The Effects of Universal Screening for Gestational Diabetes on Maternal and Child Health

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Gestational diabetes mellitus (GDM) as a challenge:

Medical, societal, & economic

- Elevated blood glucose levels, first diagnosed during pregnancy (Lappe et al. 2023)
- One of the most common pregnancy-related conditions
- **Rising prevalence**: from <1% in the 1990s to currently ~17% worldwide; ~10–15% in Germany (e.g., Wang et al., 2022)
- Main risk factors: maternal age and overweight (Shah et al., 2021)

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- Main risk factors: maternal age and overweight (Shah et al., 2021)
- Glucose metabolism usually normalizes postpartum BUT
- Associated with **birth complications** and **long-term health risks**:
  - Children: fetal macrosomia, shoulder dystocia, diabetes, obesity
  - Mothers: C-sections, birth trauma, diabetes, cardiovascular diseases
- Untreated, leads to **high costs**: direct (up to €15,000) and indirect (?)
  (Metzger et al. 2008; McIntyre et al. 2019; Shah et al. 2021; Staynova et al. 2022)

Birth weight is a strong predictor of later outcomes

Low Birth Weight

(< 2,500g; prevalence in DE: ~7%)

Source: ChatGPT

Fetal Macrosomia

(≥ 4,000g; prevalence in DE ~10%)

Source: ChatGPT

- Widely used indicator of infant health
- Long-lasting imprints on later-life outcomes (e.g. Royer, 2009; Figlio et al., 2014; Bharadwaj et al., 2018)
- Particular focus on causes and consequences of **low** birth weight
- Much less attention has been paid to **excessive** birth weight

In a nutshell

This paper

- Evaluates a **policy aimed at** preventing and mitigating **excessive fetal growth** and its later consequences
- Estimates the ITT effects of introducing **free universal GDM screening** in Germany in 2013 (replacing risk-based assessment)
- Applies a diff-in-diff design to (nearly) **population-level data** from hospital discharge records
- Studies the short-term (& long-term) consequences for **child and maternal health**
- Finds precisely estimated **zero effects** on neonatal health and maternal birth outcomes

Connection to the literature

- Research on the **effects of GDM screening on birth outcomes** using quasi-experimental designs (FIN: Riukula, 2023; Bradford in ENG: Conti & Rodriguez-Lesmes, 2021)
  - So far, mixed and imprecise estimates of local treatment effects

  → Precisely estimated ITT effects of a universal GDM screening

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  - → Precisely estimated ITT effects of a universal GDM screening
- Causal evidence on **short- and long-run consequences of prenatal care**, esp. monetary incentives (e.g., Corman et al., 2019; Cygan-Rehm & Karbownik; 2022, Di Giacomo et al., 2022)
  - So far, focus on preventing poor fetal growth and low birth weight
  - → Evidence from a policy targeted at the upper tail of the distribution

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  - So far, focus on preventing poor fetal growth and low birth weight
  - → Evidence from a policy targeted at the upper tail of the distribution
- Literature evaluating the **effectiveness of universal screening schemes** for other diseases (e.g., Sabik & Bradley, 2016, Guthmuller et al., 2023, Alalouf et al., 2024; Einav et al., 2020)
  - So far, universal screening recommendations are highly controversial
  - → Evidence of no effect of universal GDM screening on birth outcomes despite increased detection rates and long-term effects (?)

Outline

1 Institutions

2 Empirical Strategy

3 Data & Sample

4 Results

5 Conclusions & Outlook

Institutions

Screening for GDM in Germany

details

- Two-step sceening strategy
  - 1st step: 50g glucose challenge test in non-fasted condition
  - 2st step: 75g oral glucose tolerance test in fasted condition
    (conditional on positive test result of 50g glucose challenge test)
- Conducted between week 24-28 of pregnancy
- Costs: €10-25 in the early 2010s (currently, max. €30)
- Historically: out-of-pocket cost within the statutory health insurance (SHI)

