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DISCUSSION PAPER SERIES

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ABSTRACT

Conflict, Rockets, and Birth Outcomes: Evidence from Israel's Operation Protective Edge*

In summer 2014, southern Israel experienced rocket attacks from the Hamas-ruled Gaza strip on a nearly daily basis for over 50 consecutive days. We exploit this unexpected escalation in the Israeli-Palestinian conflict and variation across localities in Israel in the amount of sirens that warned of rocket attacks to measure the effect of conflict intensity on birth weight and gestation length among mothers who were pregnant during this period. In addition to the common notion that conflict intensity induces stress and anxiety, we also show that conflict intensity is correlated with absences from work and lack of prenatal care. Results on changes in birth outcomes are consistent with a detrimental effect of stress and reduced prenatal care and a beneficial effect of reduced work attendance during pregnancy. Our results demonstrate that multiple factors can impact birth outcomes when evaluating the effect of armed conflict and that the effects can also be qualitatively different.

JEL Classification: I10, I12

Keywords: birth outcomes, prenatal stress, prenatal care, Israeli-Palestinian conflict

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1 Introduction

In summer 2014 Israel entered another round of armed conflict against the Hamas-ruled Gaza strip, as part of a series of violent escalations and military operations taking place intermittently since the Hamas took power there in 2007. This round, during which Israel responded with a military operation called Operation Protective Edge (OPE), was particularly intense. It lasted nearly two months, which was far greater than previous rounds that lasted at most for three weeks, and included over 4,500 rockets fired from Gaza towards the Israeli civilian population. We exploit this unexpected and relatively intense event, which severely disrupted the civilian population's daily lives in Israel, to examine birth outcomes for women pregnant during the conflict. We utilize regional and temporal variation in its intensity by measuring the number of siren warnings of rockets that pregnant women experienced in their locality of residence during each pregnancy trimester. These sirens provided civilians 15-90 seconds - depending on the locality's proximity to the Gaza strip - to seek shelter that can protect them in case the rocket hits the ground in close proximity to them, which can be life-threatening. We use restricted data on all births from Soroka University Medical Center, the only hospital serving the Negev region in southern Israel and match this data with the number of sirens in each locality by date.

The effects of intrauterine shocks on birth outcomes have been demonstrated with respect to shocks related to nutritional quality (Lunney (1998); Almond and Mazumder (2011)), diseases and flus (Currie and Schwandt (2013)), psychological stress (Torche (2011); Currie and Rossin-Slater (2013); Lauderdale (2006)), and air quality (Currie and Walker (2011); Currie et al. (2011)). Based on evidence of the long-lasting effects of birth outcomes on adult health, human capital accumulation and welfare (Black et al. (2007); Schwandt (2014)), economists have been intensifying their investigation of the effects of prenatal shocks. Given that various negative shocks prevail more among disadvantaged mothers or communities, these determinants can assist in explaining social and economic disparities and their intergenerational persistence.

We propose three channels through which OPE could have produced shocks experienced by pregnant women that affected their birth outcomes: the anxiety induced by each siren warning of a rocket attack; reduced work attendance; and changes in prenatal care in response to conflict intensity. We use our data to rule out other potential channels, such as migration responses following OPE or selection of mothers giving birth. Our outcomes of interest are: birth weight, gestation length, an indicator for low birth weight (<2500 grams), and an indicator for a pre-term birth (<37 weeks gestation). These are the main birth outcomes most frequently evaluated in studies of this nature, and they have been found to have a profound effect on long-term health and welfare.[1]

Our primary regression specifications include locality-year-of-conception fixed effects. These fixed effects not only allow us to control for potential correlation between the intensity of sirens and locality demographics but also for locality-specific demographics that may change over time. This considerably re-

[1] In the Appendix, we also evaluate the relationship between sirens during OPE and the probability of a caesarean section (C-section), a birth defect, an early water break, and the Apgar 5 score.

duces concern that our explanatory variables of interest - the number of sirens mothers experienced in their locality of residence during each pregnancy trimester - are correlated with other maternal demographic characteristics that may also be determinants of birth outcomes. Specifically, the main source of variation in our regressions stems from comparing between mothers conceiving a child in the same calendar year and residing in the same locality but with different conception dates, which results in different exposure to sirens during a pregnancy. All conception dates within our sample are prior to OPE or after it to avoid concern of selection into pregnancy during OPE itself. The underlying assumption is that the conception date is orthogonal to birth outcomes when controlling for seasonality through month of conception fixed effects.

Our identification also relies on the highly plausible assumption that OPE could not have been anticipated prior to June 2014. The escalated conflict was triggered by the kidnapping and murder of three Israeli teenagers by two Hamas members during June 2014, a severe and unexpected event even amidst the ongoing Israeli-Palestinian conflict.

Our results suggest non-linearities in the effects of sirens on birth outcomes. In addition, some of the effects are non-monotonous, and we explain these non-monotonicities by our potential channels that influence birth outcomes during OPE and could have opposing effects qualitatively. Anxiety and stress resulting from sirens are detrimental to birth outcomes as are decreases in prenatal care. Reduced work attendance is found to be beneficial to birth outcomes.

We find that low siren counts experienced during the first trimester adversely affected birth outcomes, which is likely driven by anxiety and stress. However, this effect diminishes at high siren counts for mothers from higher socioeconomically ranked localities, which is consistent with a decreasing marginal effect of sirens. Mothers from disadvantaged localities have a higher probability of lack of prenatal care in response to high first trimester siren counts. As such, their first trimester adverse siren effect does not diminish, as it does for mothers from higher socioeconomically ranked localities, but rather increases. The results on second trimester siren counts are more ambiguous, as both detrimental and beneficial effects are found among mothers from advantaged and disadvantaged localities. In response to third trimester sirens, we mostly observe improvements in birth outcomes that are greater among mothers from higher socioeconomically ranked localities and diminish more in response to high siren counts among mothers from low socioeconomically ranked localities. These results are consistent with an analysis we present using data from the Israeli Labor Force Survey that demonstrates increased absences from work among women during OPE, and that these increases are greater in response to sirens among pregnant women from localities ranked high socioeconomically. Thus, it seems that increased absences from work during OPE improved birth outcomes for women in their third trimester.

The paper proceeds as follows. In the next section, we propose the potential underlying mechanisms that can produce changes in birth outcomes in response to sirens during OPE. In Section 3 we describe our data from Soroka Hospital as well as the data on sirens during OPE. In Section 4, we outline our empirical strategy and establish empirically the need for specifying a quadratic regression specification in order to analyze the relationship between sirens and birth outcomes. In Section 5 results are presented both for the entire population of births in our sample and with differential effects based on localities' socioeconomic ranking. We also present results demonstrating increases in absence from work during OPE and increases in lack of prenatal care, both of which are found to be correlated with the number of sirens in women's locality of residence, although for different socioeconomically ranked localities. Based on these results, we discuss potential mechanisms for the results observed. Robustness checks are provided in Section 6, followed by the conclusions in Section 7.

2 Potential Mechanisms for the Effect of Sirens on Birth Outcomes

Numerous studies have demonstrated the importance of intrauterine shocks to mothers in determining birth outcomes. Many of the shocks investigated in these studies alter the physical environment pregnant women are exposed to in terms of environmental factors such as air quality (Currie and Walker (2011); Currie et al. (2011); Currie and Schwandt (2016)), nutritional quality (Almond and Mazumder (2011); Lumey et al. (1993)), or the availability of prenatal care (Evans and Lien (2005)). Other shocks relate to the mother's psychological condition while pregnant, which has been largely investigated in terms of maternal stress. Maternal stress has been shown to increase the production of cortisol, which is related to premature delivery (Lockwood (1999); Hobel (2004)). Several studies consider natural disasters (Torche (2011); Currie and Rossin-Slater (2013)), bereavement (Persson and Rossin-Slater (2018)), or increases in discrimination and racism (Lauderdale (2006)) to show a causal detrimental relationship between stress experienced by mothers during various phases of their pregnancies and birth outcomes several months later.

Civilian stress can also increase due to armed conflict or violent incidents. In accordance with this, several studies have investigated the costs of armed conflict in terms of birth outcomes among mothers who were exposed to such events during their pregnancies. The vast majority of these studies find adverse effects in response to stress induced from armed conflict during the early stages of pregnancy. Mansour and Rees (2012) show that mothers in the Palestinian territories who resided in a town with higher fatalities by Israeli security forces during the Second Intifada gave birth 6-9 months later to infants with a low birth weight in higher probabilities. Camacho (2008) investigates land mine explosions in Columbia as a source of stress during pregnancy and finds a detrimental effect on birth weight as a function of the number of land mine explosions during early pregnancy. Quintana-Domeque and Ródenas-Serrano (2017) investigate the effect of terror attacks in Spain over a period of more than 20 years and find that terror bomb casualties during the first trimester resulted in lower birth weight. Torche and Shwed (2015) exploit Israel's second Lebanon War in 2006, which similarly affected residents of northern Israel with rocket attacks for several weeks as OPE did, and find that exposure to the conflict early in the pregnancy had negative effects on birth outcomes. The authors do not examine localities separately and do not utilize data on sirens, as we do in the present study. Gluck et al. (2019) examine maternal stress and birth outcomes in response to OPE as well. However, their study focuses on comparing birth outcomes between mothers residing in close proximity to Gaza who experienced prolonged exposure to sirens prior to OPE and mothers residing in central Israel for whom the exposure to sirens during OPE was a new phenomenon. They find adverse effects of sirens during the first and second trimester that depend on whether continuous stress occurred. Brown (2018) finds that exposure to greater violent conflict due to drug wars in Mexico during early pregnancy decreased birth weight. Lastly, Eskenazi et al. (2007) exploit the stress induced by the September 11 attacks in New York and show increased probability of low birth weight among mothers experiencing the event early in their pregnancy.

