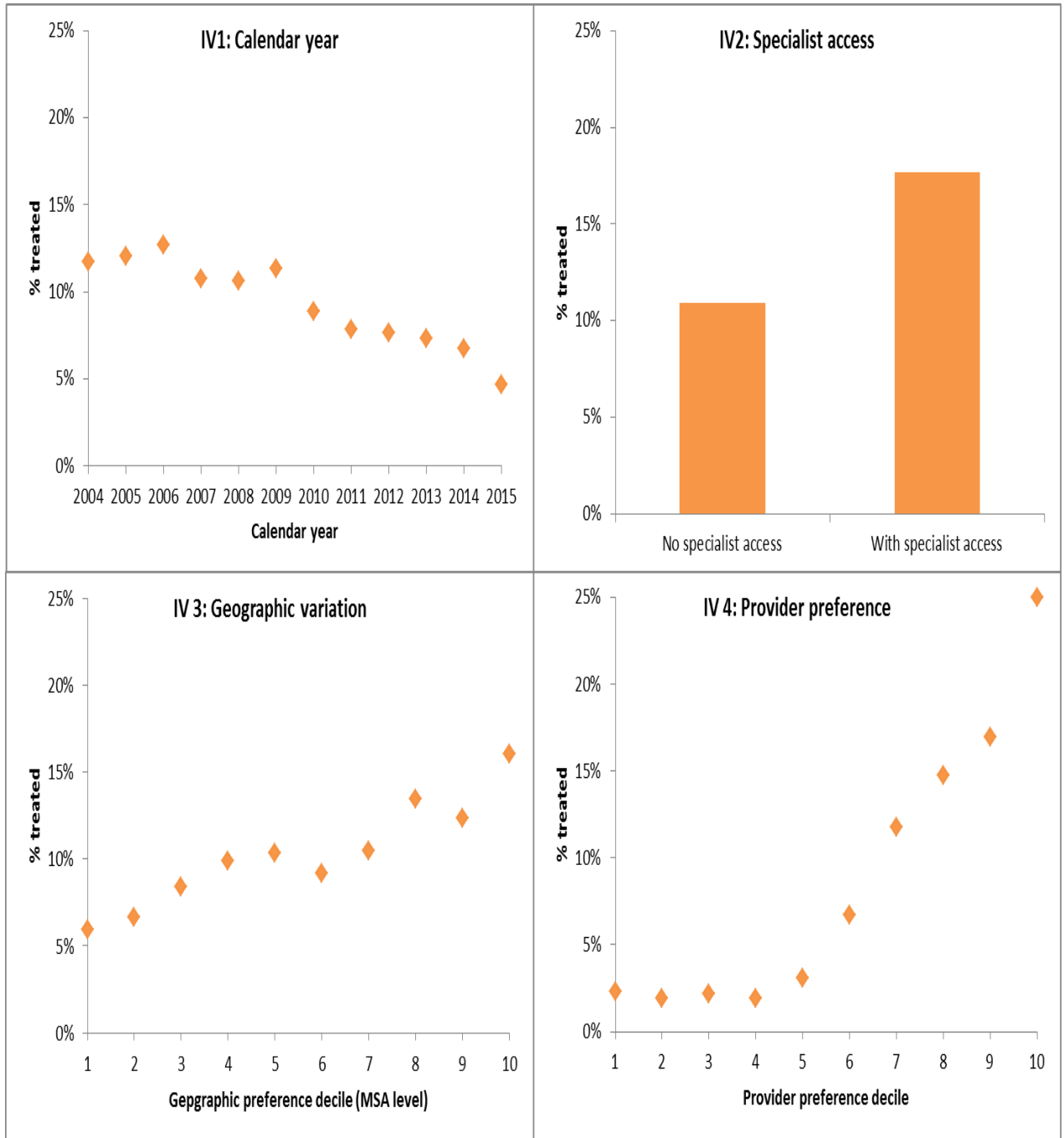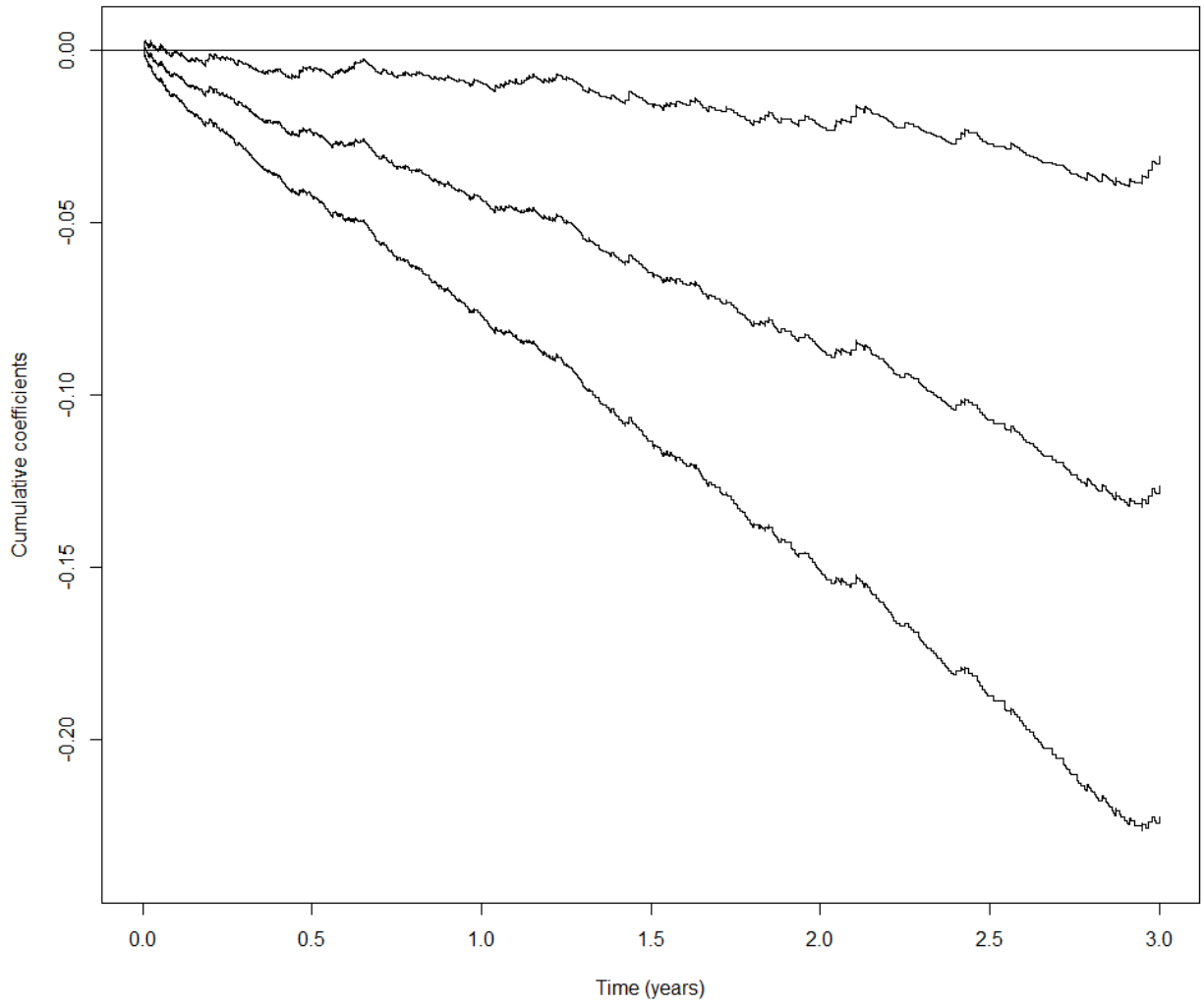
**eTable.** Components of the Composite Outcome