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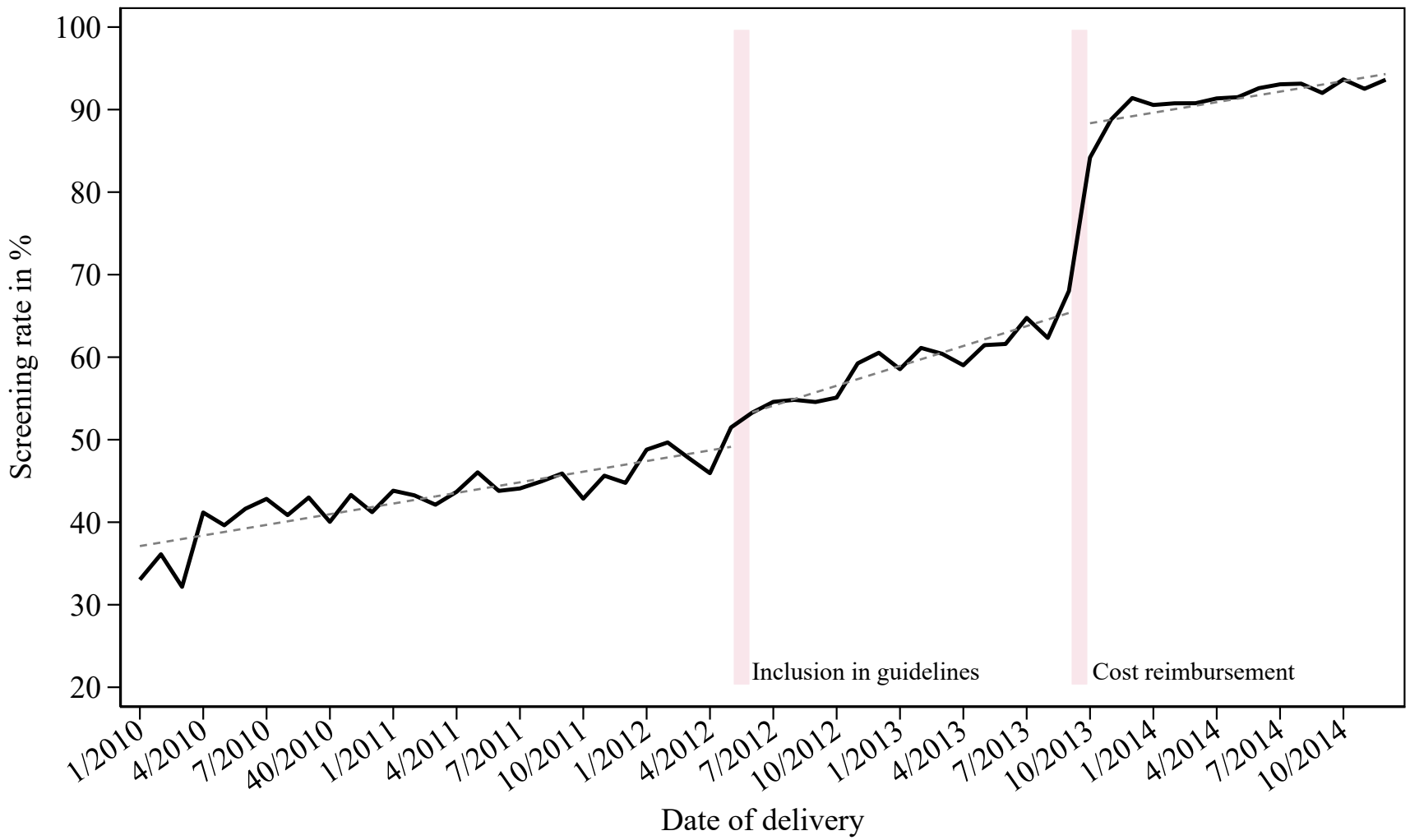
- Conducted between week 24-28 of pregnancy
- Costs: €10-25 in the early 2010s (currently, max. €30)
- Historically: out-of-pocket cost within the statutory health insurance (SHI)
- Legal changes in 2012/2013:
  - March 2012: Integrated into maternity guidelines (regulate the range of prenatal care services and their timing)
  - **July 2013**: Introduction of reimbursement billing codes for the SHI
- Since then: *actual* **universal eligibility** for free GDM screening

Increase in screening rate among first entitled birth cohorts by 22pp



Note: The solid line shows the proportion of mothers tested for GDM during pregnancy by the date of delivery. The dashed lines represent trends that fitted to the data separately for three time intervals. The data are restricted to mothers who were insured with AOK Plus for at least 267 days (i.e., since the expected start of pregnancy) and who delivered at a gestational age greater than 26 weeks.
Source: AOK Plus Sachsen.

Empirical Strategy

Empirical strategy

Difference-in-Discontinuities (DiD):

$$Y_i = \alpha\, post_i + year_i'\, \beta + \delta\, (post_i \times treat_i) + X_i'\gamma + \varepsilon_i \qquad (1)$$

- Y_i Health outcome of individual i (mother or child)
- $post_i$ Indicator for birth between Oct and Dec (vs. July to Sept)
- $year_i'$ Year of birth FE
- $treat_i$ Indicator for births in 2013
- X_i Socio-demographic characteristics (e.g., maternal age at birth, child's gender, multiple birth, state of residence FE, urbanization level FE)

Empirical strategy

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Identification assumptions for the estimate of δ (ITT):

- Parallel trends: constant seasonality patterns in outcomes
- No selective timing of conception in response to GDM screening

Data & Sample

Data

Diagnosis-Related Groups Statistic (DRG 2008-2014)

- Microdata from hospital discharge records
- Covers nearly all inpatient cases in Germany: 20 million/year
- Incl. ~700k hospital births - 98% of all newborns and mothers details
- Detailed and high-quality information on:
  - Date and reason of admission
  - Birth weight and birth date for newborns
  - Diagnoses (ICD-10) & procedures (OPS), reimbursement claim (costs), length of stay
  - Sociodemographic characteristics: patient's age, gender, place of residence, hospital's location
- No identifier for mother-child linkage

Samples & Outcomes

descriptives

Sample restrictions

- Hospital births from July-December of the years 2008-2013 (N: ~2 million)
- Country of residence: Germany

