The Effect of Unconventional Oil and Gas Drilling on Healthcare Utilization: Evidence from Texas

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Abstract

This paper examines the relationship between inpatient healthcare utilization and the entry of unconventional drilling in Texas's Eagle Ford region. Using a staggered difference-in-differences design, I find that inpatient claims for dermatological conditions, perinatal conditions, and pregnancy complications increase following ZCTA-level entry of unconventional drilling relative to not-yet-treated and never-treated ZCTAs. I then construct a novel dataset that combines public groundwater-source information with healthcare claims and well-location data to identify the effect of unconventional drilling near public drinking-water infrastructure. I find that communities with unconventional drilling near a public groundwater source experience greater increases in inpatient claims compared to communities with unconventional drilling farther away, including an aggregate increase of approximately 168 claims per ZCTA-quarter at the five-kilometer threshold. Perinatal conditions and pregnancy complications follow a more localized spatial pattern, with larger estimates at shorter distances from public groundwater sources. These findings suggest that the health consequences of unconventional drilling depend not only on whether drilling occurs, but also on where it is located relative to population-serving infrastructure.

JEL Codes– Q30, Q53, I12, H23

Keywords— Fracking, Unconventional Drilling, Drinking Water, Groundwater, Social Determinants of Health

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1 Introduction

Hydraulic fracturing and horizontal drilling[1] transformed natural resource extraction. These technologies allowed oil and natural gas producers to reach resources in previously inaccessible shale formations. Over the past few decades, these methods significantly increased and expanded oil and natural gas production in the United States. However, the use of unconventional methods in resource extraction is not without controversy; supporters tout the economic benefits from increased employment and higher wages, while opponents question the environmental and health hazards resulting from these methods.

Hausman and Kellogg (2015) conduct a welfare analysis to measure the economic benefits of the hydraulic fracturing boom. The authors find significant increases in consumer surplus associated with lower natural gas prices, with an estimated $48 billion in increased total surplus. However, the authors note that their welfare calculations exclude negative externalities, such as environmental damage and negative health effects, due to a lack of research. Although numerous studies identify potential pathways that could lead to poor health outcomes associated with these new technologies (Colborn et al. 2011; Epstein 2017; McKenzie et al. 2012; Shonkoff, Hays, and Finkel 2014), the research causally identifying negative health consequences resulting from unconventional oil and gas drilling is limited. A complete assessment of the welfare effects of unconventional drilling would consider health effects. However, hydraulic fracturing is still a relatively new technology and any health-related ramifications may take time to develop. Continually updating research on the health effects of hydraulic fracturing is essential for understanding its full impact.

In this paper, I combine inpatient healthcare claims data with unconventional well locations to identify the effect of unconventional drilling on healthcare utilization. Prior work shows that unconventional drilling negatively affects infants whose mothers lived near drilling sites during pregnancy (Currie, Greenstone, and Meckel 2017; Hill and Ma 2022; Hill 2024). I extend this work by estimating the effect of unconventional drilling on inpatient healthcare utilization using changes in exposure to hydraulic fracturing between 2007 and 2015 in Texas's Eagle Ford region. Although the aggregate estimate is imprecise, I find significant increases in perinatal claims, dermatological claims, and claims related to pregnancy complications.

These effects could stem from exposure to unconventional drilling or from demographic and economic changes associated with shale development. For example, oil and gas workers may move to the region for employment, and shifts in population, income, or insurance coverage could bias the estimates upward. Therefore, I examine outcomes among women and among Medicare and Medicaid beneficiaries. This analysis yields positive estimates across all three groups, although the estimated increase is smaller for women. The directional consistency across populations less likely to experience the male-dominated migration associated

1. Hydraulic fracturing, particularly when combined with horizontal drilling, is commonly known as 'fracking.'

with oil and gas development suggests that compositional changes alone do not explain the observed increases.

Next, I investigate the health effects of drilling near public drinking water infrastructure. I compare changes in healthcare utilization across ZCTAs located on the shale formation that rely on public groundwater sources and differ in their proximity to unconventional drilling. Specifically, I compare ZCTAs where qualifying drilling occurs within one to five kilometers of a public groundwater source with ZCTAs that also experience unconventional drilling, but whose public groundwater sources remain more than five kilometers from qualifying wells.