| Fracture | Definition/codes |
|---|---|
| 1. Humerus | Humerus fracture diagnosis (ICD-9: 812.xx, 733.11) AND procedure within 30 days of fracture date (ICD-9: 78.52, 79.01, 79.11, 79.21, 79.31, 79.61; CPT-4: 23600, 23605, 23610, 23615, 23620, 23625, 23630, 23665, 23670, 23680, 24500, 24505, 24506, 24510, 24515, 24530, 24531, 24535, 24536, 24538, 24540, 24542, 24545, 24560, 24565, 24570, 24575, 24581, 24583, 24585-8, 24516) |
| 2. Radius and/or Ulna | Radius/ulna fracture diagnosis (ICD-9: 813.xx, 733.12) AND procedure within 30 days of fracture date (ICD-9: 78.53, 79.02, 79.12, 79.22, 79.32, 79.62; CPT-4: 24620, 24625, 24635, 24650, 24655, 24660, 24665-6, 24670, 24680, 24685, 25500, 25505, 25510, 25515, 25530, 25535, 25540, 25545, 25560, 25565, 25570, 25575, 25600, 25605, 25610-1, 25615, 25620, 25650) |
| 3. Hip | Hip fracture diagnosis (ICD-9 code: 820.xx,733.14) during hospitalization AND procedure code during hospitalization (ICD-9: 78.55, 79.05, 79.15, 79.25, 79.35, 79.65; CPT-4: 27230-27248) |
| 4. Pelvis | Pelvis fracture diagnosis (ICD-9: 808.xx) |