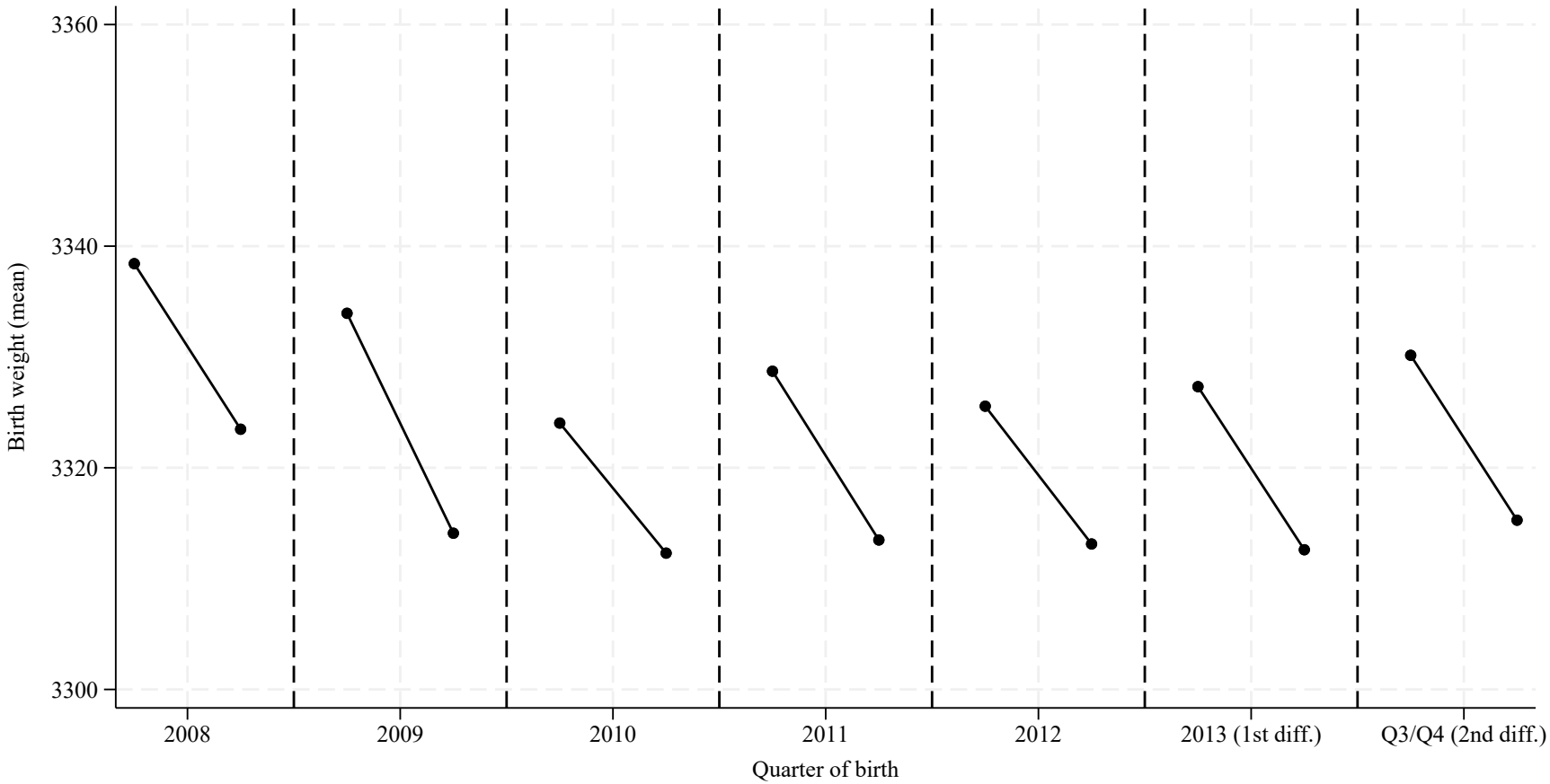
Outcomes

- Newborns: birth weight (in grams), fetal macrosomia (≥ 4,000g/4,500g), low birth weight (placebo), affected by maternal GDM
- Mothers: C-section, obstructed labor due to shoulder dystocia, gestational age (full-term, late-term, pre-term)
- Both samples: length of stay (in days), reimbursement claim (log of €)

Results

Year-to-year seasonality in birth weight (Q3 vs. Q4)

c-sec



Note: Sample restricted to births from July to December in the years 2008 to 2013. Each set of connected dots compares the sample means for children born in the 3rd and 4th quarters of a given calendar year. The 2nd difference comparison is between the means for the 3rd and 4th quarters aggregated over the pre-reform years 2008-2012.

Source: Diagnosis-Related Groups Statistic (DRG).

Effects of free GDM screening eligibility on newborns

	(1) Affected by GDM	(2) Birth weight	(3) Macrosomia (≥ 4,000g)	(4) Macrosomia (≥ 4,500g)	(5) Low birth weight	(6) Length of stay	(7) Reimbursement claim (log)
post × *treat*	0.002***	0.092	0.001	0.000	0.001	0.036	0.006*
	(0.001)	(2.207)	(0.001)	(0.000)	(0.001)	(0.032)	(0.003)
	[0.001; 0.004]	[-4.234; 4.418]	[-0.001; 0.003]	[-0.000; 0.001]	[-0.001; 0.003]	[-0.027; 0.099]	[-0.000; 0.012]
Y-Mean	0.042	3,322.7	0.100	0.013	0.073	5.134	6.874
Obs.	2,053,690						

- GDM diagnosis rates: moderate ↑5.2% (relative to sample mean)
- Birth weight and length of stay: no meaningful effects
- Cost to the health insurer: small (and marginally significant) ↑0.6% (~€12)