A few of the studies on armed conflict and the stress induced from it during pregnancy exploit regional and temporal variation in the intensity measures of armed conflict, such as casualties (Mansour and Rees (2012); Quintana-Domeque and Ródenas-Serrano (2017)), explosions (Camacho (2008)) or homicide rates (Brown (2018)). Our study also exploits such variation by assigning to each mother the number of sirens she experienced in her locality of residence during each trimester of her pregnancy. Our main regression specification assumes a non-linear relationship between sirens and birth outcomes - for which we empirically demonstrate the need in Section 4. A non-linear relationship between stress and birth outcomes has also been demonstrated in Camacho (2008).

Armed conflict can result in other changes in the environment faced by pregnant women that can affect birth outcomes, besides stress. OPE was a conflict lasting less than 2 months. As such, migration or fertility responses are not relevant for this setting. Nevertheless, we do test whether our results may be driven by migration patterns shortly after OPE and find no evidence for this (see Table 7 in the Appendix).[2] Environmental factors were not affected in any way by OPE. The combat fighting was confined to the Gaza strip, where Israelis do not reside, and missiles shot at Israel do not produce any environmental pollutants or chemical hazards. While OPE did affect the economy in Israel, this effect was marginal for the vast majority of households with an estimated loss of 0.4% of GDP. We note two other potential channels that can affect birth outcomes and may change in response to conflict: work attendance and prenatal care.

Absences from work increased during OPE, as child care services were not available in many localities and some employees may have had concerns on traveling to reach their work destinations.[3] For pregnant women, this could lead to a substantial decrease in work attendance, as paid parental leave in Israel does not include the prenatal period.[4] Results on the effect of work attendance on birth outcomes are not concise.

[2]Migration responses *during* OPE were very minimal. In the localities that were extremely close to Gaza (up to a few kilometers and excluded from our sample), many families left their towns and communities during the peak of the conflict. However, in most other localities, the vast majority of residents remained. There were no official instructions from the IDF or the government to evacuate any residential area during OPE.

[3]Many summer camps and child care facilities in the south did not operate during OPE. While most of the population continued to work regularly during OPE, a large share of adults took (paid or unpaid) time off from work, especially if child care services were unavailable to them. According to Israeli law, if child care services are canceled due to heightened security events for children age 14 and under, one parent can take paid time off from work to stay with their child - unless employed in an "essential" establishment - hospital, security forces, fire department, utilities, etc. A summary of worker's rights during OPE is available in an article (in Hebrew) dated July 2014 - https://www.themarker.com/career/1.2372240

[4]Employed women giving birth in Israel were entitled (as of 2014) to 14 weeks of paid leave, beginning on the child's birth date

Stearns (2015) finds improved birth outcomes when antenatal and postnatal paid leave are introduced in the U.S. While the improvements can result from reduced work attendance due to antenatal leave, they can also be attributed to reduced stress due to certainty with respect to paid leave after giving birth, as exhibited in Rossin (2011) where increases solely in unpaid postnatal leave for U.S. mothers improved birth outcomes. Ahammer and Schneeweis (2020) find no effect of increased prenatal leave in Austria on birth outcomes. However, their policy change is an increase of prenatal leave from 6 to 8 weeks - a relatively minor change in comparison to changes from no prenatal leave to several weeks of reduced work attendance. Wüst (2015) finds that *less* employment during the first trimester of a pregnancy in Denmark is detrimental to birth outcomes and argues that this is due to stress induced by less employment in countries with high female employment rates. Vrijkotte et al. (2009) evaluate pregnant women in Amsterdam and find that longer work weeks ($\geq$ 32 hours) and greater job strain are associated with adverse birth outcomes.[5]

Conflict can also result in changes in prenatal care, which in turn, can affect birth outcomes. Torche and Villarreal (2014) find that the drug wars in Mexico improved birth weight outcomes, and this is due to a behavioral response among pregnant women that increased prenatal care take-up and potentially other health-enhancing activities. Causal effects of prenatal care on birth outcomes are difficult to establish, due to the endogeneity of the extent of prenatal care pregnant women choose. However, Evans and Lien (2005) have managed to overcome these challenges through a natural experiment that exploits a bus strike in Pittsburgh, which limited access to prenatal care clinics among disadvantaged pregnant women. Their findings show that reduced prenatal care visits early in the pregnancy negatively affects birth weight. Evans and Lien (2005)'s results also suggest that less visits later in the pregnancy do not entail a cost in terms of birth weight.

To summarize, we outline three potential underlying mechanisms that can affect birth outcomes due to OPE and sirens more particularly: stress, reduced work attendance during pregnancy, and changes in prenatal care. As part of our analysis, we test for these potential mechanisms in an effort to determine what may drive our results. Our findings suggest detrimental effects on birth outcomes resulting from stress and reduced prenatal care and beneficial effects on birth outcomes resulting from reduced work attendance.

3 Data

Data for our analysis are primarily from two sources. The first source is restricted confidential data for all births delivered in Soroka University Medical Center (Soroka) between January 2007 and early August 2015. The second source documents all sirens in Israel by locality and date beginning in June 2014 and ending in September 2014.

and without a possibility to transfer the post-natal paid leave to a period prior to giving birth. As a result, antenatal leave in Israel is quite rare.

[5]Several studies evaluate occupation-specific factors and find adverse birth outcomes among pregnant employed women. These include drugs, gases and X-ray exposure among U.S. nurses (Lawson et al. (2012)), exposure to benzene in the petrochemical industry (Chen et al. (2000)), exposure to smoking in the dining industry (Bharadwaj et al. (2014)), shift work (Bonzini et al. (2011)), and longer commutes to work (Wang and Yang (2019)).

Soroka University Medical Center (Soroka) is the only hospital serving the Negev region in southern Israel. The hospital is located in Beer Sheva, the largest city in southern Israel, and provides medical services to approximately one million residents of the South, from Kiryat Gat and Ashkelon to Eilat. Soroka is the third largest hospital in Israel, with 1,151 hospital beds. The nearest hospital to Soroka is roughly an hour drive from Soroka. Thus, for the vast majority of mothers giving birth in the Negev region, Soroka was the only option for delivery.[6] The number of annual births in Soroka ranged from over 12,000 in 2007 to roughly 15,000 in 2014, steadily increasing over the years. Of these, roughly 55% of births are to Arab mothers and 45% of birth are to Jewish mothers. We focus our analysis on Jewish births, due to concern that the locality for some of the Arab mothers is imprecise, as a large fraction of Arabs in southern Israel reside in unrecognized communities that are not documented in the Soroka birth data. During OPE, Soroka was fully functional. The hospital complex has built-in protective shelters in nearly every hallway in case of a missile attack. All labor and delivery rooms (as well as operation rooms) in Soroka are fully protective in case of a missile attack.

Our birth data details for each birth the month of birth, the month of release from the hospital, mother's age, birth parity, locality, whether she is Jewish or Arab, and a vast range of pre and post birth health conditions and outcomes documented by ICD codes. Mother identification numbers are provided, so that it is possible to identify multiple births for the same mother over time.

Due to data confidentiality, only the month of birth and release from the hospital are provided, rather than exact dates. Our treatment variables - the number of sirens experienced by the mother during her pregnancy - are relative to the conception date. In order to derive an approximate date of conception, we first assume that all birthdates are on the 15^{th} of the birth month provided, except in cases where the release from the hospital is in the month proceeding the birth month, for which we assume a birthdate at the end of the birth month provided. This should generate errors of at most two weeks in the exact date of birth. For the conception date, we take the birthdate we derive, subtract from it the gestation length provided in days, and add to that 14 days.

Our main sample is limited to Jewish mothers ages 20-45 with a birth parity of 10 or less and gestation length of at least 180 days. We exclude mothers from localities that are within 7 kilometers of the Gaza strip. These towns and communities - officially termed the Gaza Envelope in Israel - experienced rocket and mortar firings for several years prior to OPE and their residents were also more likely to leave during OPE. To avoid potential selection of births that were conceived during OPE, we exclude from our sample all births with a conception date ranging from July 1, 2014 to August 31, 2014.

Most of our analysis focuses on the sample of births conceived during 2013-2014. These are the calendar years for which births varied in the sirens experienced by mothers due to OPE. When we make use of samples from longer time frames for our analysis, we exclude pregnancies during the two other military operations in Gaza preceding OPE - Operation Cast Iron in December-January 2008 and Operation Pillar of

[6]Soroka Hospital is a public hospital in Israel. The entire population in Israel is covered by the national health insurance program that includes all hospitals for giving birth in Israel. Delivery at these hospitals is fully covered.

Defense in November 2012 - during which time towns in southern Israel also experienced missile attacks. This results in excluding all births conceived between mid-March 2008 and mid-January 2009 and between March 2012 and December 2012.