The results show that, among ZCTAs experiencing unconventional drilling, inpatient healthcare utilization increases more in communities where drilling occurs near public groundwater sources. At the five-kilometer level, I find significant increases in overall inpatient utilization and in several health categories including circulatory, respiratory, cancer, neurological, and gastrointestinal conditions. These estimates are generally similar in magnitude to those in the primary analysis but are more precisely estimated in the groundwater-source sample. Pregnancy complications and perinatal outcomes exhibit a more concentrated spatial pattern, with the largest pregnancy-complication estimate occurring when drilling takes place within one kilometer of a groundwater source and a significant increase in perinatal conditions when drilling occurs within three kilometers.

Because these estimates compare drilling near public groundwater sources with drilling located farther from those sources, the results isolate the additional health effect associated with drilling near drinking-water infrastructure among communities already experiencing shale development. The findings are therefore consistent with drilling near public groundwater sources generating additional local environmental exposures that increase healthcare utilization. The research design identifies the causal effect of drilling near public drinking-water sources relative to drilling farther from those sources, but it does not separately identify the environmental pathway responsible for that effect.

This paper adds to the growing literature on externalities related to unconventional drilling methods. One line of research studies the effect of natural gas development on property values and suggests that proximity to an unconventional drilling site is a disamenity. Muehlenbachs, Spiller, and Timmins (2015) find that the perceived risk of groundwater contamination negatively affects the property value of homes near gas wells, and particularly homes that depend on private groundwater wells for drinking water. The authors find that the property values of homes that use publicly supplied water are not affected or may even benefit from proximity to a producing well through royalty payments. Although the authors do not estimate groundwater contamination, their work suggests that individuals internalize the potential risk of contamination, driving down property values of affected homes. In a similar study, Balthrop and Hawley (2017) investigate home prices for homes largely dependent on public water, finding that houses closer (within

3,500 feet) to hydraulically fractured wells sell at lower prices than houses farther away. The authors suggest various reasons for the negative effect, such as pollution, risk of earthquakes, or visual disamenities, but they do not identify a mechanism. My results provide evidence that proximity of unconventional drilling to public water infrastructure has measurable health consequences, offering one potential explanation for why households may value distance from drilling activity.

A related literature documents environmental contamination associated with shale development, including both air and water pollution (Hildenbrand et al. 2016; Hill and Ma 2022; Litovitz et al. 2013; Osborn et al. 2011; Xu 2023). These studies establish the presence of pollutants near drilling activity, but provide more limited evidence on how these exposures translate into realized health outcomes for nearby populations. Much of the existing work in the economics literature focuses on maternal and infant health, finding that proximity to hydraulic fracturing is associated with adverse birth outcomes (Currie, Greenstone, and Meckel 2017; Hill and Ma 2022; Hill 2024). For example, Currie, Greenstone, and Meckel (2017) compare infant health outcomes before and after the entry of a hydraulically fractured well and find that mothers living within three kilometers of a well give birth to infants with worse health outcomes, including a 25 percent increase in the probability of low birth weight. Hill and Ma (2022) extend this work by showing that drilling near public water sources increases the risk of shorter gestation and low birth weight.

Epidemiological studies document associations between unconventional drilling and a wide range of adverse health outcomes. Black et al. (2021) synthesize this evidence, highlighting links between drilling activity and increased hospitalizations as well as disease incidence. Existing studies identify associations across multiple systems, including respiratory, dermatological, and genitourinary conditions, as well as more severe outcomes such as pediatric asthma hospitalizations and elevated cancer risk among children living near high concentrations of wells (Denham et al. 2019; Willis et al. 2018; McKenzie et al. 2017).

Despite this broad evidence of potential health effects, causal research remains much narrower in scope. Existing quasi-experimental studies are concentrated on infant and child health and on a small number of respiratory outcomes. As noted by Black et al. (2021), relatively few studies causally identify effects on adult health or examine the broader set of conditions that may respond to unconventional drilling. Peng, Meyerhoefer, and Chou (2018) find increases in pneumonia hospitalizations among elderly patients, while Xu (2023) documents increases in respiratory-related hospitalizations in Texas following drilling activity. This paper broadens the causal evidence by examining inpatient utilization across a broad set of health conditions and by testing whether these effects vary with the location of drilling relative to public drinking-water infrastructure.

I also extend prior research by examining healthcare utilization in an understudied region: the Eagle Ford Shale formation. Much of the existing causal evidence on the health effects of unconventional drilling comes

from the Marcellus Shale in Pennsylvania and New York[2]. Differences in geology across shale formations imply that drilling techniques and the composition of released pollutants vary by region (Speight 2019). In contrast to the Marcellus, which primarily produces natural gas, the Eagle Ford produces both oil and natural gas, leading to additional byproducts such as flaring-related emissions. These differences may alter both the type and intensity of environmental exposures.