Codes used for identification of confounding variables: Osteoporosis diagnosis (ICD-9-CM codes 733.0x), presence of bone mineral density test (CPT code 77080, 77085), Parkinson's disease (ICD-9-CM codes 332.xx or 333.0x), Alzheimer's disease or other dementia (ICD-9-CM codes 290.xx, 294.xx, 330.xx, 331.xx), obesity (ICD-9-CM codes 278.0x, 649.1x, V85.3x, V85.4x), diabetes mellitus (ICD-9-CM codes 250.xx), rheumatoid arthritis (ICD-9 codes 714.x), or history of falls, syncope, or gait abnormality (ICD-9-CM codes E885, E885.9x, E888.xx, 780.2x, 458.0x, 781.2x, 782.3x)

**eAppendix.** Model Equations

1. **Mixed effect models for calculating adjusted rates of treatment for creating geographic and provider preference IVs**

$$logit\left(P(Y_{ij} = 1 | Age_i, Gender_i, Random\ effect_j{}^*)\right) = \beta_0 + \beta_1 Age_i + \beta_2 Gender_i + \beta_{3j}$$

$^*$ *MSA Region was the random variable for IV*3 *and Primary provider was the random variable for IV*4

$Y_{ij} = tretament\ initiation\ status\ in\ individual\ i\ in\ region\ j\ (or\ with\ provider\ j)$

$\beta_0 = Fixed\ intercept$

$\beta_1 = Age\ co - efficient$

$\beta_2 = Gender\ co - efficient$

$\beta_{3j} = Random\ intercept\ specific\ to\ region\ j\ (or\ provider\ j)$

2. **First stage instrumental variable models**

$$\Pr(A_i = 1 | IV = IV_i, X = x_i) = \frac{\exp\left(\beta_0 + \beta_1 IV_i + \sum_{k=2}^{n} \beta_k x_{k,i}\right)}{\left\{1 + \exp\left(\beta_0 + \beta_1 IV_i + \sum_{k=2}^{n} \beta_k x_{k,i}\right)\right\}}$$

$$\Pr(A_i = 1 | IV = IV_i, X = x_i)$$

$= Probability\ of\ osteoporosis\ medication\ initiation\ given\ covariates\ and\ instrumental\ variable\ values\ for\ each\ individual\ i$

$$\beta_0 = Intercept$$

$$\beta_1 = IV\ co-efficient$$

$$\beta_k = Co-efficients\ (\beta_2\ through\ \beta_n)\ for\ predictor\ variables$$

$$x_{k,i} = Covariate\ values\ for\ individual\ i$$

3. **Second stage instrumental variable model (Additive hazards model)**

$$h\ (t|A,X) = h_0(t) + \ \beta_1(t)A + \beta_2(t)\Delta\ + \sum_{k=3}^{n} \beta_k(t)x_k$$

$h_0(t) = baseline\ hazard$

$\beta_1 = Treatment\ effect\ estimate$

$A = Actually\ recieved\ treatment$

$\beta_2(t)\Delta$

$= Control\ function\ which\ is\ meant\ to\ capture\ variation\ in\ the\ hazard\ functon\ due\ to\ unobserved\ correlates\ of\ the\ treatment;$

$where\ \Delta = A - \Pr(A_i = 1 | IV = IV_i, X = x_i)$

$\beta_k = Co-efficients\ for\ other\ covariates\ in\ the\ model$