Our outcome variables consist of the following post-natal maternal and newborn health conditions: birth weight in grams along with an indicator for low birth weight (LBW) ($\leq$ 2500 grams), and gestation length in days along with an indicator for pre-term delivery (<37 weeks gestation length).[7] We utilize the health conditions available in the Soroka birth data to control for the following pre-birth conditions in our regression analysis: maternal age (categorical - 20-26, 26-30, 30-35, 35-40, 40-45), child sex, maternal abortion history, birth parity (categorical), high fertility, past caesarean delivery, late pregnancy loss in the past, and infertility treatment.[8]

Our birth data is merged with data on all sirens by date and locality during OPE and the month preceding OPE. Israel's Home Front Command - an IDF branch responsible for instructing the civilian population on coping with military threats facing Israel - has on its web site detailed documentation of all sirens by date and locality beginning in mid-July 2014. Because we needed data on sirens from as early as June 2014, we complemented the Home Front Command data with documentation of all sirens by date and locality from a provider of a cell phone application that alerts sirens in Israel.[9]

Israel's Home Front Command divides large cities in Israel into areas such that a single rocket targeted towards the city does not automatically initiate sirens across the entire city but rather just for the areas that are at risk. The data on sirens and maternal residence is just at the locality level. As such, it is likely that the number of sirens in large cities does not reflect the true number of sirens mothers experienced in the locality. For this reason, for the three largest cities in our data - Beer Sheva, Ashkelon and Ashdod - we divide the total number of sirens by two.[10]

Based on our derived conception date, we assign to each mother the number of sirens in her locality during each trimester of her pregnancy. If exposure to OPE or to sirens affected the birthdate, then the number of sirens a mother experiences is endogenous to our outcomes of interest. To address this potential violation of our exclusion restriction, we follow Persson and Rossin-Slater (2018), and define our treatment variables - the number of sirens experienced during pregnancy trimesters - relative to the expected due date at full term rather than the actual birthdate.

We note that we only observe maternal locality when giving birth, rather than during pregnancy. This does not pose a problem to our analysis as long as migration is minimal (so that the noise in assigning sirens based on locality at birth remains minimal) and migration patterns post-OPE are not systematically

[7] In the Appendix, we also present results for 4 additional birth outcomes: caesarean delivery, birth defects, early water prior to delivery, and the Apgar score 5 minutes after birth.

[8] Several pre-birth health conditions could not be included as control variables due to substantial changes in their coding over the course of the sample period. These include: all diabetic (including gestational) health conditions, and whether the mother had early births in the past.

[9] We verified that the sirens data from the cell phone application provider was identical to the Home Front Command official data during mutual dates covered to ensure consistency in our assignment of sirens to pregnant mothers during OPE.

[10] We note that if multiple rockets were fired at a large city at the exact time, then this would be registered as a single siren for that city in the siren data, although it may be that all or most areas in the city had a siren.

correlated with the number of sirens in a locality. We test for this using data from the Israel Central Bureau of Statistics (CBS) on the migration balance for all towns and cities in Israel in 2015. Migration balances are relatively small - 2.5-4.8 individuals per 1000 residents. Furthermore, we do not find a correlation between migration balances per 1000 residents in Jewish towns and the total number of sirens the town experienced during OPE (coefficient estimates for various regressions were positive with p-values ranging between 0.21–0.38). Actual results are presented in Table 7 in the Appendix.

Our birth and siren data are complemented by locality-level data from the CBS. This particularly includes the locality socioeconomic ranking, an official measure in integers ranging between 1 (the lowest) and 10 (the highest), which is based on population characteristics such as the mean age, dependency ratio, the share of families with 4 or more children, educational attainment, employment and retirement, and living standards (mean income, vehicle ownership and travel abroad). We separately examine our results for mothers residing in localities that are ranked low and high socioeconomically among Jewish localities.

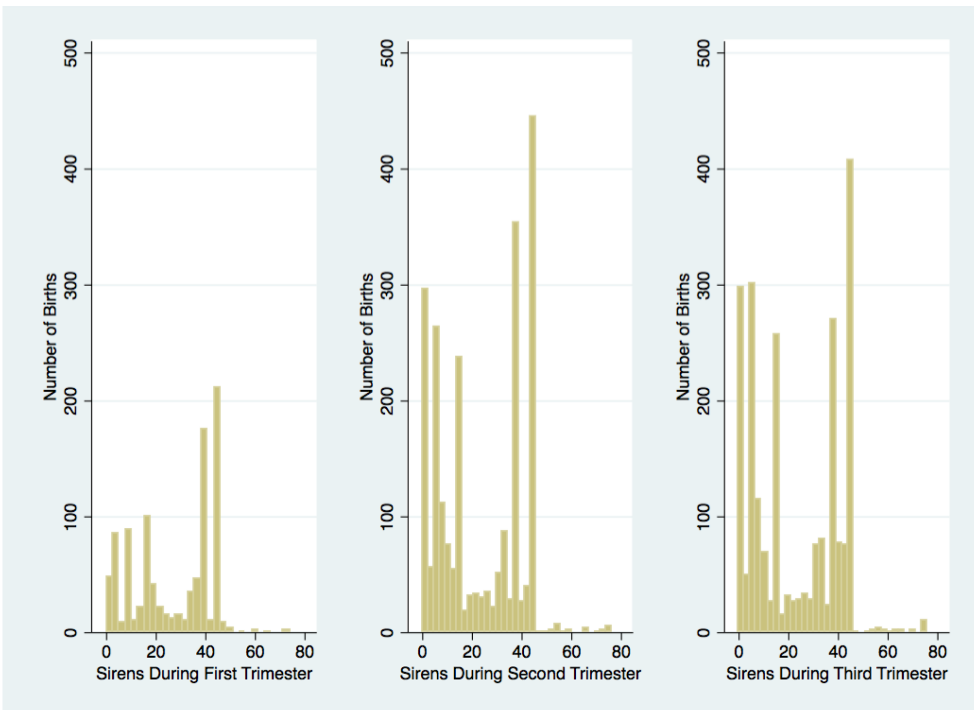
3.1 Descriptive Statistics

Table 1 presents summary statistics for the main sample of births used in our regression analysis. Our regression specifications exploit variation in the amount of sirens experienced by pregnant mothers within localities by inclusion of year-of-conception-locality fixed effects. As such, births conceived prior to 2013, when there was no variation in sirens, are redundant for our analysis, so our main sample covers births conceived during 2013-2014.

Table 1 shows pre-birth characteristics for our sample of mothers. We test for potential selection of mothers based on exposure to OPE at pregnancy trimesters through t-tests for differences in the mean characteristics between mothers who did not experience OPE and mothers who did experience OPE in any of the trimesters. P-values for these t-tests are presented in columns 2, 4, and 6. Most pre-birth characteristics are balanced between the sub-samples, with the exception of differences in the high fertility and c-section history indicators between mothers experiencing OPE during the third trimester and mothers who did not experience OPE. These are two differences out of a total of 24 differences that are tested for in Table 1, so statistically significant differences for two tests are possible by chance. We further note that there are several p-values for the t-test results presented in Table 1 that are less than 0.2. In total, there are 5 such p-values, which can also result by chance in a series of t-tests.

The last row in Table 1 shows the mean number of sirens experienced by mothers exposed to OPE during each of the pregnancy trimesters. Figure 1 displays how the number of sirens is distributed across births that are exposed to OPE during each trimester. Bunching at some of the siren values in Figure 1 is due to more births being attributed to larger towns that experienced that amount of sirens. We note though that even within these towns, there is variation across births exposed to OPE in the number of sirens due to different dates for each of the trimesters across births.

Figure 1: Number of Sirens Experienced during OPE by Pregnancy Trimester Exposure to OPE



Notes: The sample is limited to all Jewish births in Soroka Hospital conceived during 2013-2014 with gestation length of at least 180 days and residents of localities in Southern Israel. Each histogram is limited to births that were exposed to OPE during the relevant trimester. The number of births is smaller for first trimester exposure to OPE due to the exclusion of all births conceived during OPE to avoid selection concern. Total number of localities is 85.

Table 1: Summary Statistics - Pre-Birth Characteristics

	Did Not Experience OPE During Pregnancy	1st Trimester During OPE	P-Value for T-Test of Difference 1st Trim.	2nd Trimester During OPE	P-Value for T-Test of Difference 2nd Trim.	3rd Trimester During OPE	P-Value for T-Test of Difference 3rd Trim.
Number of Births	5180	978		2323		2327	
Mother's Age	30.664	30.831	0.331	30.800	0.273	30.788	0.317
	(4.906)	(5.000)		(5.045)		(5.076)	
Birth Number	2.367	2.414	0.345	2.415	0.187	2.402	0.337
	(1.415)	(1.450)		(1.471)		(1.480)	
Male Baby	0.512	0.498	0.409	0.519	0.610	0.526	0.259
	(0.500)	(0.500)		(0.500)		(0.499)	
Abortion History	0.033	0.034	0.882	0.032	0.828	0.026	0.102
	(0.178)	(0.181)		(0.176)		(0.159)	
High Fertility	0.070	0.076	0.518	0.080	0.103	0.082	0.061
	(0.255)	(0.265)		(0.272)		(0.275)	
C-Section History	0.131	0.141	0.416	0.132	0.935	0.115	0.049
	(0.338)	(0.348)		(0.339)		(0.319)	
Late Pregnancy Loss	0.015	0.014	0.792	0.012	0.322	0.012	0.318
	(0.123)	(0.119)		(0.111)		(0.111)	
Infertility Treatment	0.042	0.044	0.725	0.038	0.461	0.037	0.309
	(0.199)	(0.205)		(0.191)		(0.188)	
Sirens During Trimester	0.000	27.339	N/A	24.002	N/A	23.737	N/A
		(15.961)		(17.388)		(17.456)	

Notes: The sample is limited to all Jewish births in Soroka Hospital conceived during 2013-2014 with gestation length of at least 180 days and residents of localities in Southern Israel. The number of births is smaller for first trimester exposure to OPE due to the exclusion of all births conceived during OPE to avoid selection concern. Columns 1, 2, 4 and 6 present means with standard deviations in parenthesis. The sample for experiencing OPE during the first, second, or third pregnancy trimesters are not mutually exclusive.