In addition, the timing of development in the Eagle Ford provides useful variation for identification. Unlike the Marcellus, where portions of the resource were accessible through earlier conventional drilling, the Eagle Ford became economically viable only after its discovery in 2008, followed by a rapid expansion in drilling beginning around 2010. This rapid and staggered expansion in drilling provides substantial temporal and geographic variation in exposure, which I exploit using a staggered difference-in-differences design.

In the next section, I describe the history of the Eagle Ford Shale formation, the process of hydraulic fracturing and horizontal drilling, and potential pathways for negative health outcomes. In section three, I outline the data and provide descriptive statistics. Section four reviews my methods and results. Section five concludes.

2 Background

2.1 UNCONVENTIONAL DRILLING

Unconventional drilling refers to newer methods of extracting oil and natural gas from underground reservoirs that were inaccessible using previous technologies. While conventional drilling involves drilling vertically into oil or natural gas reservoirs, unconventional drilling uses alternative methods to release oil and natural gas trapped in tight geological formations. Two unconventional drilling methods, often used in combination, are hydraulic fracturing and horizontal drilling. The process of unconventional drilling involves several phases between preparation and production (Hill 2018). Once a drilling site is located and permitted, well pad construction begins, which includes clearing and preparing the area for drilling. Next, wells are drilled on the well pad, which can take up to two months for horizontally drilled wells. After drilling, hydraulic fracturing takes place for around seven days to stimulate oil and natural gas production. The hydraulic fracturing process involves injecting water, chemicals, and/or sand into rock formations to break up the rock and release the oil and gas. Conversations with oil and natural gas engineers suggest that after the vertical portion of the well reaches the target formation, the wellbore extends horizontally through the shale, and hydraulic fracturing is conducted along this lateral section of the well. After fracturing, there is a period of

2. One exception is Willis et al. (2021), which examines birth outcomes in Texas, though the health data end in 2009.

owback. During the owback period, injected fracturing uid returns to the surface along with formation water and hydrocarbons. The resulting wastewater, including owback and produced water, may be reused or transported for treatment or disposal in injection wells (Kondash, Albright, and Vengosh 2017).

Cost-e ective hydraulic fracturing and horizontal drilling began in the late 1990s and early 2000s in the Barnett Shale region of Texas. By 2008, Texas produced more than 70 percent of shale gas in the United States (Gilmer and Kerr 2010). In addition to the Barnett Shale region, unconventional drilling technology opened new opportunities in several other Texas geological formations including the Permian Basin, the Haynesville Shale formation, and the Eagle Ford Shale formation. According to Gilmer, Hernandez, and Phillips (2012), drilling began in the Eagle Ford region in 2008 in La Salle County. Production subsided in 2009 as a result of declining oil and gas prices and the Great Recession, but picked up again in 2010 and grew rapidly, creating useful temporal and geographic variation to study the health consequences of unconventional oil and gas drilling. Though nearby formations were accessible using conventional techniques, oil and natural gas in the Eagle Ford Shale formation was not accessible prior to 2008, and therefore the new technology allowed for a sharp increase in production after discovery (Speight 2019). By 2021, Eagle Ford was one of the most productive formations in Texas. Figure 1 shows the increase in oil and gas wells drilled in the Eagle Ford formation following the expansion of horizontal drilling, and captures the small increase in wells after 2008 with a much larger increase after 2010.

2.2 HYDRAULIC FRACTURING AND HEALTH

The process of extracting oil and natural gas through both conventional and unconventional methods gives rise to health concerns, primarily through air and water pollution (Shonko , Hays, and Finkel 2014; Speight 2019). The use of large volumes of fracturing uid, which contains potentially hazardous chemicals and can leach toxic substances from shale formations, distinguishes unconventional from conventional drilling. This water-intensive process contributes to concerns about drinking water contamination, and studies document elevated concentrations of potentially hazardous chemicals in drinking water near unconventional drilling sites (Alawattegama et al. 2015; Hill 2018; Rozell and Reaven 2012; U.S. EPA 2016; Wollin et al. 2020). In a review of the relationship between drinking water contamination, hydraulic fracturing, and health, Shonko , Hays, and Finkel (2014) cite studies that nd elevated concentrations of methane (Jackson et al. 2013; Osborn et al. 2011), heavy metals and total dissolved solids (Fontenot et al. 2013), and volatile organic compounds (VOCs) including benzene, toluene, ethylbenzene, and xylenes (BTEX) (DiGiulio et al. 2011; Gross et al. 2013; Hildenbrand et al. 2015) in drinking water near unconventional drilling sites.