Effects of free GDM screening eligibility on mothers

	(1) C-section	(2) Shoulder dystocia	(3) Late-term (>41 weeks)	(4) Full-term (37-41 weeks)	(5) Pre-term (<37 weeks)	(6) Length of stay	(7) Reimbursement claim (log)
post × *treat*	-0.001	0.000	-0.002*	0.000	0.001	0.010	0.004**
	(0.002)	(0.000)	(0.001)	(0.001)	(0.001)	(0.012)	(0.001)
	[-0.004; 0.003]	[-0.001; 0.001]	[-0.004; 0.000]	[-0.003; 0.003]	[-0.001; 0.003]	[-0.015; 0.034]	[0.001; 0.007]
Y-Mean	0.308	0.014	0.097	0.820	0.069	4.427	7.495
Obs.				1,981,460			

- Birth complications and hospital stay: no meaningful changes
- Late-term birth: marginally significant ↓2% (relative to sample mean)
- Cost to the health insurer: small ↑0.4% (~€8)

Validity, Robustness, & Heterogeneity

- "First-stage" effects on screening rates ->
- Balancing tests ->
- Effects on the number of births ->
- Sensitivity to incl. covariates & donut-hole (-/+2 weeks) ->
- Heterogeneity by child's gender & maternal age gender age

Other ideas?

Conclusions & Outlook

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- We evaluate the effects of a universal GDM screening on maternal and child health
- Preliminary findings
  - Substantial ↑ screening rates (~22pp/34%), modest ↑ diagnosis rates (~5%)
  - No effects on birth outcomes, small ↑ hospitalization costs (~0.5%)

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- Before 2013, the risk-based assessment was sufficient for identifying mothers at the highest risk for adverse birth outcomes due to GDM
- Abolish or not? That's a question!
  - YES: – Cost pressure on statutory health insurance (~€2M/year savings)
    – AI-supported risk profiling becomes more precise and cheaper
  - NO: – Savings negligible (<0.001% of total SHI spending ~€300B/year)
    – Long-term health benefits (e.g., diabetes or overweight)?
    – If so, €30 per pregnancy would be a worthwhile investment

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    – If so, €30 per pregnancy would be a worthwhile investment
- In progress: extension to long-run outcomes

Thank you!

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GDM testing procedure

Back

How is GDM testing conducted?

- Timing: During pregnancy weeks 24-28
  - Exception: earlier screening due to preexisiting risk factors (10 %)
- Two-step screening strategy
  - 1st step: Glucose Challenge Test (GCT) in non-fasted condition
    - Blood glucose levels above certain treshold (≥ 135 mg/dL) are considered critical
  - 2nd step: Oral Glucose Tolerance Test (OGTT) in fasted condition
    - Blood glucose measured three times → GDM diagnosed if positive result at least once

Comparison with official statistics

back

	Number of newborns			Number of deliveries		
Year	DRG newborn sample	Official stats. (Destatis)	Share (in %)	DRG mothers' sample	Official stats. (Destatis)	Share (in %)
2008	671,694	682,514	98.41%	643,451	662,783	97.08%
2009	656,364	665,126	98.68%	629,904	644,274	97.77%
2010	669,109	677,947	98.70%	647,201	656,390	98.60%
2011	652,366	662,685	98.44%	631,630	642,791	98.26%
2012	663,710	673,544	98.54%	643,045	653,215	98.44%
2013	669,490	682,069	98.16%	650,626	661,138	98.41%
Total	3,982,733	4,043,885	98.49%	3,845,857	3,920,591	98.09%

Note: Share corresponds to the ratio of the year-specific number of observations in the DRG estimation samples to the number of newborns or deliveries from official statistics.

Source: Diagnosis-Related Groups Statistic (DRG); Federal Statistical Office (Destatis).

Sample means

back

Estimation sample	Newborns	Mothers
A: Outcomes		
Affected by maternal GDM	0.042	
Birth weight (in grams)	3,322.686	
Macrosomia ≥ 4,000g	0.100	
Macrosomia ≥ 4,500g	0.013	
Low birth weight (≤ 2,500g)	0.073	
C-section		0.308
Obstructed labor due to shoulder dystocia		0.014
Late-term birth (> 41 weeks)		0.097
Full-term term (37-41 weeks)		0.82
Pre-term birth (< 37 weeks)		0.069
Length of stay (in days)	5.134	4.427
Reimbursement claim to the insurer (in euros)	1,977.360	1,947.755
B: Individual characteristics		
Female	0.487	1.000
Age	0.000	29.959
Schleswig-Holstein	0.032	0.033
Hamburg	0.025	0.025