4 Empirical Strategy

4.1 Exploring Relationship between Sirens and Birth Outcomes

We begin by presenting results for a non-parametric flexible specification that allows siren effects to vary for each range of siren counts (for each trimester). We split the siren count variables for each trimester into indicator variables for the following: 1-10 sirens, 11-20 sirens, 21-30 sirens, 31-40 sirens, and 41+ sirens, producing a total of 15 coefficients of interest. The excluded group consists of mothers who did not experience sirens during their pregnancy.

The regression specification is of the following form:

$$\begin{aligned} Outcome_{ilym} &= \alpha_0 + \sum_{t=1}^{3}\sum_{k=1}^{5} \alpha_k^t SirensIndic_{ilym}^{t,k} \\ &\quad + \eta X_{iym} + \rho_m + \theta_{ly} + \varepsilon_{ilym} \end{aligned} \tag{1}$$

Our dependent variables are birth outcomes for mother i in locality l with a child conceived in year and month (y, m). The main coefficients of interest in equation (2) are $\alpha_1^t - \alpha_5^t$ for $t \epsilon \{1, 2, 3\}$ that represent trimesters 1,2, and 3, respectively. These 15 coefficients of interest indicate how birth outcomes change when the mother experiences the respective range of sirens during the specific pregnancy trimester in comparison to mothers who experienced no sirens during their pregnancy.

Equation (1) controls for pre-birth maternal and fetal characteristics (X_{iym} - mother's age (categorical), child sex, maternal abortion history, birth parity (categorical), high fertility, past cesarean delivery, late pregnancy loss in the past, and infertility treatment). ρ_m are month of conception fixed effects.

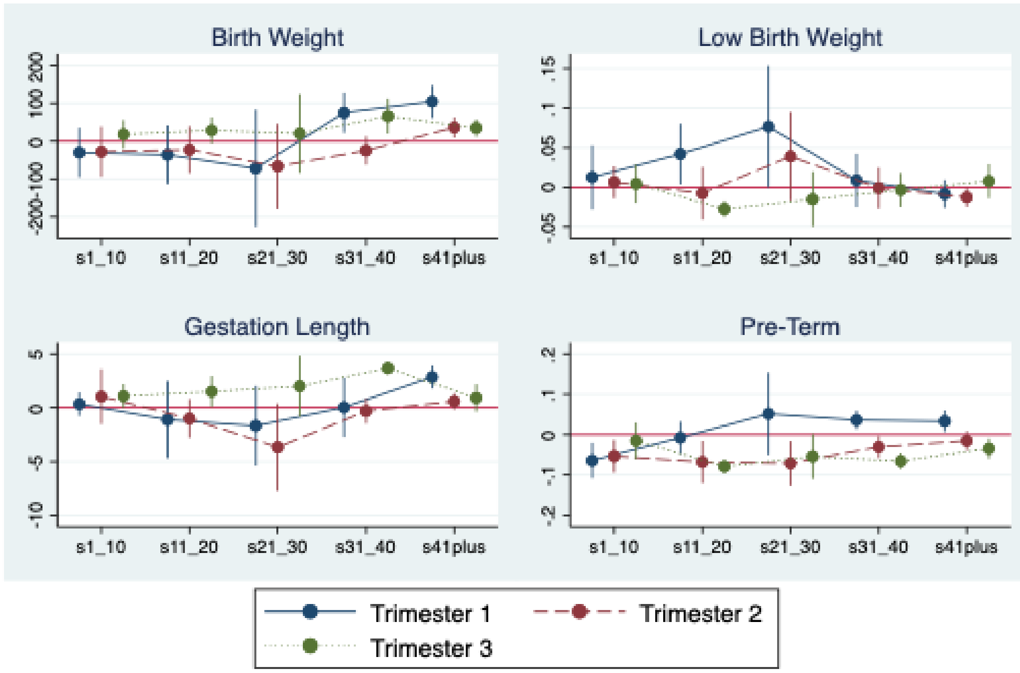
The intensity of sirens may be correlated with locality characteristics that may also be determinants of birth outcomes - for example, sirens were relatively more frequent in larger localities and the larger localities in southern Israel are relatively more disadvantaged. Locality fixed effects can control for that. However, if locality characteristics are changing over time and this is correlated with OPE exposure at the end of our sample period, then locality fixed effects cannot control for that. As such, our regression specification is more conservative and controls for locality-year-of-conception fixed effects, θ_{ly}, rather than just locality fixed effects. This entails that the main source of variation for deriving the effect of sirens on birth outcomes is changes in the intensity of sirens for mothers within the same locality with different conception months during 2013-2014, while controlling for seasonality in birth outcomes through ρ_m. Because this is the main source of variation, the inclusion of births conceived prior to 2013 - years during which there was no variation in sirens experienced during pregnancy within localities - is redundant. As such, our sample for the regression analysis is limited to births conceived during 2013-2014.

Figure 2 plots the 15 coefficients of interest for each dependent variable. The horizontal axis lists the relevant indicator variable on top of which three dots represent the coefficient estimate values for the three pregnancy trimesters. The vertical lines branching out of each dot represent the 95% confidence intervals. Each dot presents the mean change in the dependent variable for mothers experiencing the indicated range of sirens during the respective pregnancy trimester, in comparison to mothers who did not experience any sirens.

While the effects of first and second trimester sirens in Figure 2 do not present a fully consistent pattern, for third trimeter sirens, the results suggest improvements in birth outcomes. First trimester coefficient estimates suggest that the probability of a low birth weight increases in response to medium first trimester siren counts and the probability of a pre-term delivery increases in response to high first trimester siren counts. However, first trimester estimates also point at improvements in birth weight and gestational length in response to very high siren counts. Second trimester coefficient estimates in Figure 2 are often not statistically significant, with the exception of those for a pre-term delivery, which suggest a reduction in this probability in response to various levels of siren counts. For the third trimester, statistically significant coefficient estimates consistently imply improved birth outcomes resulting from sirens, and this particularly stands out for gestation length and the probability of a pre-term delivery.

A linear relationship between sirens and birth outcomes would result in coefficient estimates in Figure 2 that gradually increase in their magnitude. As can be seen in Figure 2, this is not the case. For some of the coefficient estimates there appear to be non-linearities in response to siren counts. Furthermore, many

Figure 2: Non-Parametric Effect of Sirens on Birth Outcomes



Notes: The sample is limited to all Jewish births in Soroka Hospital conceived during 2013-2014 with gestation length of at least 180 days and residents of 85 localities in southern Israel. See Section 3 for information on the sample. Each figure plots the coefficient estimates from a regression specification similar to equation (1), only instead of the siren count variables, there are indicator variables for siren ranges during each trimester: 1-10 sirens; 11-20 sirens; 21-30 sirens; 31-40 sirens; and 41+ sirens. Each dot represents the coefficient estimate for the indicator variable on the horizontal axis and the vertical lines branching from the dot are the 95% confidence intervals. The various trimester dots for each of the siren count variables are supposed to be vertically aligned but are not for presentation purposes. Birth-specific controls are: mother's age at birth (categorical), mother's age (categorical), child sex, maternal abortion history, birth parity (categorical), high fertility, past cesarean delivery, late pregnancy loss in the past, and infertility treatment. Standard errors are clustered at the locality level.

coefficient estimates within the trimesters are statistically indistinguishable from each other, which poses a challenge in terms of fully understanding the pattern of siren effects on birth outcomes. We further present results of a regression specification with indicator variables for non-zero sirens during each trimester as the main explanatory variables or a quantitative measure of the number of sirens during each trimester, under the assumption that siren effects are linear in Table 8 in the Appendix. The results there further point towards the need for an alternative specification to fully capture the relationship between sirens and birth outcomes. We proceed to a more structured and parametric approach of the effect of sirens on birth outcomes: a quadratic regression.

4.2 Quadratic Regression Specification

We assume a non-linear relationship between sirens and birth outcomes and focus our analysis on the following quadratic regression specification:

$$
\begin{aligned}
Outcome_{ilym} \quad = \quad & \beta_0 + \beta_1 SirensTr1_{ilym} + \beta_2 SirensTr2_{ilym} + \beta_3 SirensTr3_{ilym} \\
& \beta_4 Sirens^2 Tr1_{ilym} + \beta_5 Sirens^2 Tr2_{ilym} + \beta_6 Sirens^2 Tr3_{ilym} \\
& + \eta X_{iym} + \rho_m + \theta_{ly} + \varepsilon_{ilym}
\end{aligned} \tag{2}
$$

The main coefficients of interest in equation (2) are $\beta_1 - \beta_6$. Given the quadratic terms in equation (2), the effect of sirens on birth outcomes varies with the value of sirens.