Exposure to these chemicals can have signi cant health consequences. For example, Webb et al. (2018)

Figure 1: Total wells drilled on Eagle Ford over time

Notes: Figure 1 shows the number of wells drilled each year-quarter in Eagle Ford during the sample period. `Total Wells' includes all wells drilled during the period. `Horizontal Wells' represents all horizontally drilled wells, which are the wells most likely to use hydraulic fracturing. Horizontal wells are a subset of the `Total Wells.' Source: Author's Calculations using Texas Railroad Commission (2007{15) data.

draws attention to the serious neurological health e ects of chemicals used in the hydraulic fracturing process, such as heavy metals, particulate matter (PM), BTEX, and endocrine-disrupting chemicals (EDCs), all of which are associated with poor neurodevelopment, cognitive, and mental health outcomes through drinking water exposure. BTEX chemicals are also associated with damage to the nervous and endocrine systems, birth defects and low birth weight, respiratory conditions, abnormal heart rhythms, and blood diseases, including aplastic anemia and acute myelogenous leukemia (Epstein 2017). Shrestha et al. (2017) examine the health e ects of chemicals found in groundwater near hydraulic fracturing sites, and nd chemicals related to gastrointestinal distress, kidney disease or kidney damage, skin sensitivity or sores, cancer, dehydration, and liver disease, in addition to the conditions mentioned above. Chemicals used in drinking water treatment can also interact with chemicals used in hydraulic fracturing, transforming them into more toxic compounds. For instance, Wollin et al. (2020) explain that chemicals used to disinfect drinking water can cause oxidation of bromide used in hydraulic fracturing, creating the chemical bromate, which is mutagenic and carcinogenic.

Although the health e ects of some chemicals used in the hydraulic fracturing process are known, there remains considerable uncertainty about both the substances used and their potential health consequences. Colborn et al. (2011) compile a non-exhaustive list of products used in the fracturing process and identify potential health e ects for 353 chemicals for which Chemical Abstracts Service (CAS) numbers were available.

The chemicals with known health effects can impact the skin, eyes, kidneys, and brain as well as the nervous, immune, endocrine, respiratory, and cardiovascular systems. Twenty-five percent of the chemicals identified could cause cancer or mutations, and thirty-seven percent are candidate endocrine-disrupting chemicals (EDCs), which can affect reproductive systems and fetal and early childhood development. In a 2016 study on the impact of hydraulic fracturing on drinking water, the EPA finds that hydraulic fracturing can impact drinking water and considers the health effects of over 1,600 chemicals used in the hydraulic fracturing process. The authors note that the health effects of many of the chemicals used in the process are unknown and many are not regulated or measured in drinking water (U.S. EPA 2016).

In a cautionary public health paper, Finkel and Law (2011) explain that the timing of health effects after exposure to the chemicals used in hydraulic fracturing is largely understudied. For example, a review of clinical, observational, and epidemiological studies on EDCs suggests that numerous factors, such as age at exposure, exposure dosage, and mixtures of contaminants can all impact the timing between exposure and disease, and some endocrine-disrupting effects may appear decades after exposure or even transgenerationally. Prior studies also document adverse health outcomes in areas exposed to hydraulic fracturing, including higher rates of congenital heart defects among infants whose mothers lived near unconventional wells (McKenzie et al. 2014) and higher rates of hematological cancer among children living closer to oil and gas development (McKenzie et al. 2017).

Water contamination can affect both groundwater and surface water, but the spatial relationship between drilling and groundwater sources is more localized than the relationship between drilling and surface-water exposure. Rozell and Reaven (2012) identify several pathways through which unconventional drilling may affect water quality, including spills during fluid transportation, well-casing failures, subsurface migration, site discharge, and wastewater disposal. Surface-water exposure can depend on hydrologic features such as flow direction, elevation, and upstream activity (Bonetti, Leuz, and Michelon 2021; Hill and Ma 2022), making the relevant exposure area difficult to define geographically. By contrast, potential contamination of a groundwater source is more closely tied to drilling activity near the source location. Prior work suggests that contamination may arise from surface spills during the pre-production period (Shanafield, Cook, and Simmons 2019) or later through structural impairment, fluid migration, or discharge during flowback (Rozell and Reaven 2012; Shonkoff, Hays, and Finkel 2014). I therefore use proximity between drilling and public groundwater sources to examine whether the health effects of unconventional drilling vary with the location of population-serving water infrastructure. This measure captures the potential for a drinking-water pathway, but does not uniquely identify drinking-water exposure.