Sample means

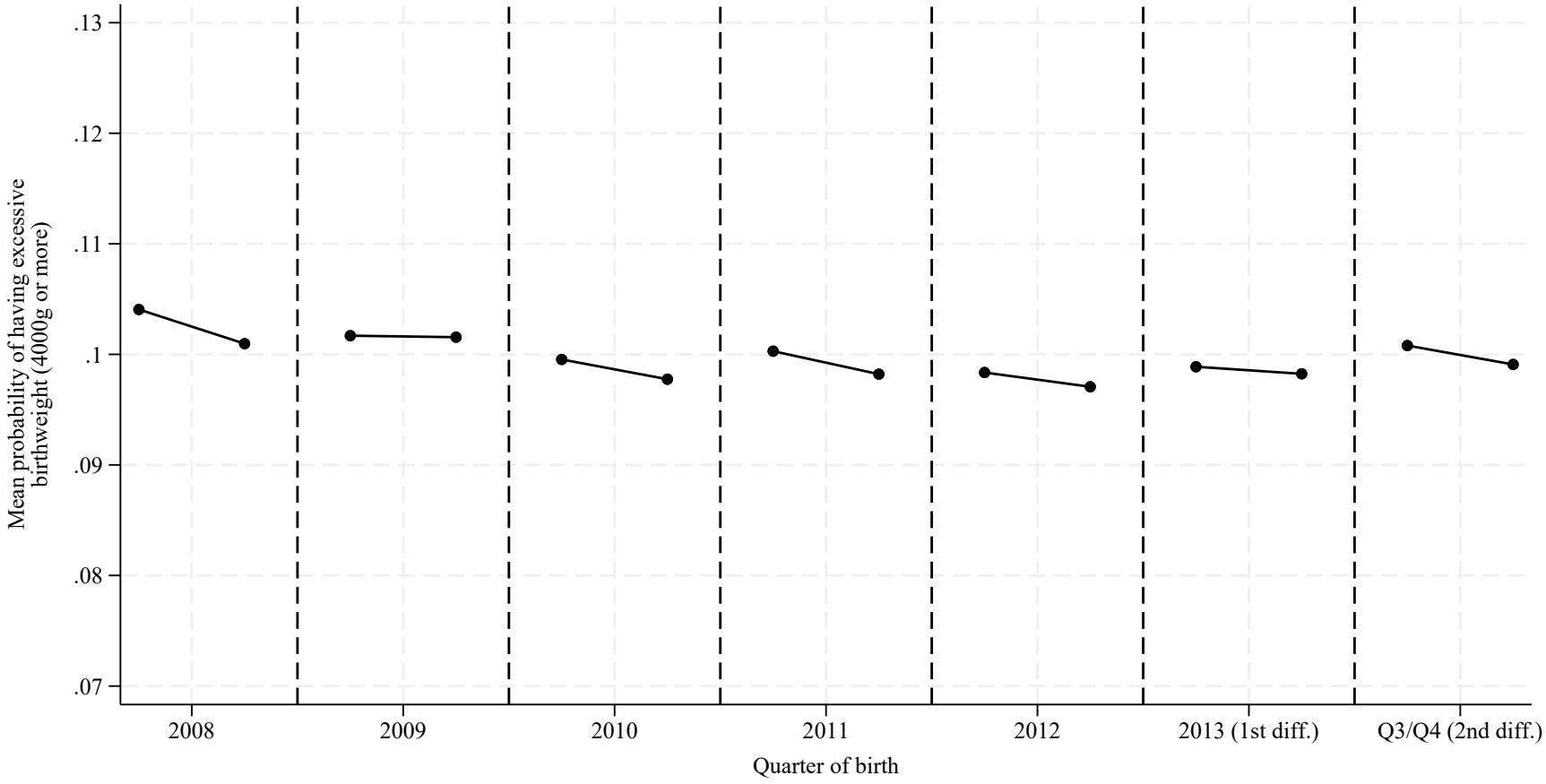
back

Estimation sample	Newborns	Mothers
Lower Saxony	0.093	0.094
Bremen	0.008	0.008
North Rhine-Westphalia	0.218	0.217
Hesse	0.077	0.076
Rhineland-Palatinate	0.048	0.047
Baden-Wuerttemberg	0.134	0.134
Bavaria	0.158	0.158
Saarland	0.011	0.01
Berlin	0.048	0.048
Brandenburg	0.027	0.027
Mecklenburg-Western Pomerania	0.019	0.019
Saxony	0.051	0.051
Saxony-Anhalt	0.025	0.026
Thuringia	0.025	0.026
City	0.525	0.522
Urban	0.318	0.319
Rural	0.157	0.159
Obs.	2,053,690	1,981,460

Note: Samples restricted to births from July to December in years 2008 to 2013. The regional indicators refer to the place of residence.

Year-to-year seasonality in macrosomia (≥ 4,000g)