We expand our analysis by examining results for equation (2) that allow us to differentiate the OPE siren effects based on locality characteristics. Specifically, we vary equation (2) such that all siren variables are interacted with dummies for localities ranked low or high socioeconomically, thus generating 12 rather than 6 main coefficients of interest - 6 coefficients for the effect of sirens in each of the trimesters on mothers from low socioeconomically ranked localities, and 6 coefficients for the siren effects in each of the trimesters on mothers from high socioeconomically ranked localities.

We argue that our coefficients of interest are capturing a causal relationship between birth outcomes and sirens during OPE. This is under the assumption that absent OPE, birth outcomes would have continued on the same path they were on prior to OPE. Because OPE - especially its exact timing and its length - can be viewed as an exogenous shock in Israel, this identification assumption seems highly reasonable. We stress further that all treated births in our sample were conceived prior to OPE, and that it was not possible to foresee OPE even a month before its onset. Given the locality-year-of-conception fixed effects, we can broadly generalize our identification strategy to comparing between mothers conceiving during the same year and residing in the same locality, only their conception dates vary by several months. This difference in the conception date generates exogenous variation in the number of sirens each of these mothers experienced. This is while accounting for seasonality of conception by including in our regression specification month of conception fixed effects.

5 Results

5.1 Base Results - Quadratic Specification

Table 2 presents results for our four dependent variables of interest - birth weight (in grams), gestational length (in days), low birth weight, and pre-term delivery. For each dependent variable, the first column shows the coefficient estimates $\beta_1 - \beta_6$ from a regression specification as in equation (2) but with only year of conception, month of conception and locality fixed effects. The second column adds birth-specific controls to the regression specification. We can see that the results do not change substantially, which is reassuring as this is evidence that our main explanatory variables of interest are not correlated with our control variables. The third column replaces the locality and conception year fixed effects with locality-conception-year fixed effects. This does not alter the results substantially. For all specifications presented in Table 2, F-tests for the joint significance of the siren quadratic terms are highly significant with p-values under 0.05 for birth weight and under 0.001 for gestational length. This lends further support for the need to examine the relationship between sirens and birth outcomes non-linearly.

The quadratic specification results suggest that sirens adversely affect birth outcomes in the first trimester and benefit them in the third trimester, although the third trimester coefficient estimates are statistically significant for gestation length and not for birth weight. The effects of sirens during the second trimester are not conclusive according to Table 2, with a decrease in birth weight and gestation length but a decrease in the probability of a pre-term birth.

Given the quadratic nature of the regression specification, the exact quantitative effect of sirens during each pregnancy trimester and their statistical significance varies across values of sirens experienced during the different pregnancy trimesters. We thus plot the predicted values of the various dependent variables as a function of the sirens experienced during each trimester.[11] Figure 3 presents predicted values resulting from the regression results from equation (2) along with their 95% confidence intervals for various values of sirens experienced during the first, second, or third trimester. In order to understand the effect of sirens on birth outcomes, the predicted values for the various siren levels should be compared to the predicted values when sirens are equal to zero. The results show that sirens during the first trimester adversely affect birth outcomes, but this is only when the number of sirens is relatively low. For all birth outcomes in Figure 3, with the exception of a pre-term delivery, a very large number of sirens during the first trimester may even generate improvements. Second trimester sirens also affect birth outcomes qualitatively differently as a function of the number of sirens experienced during the trimester. All birth outcomes are adversely affected by sirens when the number of sirens is relatively low. However, when second trimester siren are over 45 sirens, then birth outcomes appear to benefit from sirens. Third trimester sirens have a beneficial effect on birth outcomes, with the exception of the probability of a low birth weight, which does not appear to be affected by sirens. For all birth outcomes with the exception of low birth weight, while the third trimester siren effects are non-linear, they remains monotonous with zero marginal effects at higher sirens values.

Quantitatively, birth weight decreases by less than 100 grams in response to up to 25 sirens during the first trimester (with the mean number of sirens during the first trimester being roughly 27 - see Table 1). In response to 25-35 sirens during the first trimester the change in birth weight is not statistically significant, but for 40 sirens or more, birth weight increases by as much 150 grams. For the second trimester, there's a slight decrease in birth weight in response to up to 25 sirens but for 50 sirens birth weight increases by roughly 50 grams. When 30 or more sirens are experienced during the third trimester, birth weight increases by up to 60 grams. The patterns are slightly similar for gestation length, although in response to small amounts of first trimester sirens gestation length does decrease in a statistically significant amount

[11] This is done with the margins command in Stata.

Table 2: Birth Weight and Gestational Length following Sirens During Pregnancy - Quadratic Specification

	Birth Weight (Grams) (Mean=3223)			Gestational Length (Days) (Mean=272.3)		
Sirens - Trimester 1	-5.456***	-5.530***	-5.562***	-0.099*	-0.083	-0.100*
	(1.887)	(1.674)	(1.517)	(0.055)	(0.052)	(0.054)
Sirens - Trimester 2	-4.206***	-3.844**	-3.915**	-0.186***	-0.173***	-0.187***
	(1.595)	(1.606)	(1.571)	(0.041)	(0.041)	(0.045)
Sirens - Trimester 3	2.273	1.389	1.424	0.168***	0.143***	0.146***
	(1.518)	(1.488)	(1.580)	(0.038)	(0.040)	(0.042)
Sirens Sq - Trimester 1	0.175***	0.175***	0.183***	0.004**	0.003**	0.004***
	(0.048)	(0.045)	(0.042)	(0.001)	(0.001)	(0.001)
Sirens Sq - Trimester 2	0.101**	0.095**	0.103***	0.004***	0.004***	0.005***
	(0.041)	(0.040)	(0.038)	(0.001)	(0.001)	(0.001)
Sirens Sq - Trimester 3	-0.017	-0.000	-0.003	-0.002**	-0.002*	-0.002*
	(0.034)	(0.034)	(0.036)	(0.001)	(0.001)	(0.001)
	Low Birth Weight (Mean=0.064)			Pre-Term Delivery (Mean=0.134)		
Sirens - Trimester 1	0.004***	0.004***	0.004***	0.002	0.001	0.000
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
Sirens - Trimester 2	0.001	0.001	0.001	-0.002*	-0.002**	-0.003***
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
Sirens - Trimester 3	-0.001	-0.000	-0.000	-0.005***	-0.004***	-0.004***
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
Sirens Sq - Trimester 1	-0.000***	-0.000***	-0.000***	-0.000	-0.000	-0.000
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Sirens Sq - Trimester 2	-0.000**	-0.000*	-0.000**	0.000	0.000	0.000*
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Sirens Sq - Trimester 3	0.000	0.000	0.000	0.000**	0.000*	0.000*
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Observations	9,214	9,214	9,214	9,214	9,214	9,214
Conception Year Fixed Effects	✓	✓		✓	✓	
Conception Month Fixed Effects	✓	✓	✓	✓	✓	✓
Locality Fixed Effects	✓	✓		✓	✓	
Birth-Specific Controls		✓	✓		✓	✓
Locality-Conception Year Fixed Effects			✓			✓

Notes: The number of localities is 85. See Section 3 for information on the sample. The coefficient estimates presented are $\beta_1 - \beta_6$ from equation (2). Birth-specific controls are: mother's age at birth (categorical), mother's age (categorical), child sex, maternal abortion history, birth parity (categorical), high fertility, past cesarean delivery, late pregnancy loss in the past, and infertility treatment. Mean of Dependent Variable is the mean for non-OPE births in the sample. Standard errors are clustered at the locality level. *** p<0.01, ** p<0.05, * p<0.1

and in response to 35 first trimester sirens or more, gestation length increases by 2-4 days. The increase in gestation length in response to third trimester sirens is statistically significant already at very low siren counts and ranges from nearly a one day increase in response to 5 sirens and up to a 3 day increase in response to 50 sirens.

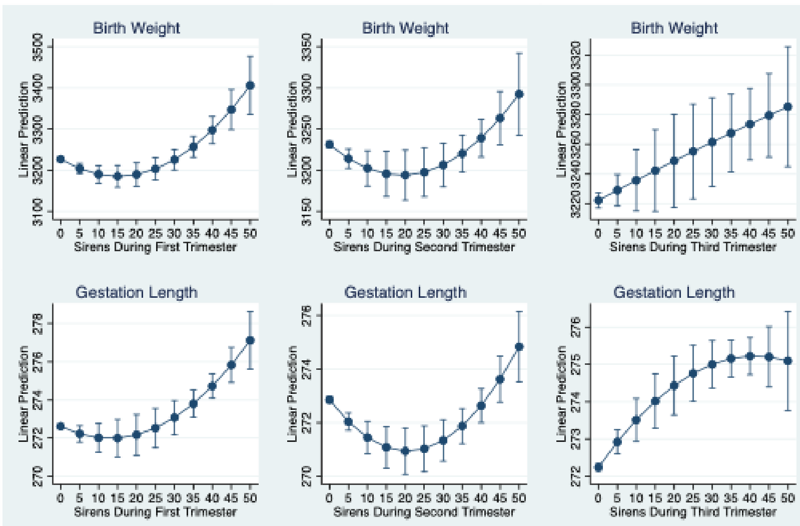
For low birth weight and pre-term delivery, some of the results are consistent with the birth weight and gestation length results, while others are less so. Consistent with the birth weight results, we observe statistically significant increases of up to 5 percentage points in the probability of low birth weight for first trimester sirens under 35, followed by up to 2.5 percentage points decreases in this probability in response to higher first trimester siren counts. We also observe increases in the probability a low birth weight for very low siren counts followed by decreases in this probability of up to 2 percentage points in response to very high siren counts. The probability of low birth weight does not appear to change in response to third trimester sirens although birth weight does increase in response to high siren counts. For pre-term delivery, the probability decreases in response to a greater amount of third trimester sirens and this is consistent with the effect third trimester sirens have on gestation length. However, the response to second trimester sirens is a decrease in the probability of a pre-term delivery and this is contrast to decreases in gestation length in response to low and medium-level second trimester sirens. Furthermore, the probability of a pre-term delivery does not appear to respond to first trimester sirens although gestation length does.