Air pollution provides an additional pathway through which unconventional drilling may affect health. Emissions arise from both drilling and production activities as well as the transportation of water, equipment,

and oil and natural gas to and from drilling sites. Prior studies document elevated concentrations of air pollutants near conventional and unconventional oil and gas development (McKenzie et al. 2012; Petron et al. 2012; Roy, Adams, and Robinson 2014). Hydraulic fracturing also requires substantial truck traffic, which can increase diesel particulate matter along transportation routes (Shonkoff, Hays, and Finkel 2014; Speight 2019). Consistent with this pathway, Blundell and Kokoza (2022) use quasi-random variation in upwind natural gas flaring to identify a causal increase in respiratory-related hospital visits. Because these emissions can disperse beyond the immediate drilling site, the geographic footprint of air-pollution exposure may differ from the more localized relationship between drilling and groundwater-source locations. Drilling and production may also generate other localized exposures, such as noise, associated with industrial activity. The empirical analysis therefore does not separately identify a drinking-water pathway from other potential environmental pathways.

In addition to environmental exposures, shale development may affect healthcare utilization through economic and demographic channels. Shale booms can increase employment and wages and may alter insurance coverage, migration, and the composition of the local population. Inpatient care generally reflects more severe health needs than outpatient care and may therefore be less sensitive to short-run changes in income or employment (Hamad, Modrek, and Cullen 2016). Nonetheless, changes in population composition or insurance coverage could still affect measured inpatient utilization. I address these concerns empirically by examining utilization among women and among Medicare and Medicaid beneficiaries.

3 Data and Descriptive Statistics

3.1 HEALTHCARE DATA

Claim-level inpatient data from the Texas Health Care Information Collective (THCIC) provide the primary outcome data for this paper. All hospitals within the state of Texas are required to report claims, which are the invoices submitted to health insurance companies for payment, on discharged patients. THCIC provides de-identified claim reports available for public use (Texas Health Care Information Collective 2007–15).[3] This rich data source includes information on each patient claim submitted by the hospital, the quarter and year the claim was submitted, details on the diagnosis and procedure codes associated with the claim, and patient demographic information.[4] Specifically, the data include hospital information, such as the hospital name,

3. Although data were available through 2016 at the time of this study, healthcare providers switched from ICD-9 to ICD-10 codes in October of 2015. Therefore, I use all claims made before this transition.

4. The public use files exclude claims made in hospitals located in a county with a population less than 35,000, or those in a larger county with less than 100 hospital beds. In addition, hospitals that do not seek insurance or government reimbursement are also exempt.

indicators for the facility type, [5] and categorical variables for the specialty unit[6] where the care occurred. I also observe patient demographic information for each claim including the patient's age range, gender, race, ethnicity, county, zip code, and payment information, such as insurance type. I use data between 2007 and 2015, starting one year prior to the entry of hydraulic fracturing in the Eagle Ford Shale formation. I also only include claims from individuals whose zip code can be assigned to a ZCTA in the treatment or comparison groups. If workers temporarily move to Eagle Ford for labor opportunities, but do not establish residency in the area, they are excluded from the analysis.

I categorize the ICD-9[7] codes on each claim using the Healthcare Cost and Utilization Project's Clinical Classi cations Software (HCUP CCS), which collapses over 14,000 ICD-9 diagnosis codes and 3,900 procedure codes into clinically meaningful categories. Speci cally, HCUP CCS categorizes diagnosis codes into a hierarchy of nested medical conditions. For example, a medical claim may include a set of diagnosis codes that suggest the clinically meaningful diagnosis was \Essential Hypertension," which falls under the \Hypertension" category, which is nested under \Diseases of the Circulatory System." For most conditions, I use the highest category in the hierarchy to test each medical category. I focus on health conditions that could be linked to hydraulic fracturing through pollution exposure according to prior literature described in Section 2.2. Speci cally, I focus on mental health[8], endocrine conditions, cancer, conditions of the central nervous system, respiratory, gastrointestinal, urological, circulatory, and integumentary systems, pregnancy and birth outcomes, and blood diseases (Colborn et al. 2011; Epstein 2017; Shonko , Hays, and Finkel 2014; Webb et al. 2018; Wollin et al. 2020; Garshick et al. 2008; Persico and Marcotte 2022). In addition, I test changes in `General Illness,' which includes symptoms such as fever, nausea and vomiting, and general malaise that is not attributed to a speci c condition. This list is not exhaustive and serves as an analytical starting point for this study. For more information on the conditions included in this paper, see Appendix Section A.1.1.[9]