back



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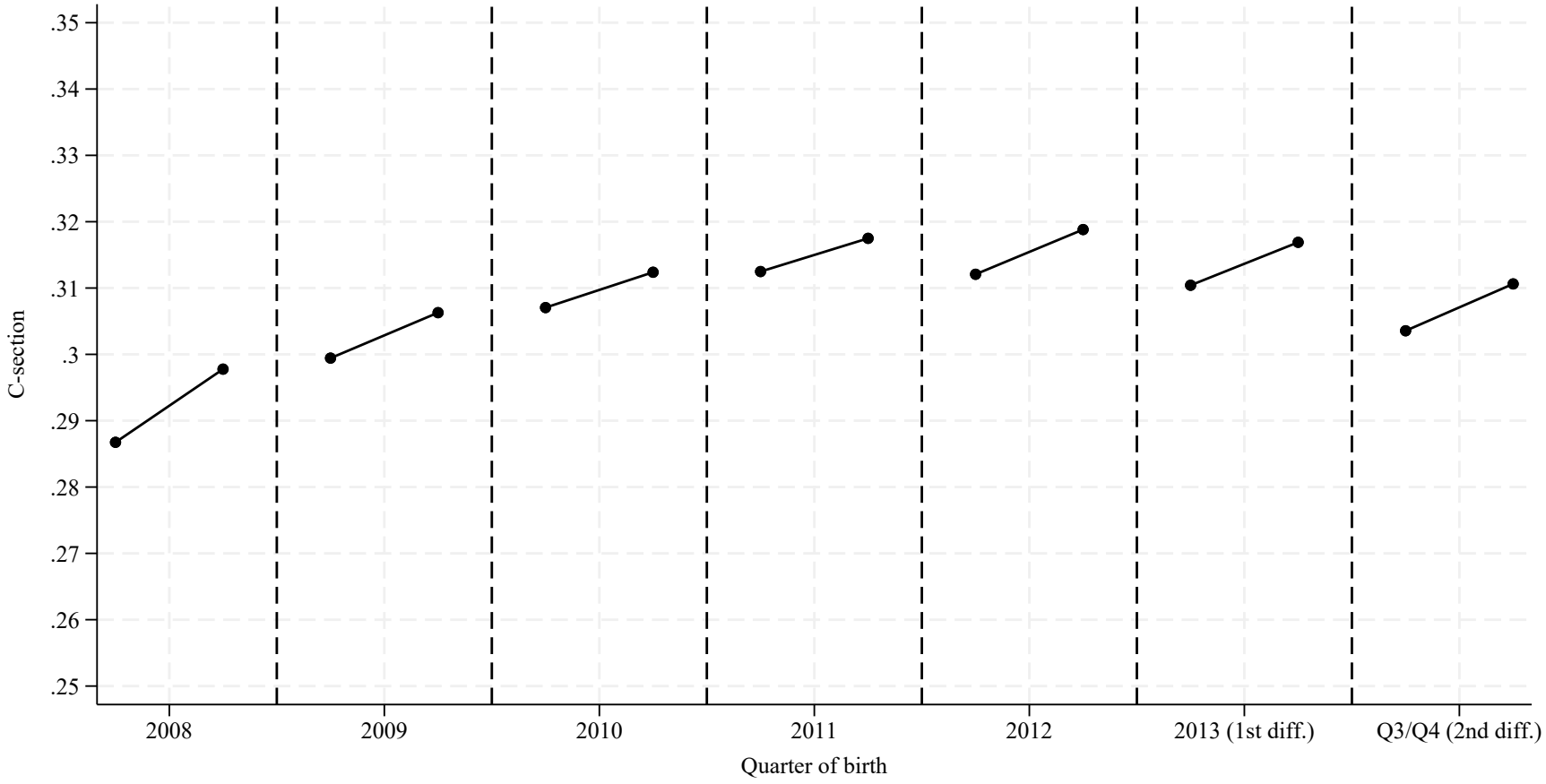
Source: Diagnosis-Related Groups Statistic (DRG).

Year-to-year seasonality in C-sections

back



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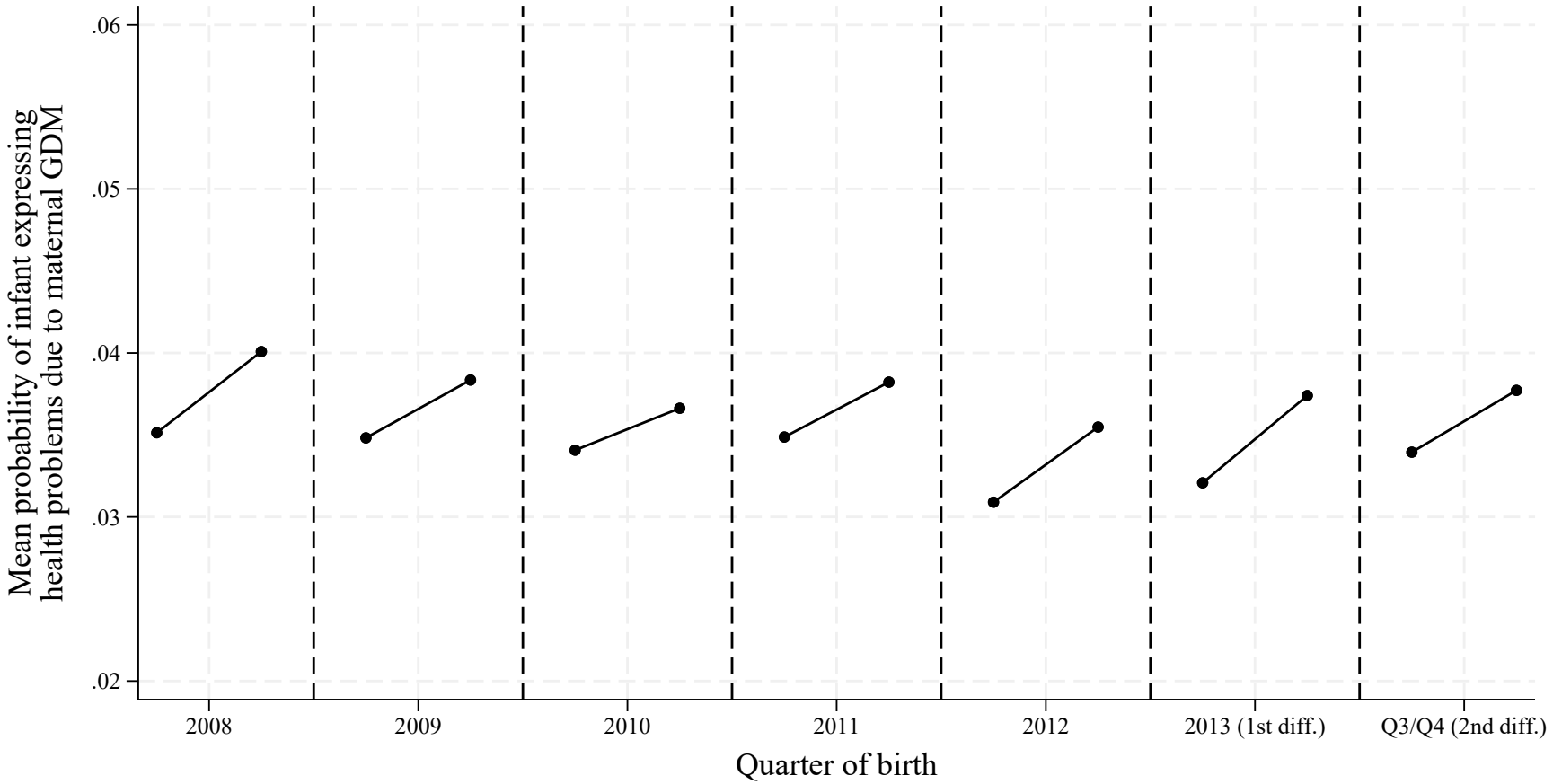
Source: Diagnosis-Related Groups Statistic (DRG).