Overall, the results in Figure 3 suggest non-linearities in the effect of sirens on birth outcomes, with adverse effects followed by beneficial ones in response to sirens experienced in the first trimester, a similar pattern in response to second trimester sirens although less consistent due to solely improvements in the probability of a pre-term delivery, and primarily improved birth outcomes with decreasing marginal effects in response to third trimester sirens. There may also be some different responses to sirens depending on whether the effects are estimated at the intensive margin (for birth weight and gestation length) as opposed to the extensive margin (for low birth weight and pre-term delivery).

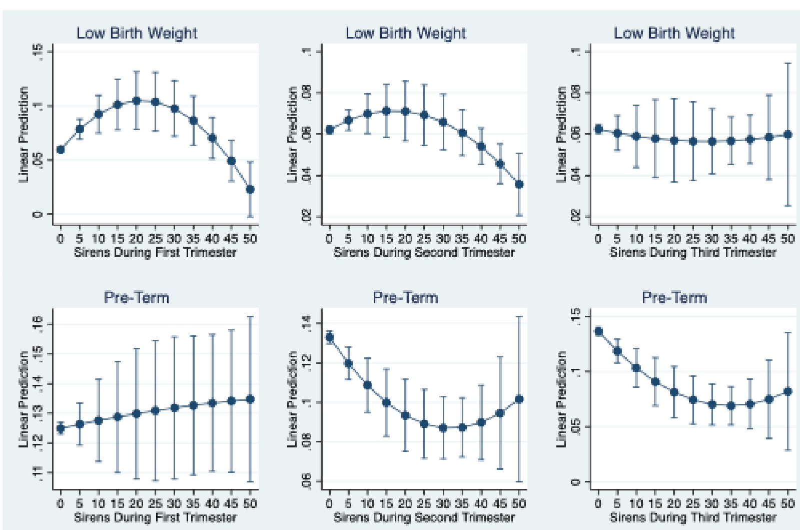
Our data enable us to include mother fixed effects in our regression specifications (not specified in equation (2)), as the data include a mother identifier. Mother fixed effects have the advantage of controlling for unobserved maternal characteristics that may be correlated both with our main explanatory variables and our outcome variables, thereby alleviating concern that are results are driven, for example, by a different population of pregnant women during OPE. However, mother fixed effects also limit the variation in our analysis to within mothers who were pregnant with a child during OPE and were pregnant with at least one other child not during OPE. This decreased variation can inflate the standard errors of our coefficient estimates. We present results for equation (2) with mother fixed effects in Table 9 in the Appendix. Although some of the adverse effects of sirens during the first trimester still persist in Table 9, and many of the coefficient estimates are of a similar magnitude to those presented in Table 2, most coefficient estimates in Table 9 are not statistically significant due to large standard errors - 2-3 times the standard errors presented in Table 2. Thus, regression specifications with mother fixed effects are not our main specification

Figure 3: Sirens Experienced During Pregnancy - Quadratic Specification Predicted Values

(a) Birth Weight and Gestation Length



(b) Low Birth Weight and Pre-Term Delivery



Notes: The figures plot the predictive values and the 95% confidence intervals from the results in the final column of each dependent variable in Table 2 for values of sirens that are listed on the horizontal axis during the first, second and third trimester in the left, middle and right columns, respectively.

for the analysis.

5.2 Differential Effects by Locality Socioeconomic Ranking

We may be able to better understand the underlying mechanisms behind the surprising positive effect of sirens on birth outcomes by running our regression specifications on different populations within our sample. This is done by running a variation of equation (2) with the siren variables interacting with indicator variables for the mother being from a high or low socioeconomically ranked locality. We categorize low socioeconomically ranked localities as ranked 4 on the Israel CBS socioeconomic ranking scale of 1-10. In 2013, this implied a mean of 11.85 years of schooling, 45.11 percent of the workforce earning below the minimum wage, and a mean monthly income of 3,183 NIS ($857) among its residents. This is compared to 2013 population means of 12.17 years of schooling, 42.48 percent below the minimum wage, and 3,870 NIS ($1,042) mean monthly income. In our sample, 17 of the 74 localities are ranked 4 (the rest are ranked higher), and this represents slightly more than 2000 births, which is over 23% of the sample.

As in Figure 3, Figure 4 plots the predicted values for the regression specification described above with interactions for the locality's socioeconomic ranking, but this variation of equation (2) allows us to separately plot predicted values for low versus high socioeconomically ranked localities. One noticeable difference between the births from the differently ranked localities concerns the effect of first trimester sirens: low socioeconomically ranked localities have a more monotonous adverse effect on birth outcomes, and for many of the birth outcomes the effect does not reverse qualitatively, as in Figure 3 and for births from higher ranked localities. This is true for all birth outcomes with the exception of gestation length. Second trimester siren effects are fairly similar between low and high socioeconomically ranked localities with the exception of gestation length, which exhibits greater improvements for higher siren counts among low socioeconomically ranked localities. Lastly, third trimester siren effects appear more monotonous among high socioeconomically ranked localities and changed their direction more in response to higher sirens counts among lower ranked localities. Overall, the first and third trimester results suggest that mothers from localities ranked higher socioeconomically are better shielded from high siren counts, potentially through a factor that is driving improvements in birth outcomes.

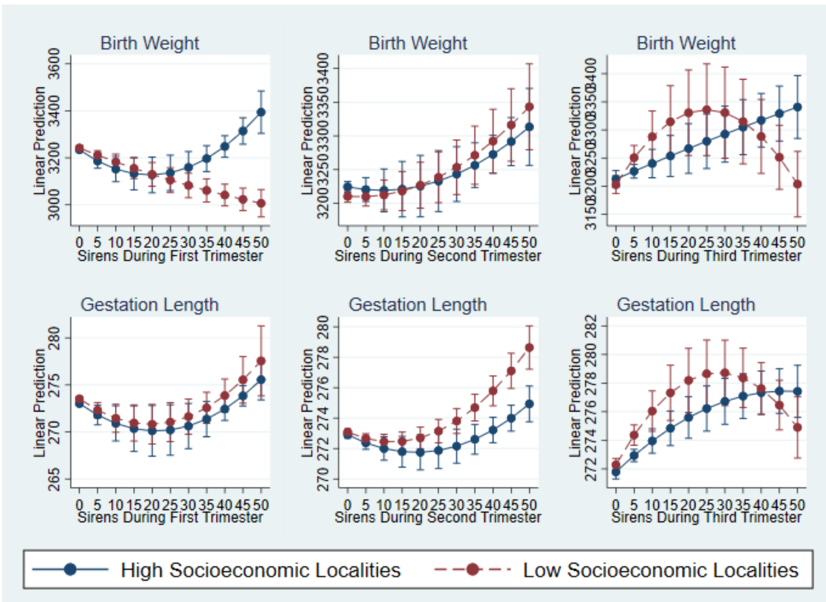
Similar patterns and conclusions regarding a higher sensitivity of mother residing in towns ranked lower socioeconomically to higher siren counts during the first and third trimester emerge when examining 4 other birth outcomes that are available in our data - the probability of c-section, whether the child was born with a birth defect, the probability of an early water break prior to delivery, and the newborn's Apgar score 5 minutes after delivery. We present these results in Figure 7 in the Appendix.