3.2 UNCONVENTIONAL DRILLING TECHNOLOGY

The data include several di erent types of wells and do not speci cally identify hydraulic fracturing sites. For my analysis, I identify horizontally drilled, non-injection wells using the RRC horizontal-well classi cation,

5. For example, this might include an indicator for a psychiatric facility or a rehabilitation facility.

6. Specialty units are the areas of the hospital dedicated to patients with speci c needs. For example, the obstetric unit is the area of the hospital speci cally for labor and delivery.

7. ICD-9 and ICD-10 are the Ninth and Tenth Revisions, respectively, of the World Health Organization's International Classi cation of Diseases, the o cial coding system used for diagnoses and procedures in the United States.

8. Mental health conditions include anxiety disorders, attention de cit disorders, depressive disorders, suicide and intentional self-harm, eating disorders, and substance abuse disorders.

9. I also tested the change in musculoskeletal conditions, such as injuries, as a potential placebo group. While I nd no signi cant change in these conditions, they could plausibly vary with changes in local activity patterns, even when unrelated to water and air pollution. For example, Xu and Xu (2020) nd an increase in fatal car accidents with the entry of a new hydraulic fracturing well. Therefore, I do not include a placebo category in this analysis.

and I refer to wells meeting these criteria as qualifying wells. I verify this classi cation using the surface and bottom well locations provided in the GIS data. Treatment is de ned as the entry of the rst qualifying well in a geographic area.

I map the Eagle Ford Shale boundary to identify wells located within two miles of the formation.[10] Ultimately, I identify 17,965 qualifying wells drilled in the Eagle Ford region during the study period.

Treatment timing is determined by the spud date of the rst qualifying well drilled in a geographic area beginning in the fourth quarter of 2008 (Blackmon 2018). This de nition requires two key assumptions. First, because the data do not directly identify hydraulic fracturing, I use horizontal drilling in the Eagle Ford as a proxy for unconventional shale development. Speight (2019) states that oil and natural gas in the Eagle Ford Shale formation are inaccessible using conventional drilling techniques. Figure 1 shows that the increase in drilling activity in the region was driven almost entirely by horizontally drilled wells. Second, I assume that hydraulic fracturing occurs reasonably soon after the well is drilled. Conversations with engineers in the eld suggest that this assumption is generally reasonable, although fracturing may sometimes be delayed. Because hydraulic fracturing stimulates oil and gas production, producers may delay completion until economic conditions, such as oil prices, are more favorable.

I conduct my analysis at the ZCTA level and identify treated Zip Code Tabulation Areas (ZCTAs) [11] using the boundaries of the shale formation. The estimation sample includes ZCTAs in the 27 Eagle Ford counties and the rural and semi-rural neighboring counties.[12] Within this sample, ZCTAs are treated if they receive a qualifying well during the study period and otherwise contribute to the never-treated comparison group. Treatment timing corresponds to the quarter when the rst qualifying well was drilled within the ZCTA. This results in staggered treatment timing, with rst treatment occurring between the fourth quarter of 2008 and the rst quarter of 2015.

The drawback of conducting the analysis at the ZCTA level is that THCIC masks zip code identi ers for claims from patients living in zip codes with fewer than 30 patients total or fewer than ve patients of a particular gender, making some utilization rates arti cially low. Overall, approximately 11 percent of claims have suppressed zip code identi ers, although the suppression rate increases somewhat over the sample period and varies across conditions. Suppression is particularly low for pregnancy complications and perinatal conditions, at 2.7 percent and 1.0 percent of claims, respectively, while approximately 24 percent of mental-health claims have suppressed zip code identi ers. Estimates for mental-health conditions should

10. I choose a two-mile radius from the well location to the shale formation based on conversations with fracking engineers.

11. Zip codes are groups of street networks and buildings used by the United States Postal Service for mail delivery, while ZCTAs are designed by the United States Census Bureau for geographic analysis.

12. I exclude Bexar County (San Antonio), Travis County (Austin), Williamson County (Austin metropolitan area), and Montgomery County (Houston metropolitan area). These large metropolitan areas may have healthcare utilization and other economic or demographic dynamics that di er from the more rural Eagle Ford region.