Year-to-year seasonality in newborns being affected by GDM

back



Note: The sample is restricted to individuals born between July and December of a year. Each set of connected dots compares the sample means for children born in the 3rd and 4th quarter of a year. The 2nd difference comparison is between the means for the 3rd and 4th quarters aggregated over the pre-reform years 2008-2012.

Source: Diagnosis-Related Groups Statistic; own calculations

"First-stage" effects on screening rates

back

	Baseline	Donut-hole	W/o 2012	Placebo
post × treat	0.222 ***	0.244 ***	0.236 ***	-0.002
	(0.027)	(0.019)	(0.027)	(0.010)
post	0.008	0.021 **	-0.006	0.008
	(0.009)	(0.009)	(0.007)	(0.009)
y2010	ref.	ref.	ref.	ref.
y2011	0.028 ***	0.028 **	0.028 ***	0.028 ***
	(0.009)	(0.010)	(0.007)	(0.009)
y2012	0.145 ***	0.151 ***	-	0.145 ***
	(0.012	(0.013)		(0.012)
y2013 = treat	0.236 ***	0.225 ***	0.229 ***	-
	(0.017)	(0.014)	(0.017)	
y2014 = treat	-	-	-	0.512 ***
				(0.008)
Const.	0.415 ***	0.411 ***	0.422 ***	0.415 ***
	(0.007)	(0.009)	(0.006)	(0.007)
Y-mean	0.651	0.636	0.651	0.927
Rel. to Y-mean	34.1%	38.4%	36.3%	-0.03%
No. of year × month cells	24	16	18	24
No. ob deliveries	33,451	22,242	25,073	33,843

Source: AOK Plus Sachsen.

Balancing tests

back

Estimation sample	Newborns			Mothers		
	Coeff.	St. Err.	p-value	Coeff.	St. Err.	p-value
Female	0.001	(0.002)	0.737	-	-	-
Age	-	-	-	-0.015	(0.020)	0.459
Schleswig Holstein	0.000	(0.001)	0.569	0.000	(0.001)	0.578
Hamburg	0.001	(0.001)	0.083	0.001	(0.001)	0.335
Lower Saxony	-0.001	(0.001)	0.505	-0.002	(0.001)	0.152
Bremen	0.000	(0.000)	0.680	0.000	(0.000)	0.970
North Rhine-Westphalia	-0.001	(0.002)	0.654	0.000	(0.002)	0.829
Hesse	0.000	(0.001)	0.666	-0.001	(0.001)	0.570
Rhineland-Palatinate	0.000	(0.001)	0.655	0.000	(0.001)	0.546
Baden-Wuerttemberg	0.000	(0.001)	0.817	0.000	(0.001)	0.710
Bavaria	0.001	(0.001)	0.456	0.001	(0.001)	0.458
Saarland	0.000	(0.000)	0.623	0.000	(0.000)	0.585
Berlin	0.001	(0.001)	0.400	0.000	(0.001)	0.556
Brandenburg	0.000	(0.001)	0.641	0.000	(0.001)	0.675
Mecklenburg-Western Pomerania	-0.001	(0.000)	0.135	-0.001	(0.001)	0.110
Saxony	0.000	(0.001)	0.792	0.000	(0.001)	0.893
Saxony-Anhalt	0.000	(0.001)	0.709	0.000	(0.001)	0.777
Thuringia	0.000	(0.001)	0.725	0.000	(0.001)	0.801
City	0.003	(0.002)	0.120	0.003	(0.002)	0.143
Urban	0.001	(0.002)	0.754	0.001	(0.002)	0.713
Rural	-0.003	(0.001)	0.018	-0.003	(0.001)	0.021
Obs.	2,053,690			1,981,460		

Source: Diagnosis-Related Groups Statistic (DRG).

Effects on the number of hospital births

back

	Newborns		Mothers	
	Baseline	Incl. controls	Baseline	Incl. controls
post × *treat*	0.005	0.005	-0.012	-0.012
	(0.031)	(0.016)	(0.016)	(0.008)
Zip code FE, gender	no	yes	no	no
Zip code FE, age group FE	no	no	no	yes
Y-mean	2.963	2.963	1.764	1.764
Obs.	63,648	63,648	191,160	191,160

Note: Samples restricted to births from July to December in years 2008 to 2013. Data in the newborn sample are aggregated into year × month × zip code × gender cells. Data in the mothers' sample are aggregated into year × month × zip code × age group cells. County refers to the location of the hospital. The dependent variable is the *log*(number of births +**1**) in each cell. Each column is based on a separate linear regression of equation (1). All regressions include year of birth fixed effects and a *post* dummy. FE = fixed effects.
Source: Diagnosis-Related Groups Statistic (DRG).