5.3 Work Attendance during Operation Protective Edge

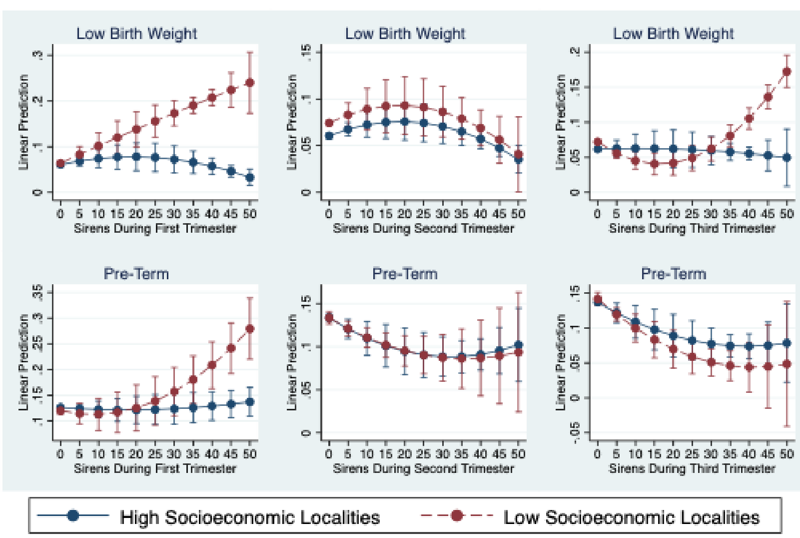
Many parents (particularly mothers) stayed home with children as child care services were canceled during OPE, and according to Israeli law, this is paid and protected leave for parents having a child who is 14 years

Figure 4: Sirens During Pregnancy by Locality Socioeconomic Ranking - Quadratic Specification Predicted Values

(a) Birth Weight and Gestation Length



(b) Low Birth Weight and Pre-Term Delivery



Notes: The figures plot the predictive values and the 95% confidence intervals from results for regression specifications that are similar to equation (2) only they interact the siren variables with dummies for high and low socioeconomically ranked localities. Siren values are listed on the horizontal axis during the first, second and third trimester of pregnancy in the left, middle and right columns, respectively.

old or less. Female labor force participation rates among the Jewish non-orthodox population in Israel are relatively high - around 80 percent for ages 25-64, compared to the OECD average of 60%. For married women with children, labor force participation in Israel is 74.6% (Mizrahi-Simon (2015)). This poses the question whether improvements in birth outcomes as a result of sirens - as observed in Figures 3-4 - may be due to decreases in work attendance.

We examine the population of females ages 20-45 from the Israeli Labor Force Survey and how their absence from work changed in Summer 2014 as opposed to the same period in the years 2012, 2013 and 2015, while comparing females in southern Israel to females in three other districts of Israel that hardly experienced sirens - Jerusalem, Haifa, and North. The top panel of Figure 5 presents this for the entire population or for the population of females residing in high and low socioeconomically ranked localities. The bottom panel of Figure 5 presents the same results for males. Both panels show substantial increases in the rates of absence from work during OPE for individuals in southern Israel. "South 2014" increases in comparison to "South Not 2014", and this is greater than the change observed between "Not South Not 2014" and "Not South 2014". We note that although the increase for individuals from southern low socioeconomically ranked localities appears smaller relative to the non-south trend - particularly for females - it is still apparent. The high rates of absences from work in Figure 5 are due to the sample period being the Summer months, when children are off from school and many parents take time off from work.

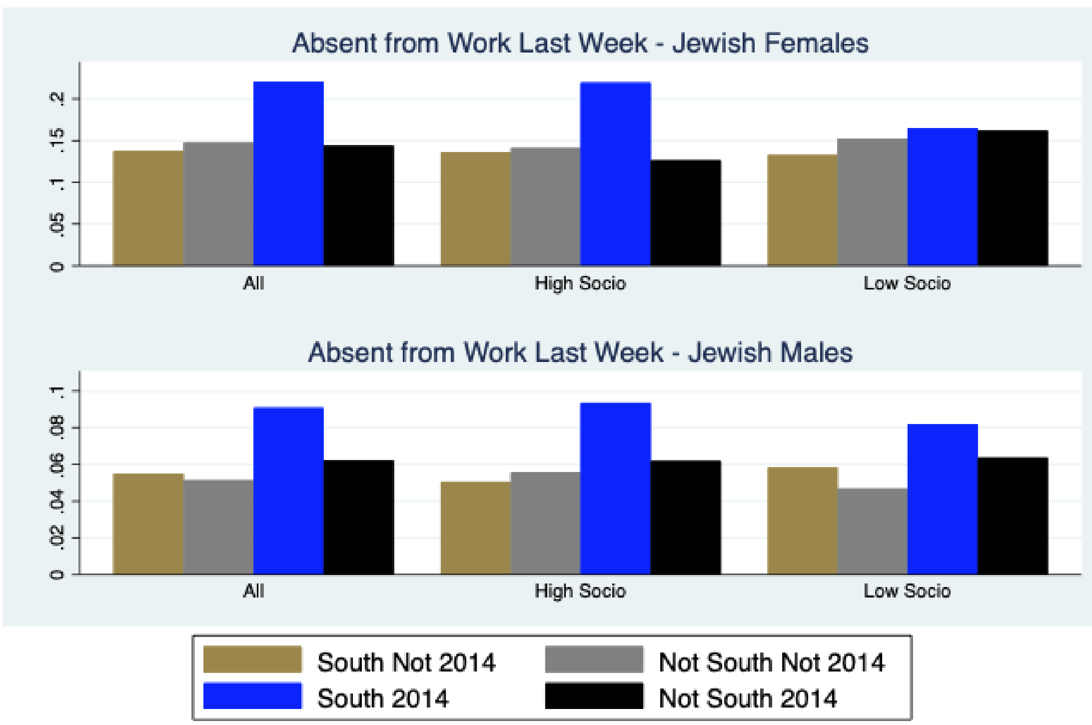
The results in Figures 3-4 suggest improvements in birth outcomes that are correlated with the number of sirens mothers experienced in their locality. Thus, a more precise assessment of whether absence from work is a potential mechanism for improved birth outcomes should test whether absence from work is correlated with the number of sirens individuals experienced in their locality of residence. We make use of the locality identifiers provided in the Labor Force Survey restricted data to assign to each survey respondent the number of sirens their locality had experienced during the week preceding their interview. This enables us to test whether the number of sirens during the week preceding the interview is correlated with the probability of absence from work during that same week. Women who reported having an additional child ages 0-1 in a subsequent survey following the summer months, for which we analyze survey responses, are identified as pregnant in our sample. Based on the structure of survey sequencing in the Labor Force Survey, this produces a sample of women who were at the end of their pregnancy during the Summer months.[12]

We examine the relationship between sirens in an individual's locality in the preceding week and whether they were absent from work that week with the following regression specification:

$$\begin{aligned} AbsentLastWeek_{ilyw} &= \delta_0 + \delta_1 SirensLastWeek * Yr2014_{ilyw} + \delta_2 SirensLastWeek_{lw} \\ &\quad + \eta X_{iyw} + \mu_y + \lambda_l + \varepsilon_{ilyw} \end{aligned} \tag{3}$$

[12]The Israel Labor Force Survey surveys households every month for 4 consecutive months, followed by an 8-month break, and then again for 4 consecutive months.

Figure 5: Changes in Work Attendance during OPE



Notes: Data is from the Israeli Labor Force Survey restricted-use data files for the years 2012-2015, responses from July through early September. The sample consists of females and males ages 20-45. The sample includes all survey respondents, including those who do not participate in the labor market.The sample is limited to individuals in the following districts: South, Jerusalem, Haifa and North, but excludes individuals residing in the Gaza Envelope. High Socio implies individuals residing in localities with a socioeconomic ranking of 5 or greater (from a scale of 1-10). Number of observations is 14,700, 8,316, and 4,838 for females All, High Socio, and Low Socio, respectively., and 3,352, 3,263, 2,463, and 548 for males All, High Socio, and Low Socio, respectively.

Equation (3) evaluates whether the number of sirens individual i in locality l in year y and week w experienced affects the probability they were absent from work. Our coefficient of interest, δ_1, tells us how the probability of being absent last week changed in response to each additional siren experienced in one's locality that same week. $SirensLastWeek_{lw}$ controls for any correlation between periods and/or localities with more or less sirens and work absence patterns.[13] We further control for individual-level characteristics (X_{iyw}), such as married or not, the number of children, year fixed effects (μ_y) and locality fixed effects (λ_l). Standard errors are clustered at the locality level. We present results for pregnant survey respondents as well as males ages 20-45. Similar to Figure 5, the sample is restricted to localities in southern Israel, with the exception of those in the Gaza Envelope (see Section 3 for a definition and explanation of these localities), and localities in districts that experienced hardly any sirens during OPE - Jerusalem, North, and Haifa - in order to control for trends relevant for all of Israel during this period (even if these trends may be related to OPE in general).

We also evaluate whether absence from work results differed by locality socioeconomic ranking. For this purpose, we specify the following variation of equation (3), which adds to the existent variables interactions with an indicator variable equal to one if the individual's locality is ranked high socioeconomically:

$$\begin{aligned} AbsentLastWeek_{ilyw} = \; & \psi_0 + \psi_1 SirensLastWeek * Yr2014_{lyw} + \psi_2 SirensLastWeek * Yr2014 * HighSocio_{lyw} \quad (4) \\ & + \psi_3 SirensLastWeek * HighSocio_{lw} + \psi_4 Yr2014 * HighSocio_{ly} + \psi_5 SirensLastWeek_{lw} \\ & + \eta X_{iyw} + \mu_y + \lambda_l + \varepsilon_{ilyw} \end{aligned}$$

Equation (4) has two coefficients of interest: ψ_1 and ψ_2. ψ_1 estimates the effect of each additional siren in one's locality on the probability of being absent among individuals residing in localities ranked low socioeconomically. ψ_2 is the differential effect for individuals residing in localities ranked high socioeconomically. The sum $\psi_1 + \psi_2$ is the overall effect for individuals residing in localities ranked high socioeconomically. All second-order interaction terms branching from the three-way interaction term $SirensLastWeek * Yr2014 * HighSocio$ are controlled for, and all other variables are as defined in equation (3). Standard errors are clustered at the locality level, as in equation (3).