Sensitivity analysis: newborns' sample

back

	Affected by GDM	Birth weight	Macrosomia (≥ 4,000g)	Macrosomia (≥ 4,500g)	Low birth weight	Length of stay	Reimbursement claim (log)
A: Baseline	0.002***	0.092	0.001	0.000	0.001	0.036	0.006*
(Obs. 2,053,690)	(0.001)	(2.207)	(0.001)	(0.000)	(0.001)	(0.032)	(0.003
Y-Mean	0.042	3,322.686	0.100	0.013	0.073	5.134	1,977.360
B: Incl. controls	0.002***	0.258	0.001	0.000	0.001	0.038	0.006*
(Obs. 2,053,690)	(0.001)	(2.194)	(0.001)	(0.000)	(0.001)	(0.032)	(0.003)
Y-Mean	0.036	3,339.775	0.101	0.012	0.064	4.786	1,715.572
C: Donut-hole	0.003***	0.839	0.002	0.000	0.001	0.015	0.005
(Obs. 1,726,117)	(0.001)	(2.415)	(0.001)	(0.000)	(0.001)	(0.035)	(0.003)
Y-Mean	0.043	3,319.378	0.099	0.012	0.074	5.146	1,989.274

Source: Diagnosis-Related Groups Statistic (DRG).

Sensitivity analysis: mothers' sample

back

	C-section	Shoulder dystocia	Late-term (>41 weeks)	Full-term (37-41 weeks)	Pre-term (<37 weeks)	Length of stay	Reimbursement claim (log)
A: Baseline	-0.001	0.000	-0.002*	0.000	0.001	0.010	0.004**
(Obs. 1,981,460)	(0.002)	(0.000)	(0.001)	(0.001)	(0.001)	(0.012)	(0.001)
Y-Mean	0.308	0.014	0.097	0.820	0.069	4.427	1,947.755
B: Incl. controls	0.000	0.000	-0.002*	0.000	0.001	0.013	0.004**
(Obs. 1,981,460)	(0.002)	(0.000)	(0.001)	(0.001)	(0.001)	(0.012)	(0.001)
Y-Mean	0.308	0.014	0.097	0.822	0.067	4.415	1,943.649
C: Donut-hole	-0.002	0.000	-0.002	0.000	0.001	0.011	0.003**
(Obs. 1,665,649)	(0.002)	(0.001)	(0.001)	(0.002)	(0.001)	(0.014)	(0.002)
Y-Mean	0.309	0.014	0.096	0.820	0.070	4.427	1,949.888

Source: Diagnosis-Related Groups Statistic (DRG).

Heterogeneity analysis: child's gender

back

	Affected by GDM	Birth weight	Macrosomia (≥ 4,000g)	Macrosomia (≥ 4,500g)	Low birth weight	Length of stay	Reimbursement claim (log)
A: Baseline	0.002***	0.092	0.001	0.000	0.001	0.036	0.006*
(Obs. 2,053,690)	(0.001)	(2.207)	(0.001)	(0.000)	(0.001)	(0.032)	(0.003
Y-Mean	0.042	3,322.686	0.100	0.013	0.073	5.134	1,977.360
B: Male	0.002	1.075	0.002	0.000	0.004	0.037	0.001
(Obs. 1,052,594)	(0.001)	(3.143)	(0.002)	(0.001)	(0.001)	(0.046)	(0.004)
Y-Mean	0.046	3,383.498	0.126	0.017	0.068	5.228	2,029.737
C: Female	0.003***	-0.780	0.000	0.000	0.002	0.036	0.010**
(Obs. 1,001,096)	(0.001)	(3.060)	(0.001)	(0.000)	(0.001)	(0.045)	(0.004)
Y-Mean	0.038	3,258.746	0.072	0.008	0.079	5.035	1,922.268

Source: Diagnosis-Related Groups Statistic (DRG).

Heterogeneity analysis: maternal age

back

	C-section	Shoulder dystocia	Late-term (>41 weeks)	Full-term (37-41 weeks)	Pre-term (<37 weeks)	Length of stay	Reimbursement claim (log)
A: Baseline	-0.001	0.000	-0.002*	0.000	0.001	0.010	0.004**
(Obs. 1,981,460)	(0.002)	(0.000)	(0.001)	(0.001)	(0.001)	(0.012)	(0.001)
Y-Mean	0.308	0.014	0.097	0.820	0.069	4.427	1,947.755
B: >= 35 years	0.003	-0.001	-0.003	-0.000	0.002	-0.002	0.005
(Obs. 418,004)	(0.004)	(0.001)	(0.002)	(0.003)	(0.002)	(0.030)	(0.003)
Y-Mean	0.366	0.015	0.092	0.821	0.074	4.676	2,041.004
C: < 35 years	-0.001	0.000	-0.002	0.000	0.001	0.014	0.003**
(Obs. 1,563,456)	(0.002)	(0.001)	(0.001)	(0.002)	(0.001)	(0.013)	(0.002)
Y-Mean	0.292	0.014	0.098	0.820	0.067	4.361	1,922.777

Source: Diagnosis-Related Groups Statistic (DRG).