Results for the specifications in equations (3) and (4) are presented in Table 3 for pregnant females and males ages 20-45 (see columns (1)-(2) and (3)-(4), respectively). For pregnant females, the results show an increase in the probability to have been absent from work for each additional siren, but only among pregnant females ranked higher socioeconomically, with a joint significance of the sum $\psi_1 + \psi_2$ at the 5% level, as indicated in the bottom row of Table 3. The magnitude of each siren's effect is quite large - an increase of 1.2 percentage points, but this is from a mean 27.3 percent (pre-OPE), as this population is frequently absent from work.[14] We note that while the mean for the entire sample of pregnant females is

[13] This variable is positive and statistically significant in a few of our specifications.

[14] Another factor that likely comes into play for the high means in Table 3 is the fact that these are summer months when many

Table 3: Sirens and Absences from Work

Sample	Pregnant Females		Males - Ages 20-45	
	Dependent Variable: Absent from Work Last Week			
Number of Sirens Last Week	0.00444	-0.0660	0.00225**	-0.00151
* Year 2014	(0.00764)	(0.0410)	(0.00103)	(0.00261)
Sirens Last Week * Yr2014		0.0786*		0.00408
* High Socio Locality		(0.0418)		(0.00280)
Observations	171	159	12,821	11,360
R-squared	0.379	0.351	0.034	0.020
Mean of Dependent Variable	0.302	0.273	0.0520	0.0523
Mean Number of Sirens Last Week	1.865	1.994	1.866	1.942
P-Value Joint Test	N/A	0.0528	N/A	0.0147

Notes: Data is from the Israeli Labor Force Survey restricted-use data files for the years 2012-2015, responses from July through early September. The sample is females identified as pregnant based on survey responses in subsequent surveys concerning the number of children they have and males ages 20-45 in columns (1)-(2) and (3)-(4) respectively. The sample includes all survey respondents, including those who do not participate in the labor market. The sample is limited to individuals in the following districts: South, Jerusalem, Haifa and North, but excludes individuals residing in the Gaza Envelope (see Section 3 for explanation). High Socio implies individuals residing in localities with a socioeconomic ranking of 5 or greater (from a scale of 1-10 - see Section 3 for explanation). The mean of the dependent variable is for 2012-2013, years not affected by OPE. Standard errors are clustered at the locality level. *** p<0.01, ** p<0.05, * p<0.1

less than 2 sirens per week, upon closer observation, the mean among pregnant females from the south is 5.8 sirens per week, thus implying an increase in the probability of being absent from work that is more than 25 precent of the mean for pregnant females from higher socioeconomically ranked localities in southern Israel.

For males, we also observe an increase in the probability of being absent from work due to a greater number of sirens in their locality. Similarly to pregnant females, this is observed among males from higher socioeconomically ranked localities. While the increase is a more modest 0.25 percentage points for each siren, the mean absences (pre-OPE) is substantially smaller at 5.2 percent. The mean number of weekly sirens for males from the south, 5.3, implies that males from higher socioeconomically ranked localities in southern Israel increased their probability of being absent from work on a given week during OPE on average also by 25 precent. While the percent increase is similar to that of pregnant females, the smaller scale of the effect for males is consistent with the notion that much of the economy continued to function in southern Israel despite the conflict.

people take vacation.

5.4 Changes in Prenatal Care

Changes in birth outcomes resulting from conflict may also be driven by changes in prenatal care rather than the actual stress accompanying the conflict. Soroka hospital documents for mothers admitted for birth whether they received "lack of prenatal care" (LOPC) during their pregnancy, defined as less than 3 prenatal care visits. Although this is an extreme case of reduced prenatal care, and its percent among Jewish mothers giving birth in Soroka is quite low (<3%), it is quite plausible that changes in birth outcomes would only be statistically detectable in response to extreme cases of reduced prenatal care.[15] Figure 6 presents predicted values of LOPC for mothers from high and low socioeconomically ranked localities as a function of the number of sirens, as derived from regression results for equation (2) with interactions for high and low socioeconomically ranked localities.

The results in Figure 6 show an increase in the probability of LOPC among mothers from low socioeconomically ranked localities who experienced large numbers of sirens during their first and second trimesters. For mothers from high socioeconomically ranked localities there is no evidence of changes in the probability of LOPC due to sirens in any of the pregnancy trimesters. These results are consistent with the fact that changes in prenatal care patterns early in the pregnancy affect LOPC status, as by the end of the pregnancy pregnant women are more likely to have received minimal prenatal care in the absence of any shocks affecting this. Furthermore, the results in Figure 6 are also consistent with the notion that disadvantaged pregnant women are less able - due perhaps to more constrained resources or means - to overcome challenges that inhibit receipt of adequate prenatal care.

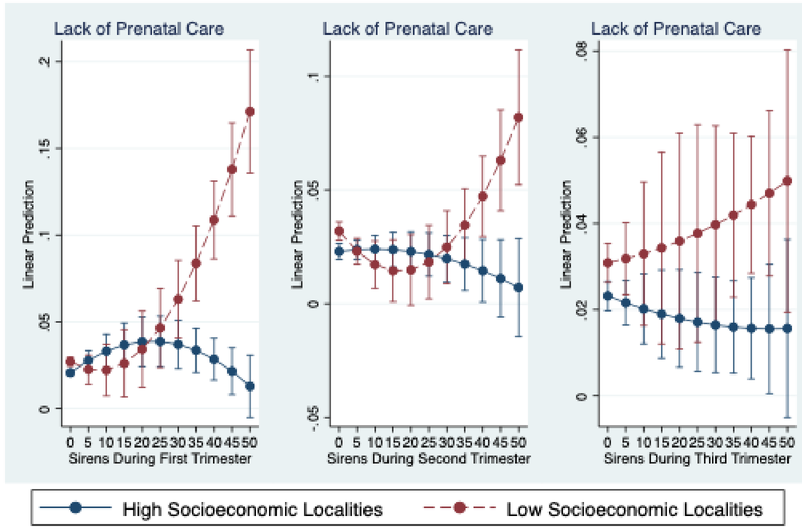
5.5 Discussion

We observe both detrimental and beneficial birth outcome responses to sirens during OPE. During the first trimester, sirens are detrimental to birth outcomes, but for higher socioeconomically ranked mothers, these adverse effects are attenuated, and there is actually an increase in birth weight and gestation length. Second trimester results are mixed, and third trimester sirens improve birth outcomes, although for mothers from lower socioeconomically ranked localities some of these improvements diminish with large amounts of sirens.

Based on our prenatal care results in Figure 6, the adverse effects resulting from low siren counts during the first trimester cannot be attributed to changes in prenatal care. We therefore attribute them to the stress induced by sirens, and this is consistent with previous studies demonstrating the effects of stress primarily during early pregnancy (Torche (2011); Torche and Shwed (2015); Mansour and Rees (2012); Camacho (2008); Eskenazi et al. (2007); Quintana-Domeque and Ródenas-Serrano (2017); Brown (2018); Khashan et al. (2008)). Responses to first trimester high siren counts diverge between mothers from low versus high socioeconomically ranked localities - higher ranked mothers' siren effects are attenuated while lower ranked mothers' siren effects continue to decrease. This is consistent with the LOPC divergence presented in Figure

[15]Prenatal care during pregnancy in Israel is fully covered as part of the National Health Insurance Program.

Figure 6: Sirens and Lack of Prenatal Care



Notes: The figures plot the predictive values and the 95% confidence intervals from the results of a regression specification of equation (2), with an indicator variable for lack of prenatal care (LOPC) as the dependent variable for values of sirens that are listed on the horizontal axis during the first, second and third trimester of pregnancy in the left, middle and right columns, respectively. The number of localities is 85. See Section 3 for information on the sample.

6 - as disadvantaged mothers received less prenatal care at higher first trimester siren counts, they were also more negatively affected by high siren counts during their first trimester. We note that the attenuated effect among higher socioeconomically ranked mothers may also be driven by reduced work attendance, which according to Table 3 is more dominant among mothers from higher socioeconomically ranked localities. At high siren counts, the beneficial effect of reduced work attendance may offset detrimental effects resulting from stress, and this would be more pronounced among mothers from higher socioeconomically ranked localities.

Figure 4's second trimester results exhibit similar patterns for mothers from low and high socioeconomically ranked localities for many dependent variables, despite the divergence in LOPC rates across the two groups for high second trimester siren counts exhibited in Figure 6. We do not have an explanation for the greater increase in gestation length for high second trimester siren counts among mothers from low socioeconomically ranked localities.

We observe improvements in response to third trimester sirens. For birth weight and low birth weight, the response to high siren counts diverges between differently socioeconomically ranked mother, with disadvantaged mothers experiencing adverse effects and more advantaged mothers experiencing null or beneficial effects. For gestation length and pre-term delivery, the divergence is less apparent in response to third trimester sirens. Improved birth outcomes can be due to decreased work attendance during pregnancy. The divergence based on socioeconomic ranking is particularly consistent with the results in Table 3 showing that reduced work attendance is driven by mothers from higher socioeconomically ranked localities. Because pregnant women from higher socioeconomically ranked localities are the ones reducing work attendance, they are the ones that derive a greater benefit from sirens during the third trimester, in contrast to mothers from low socioeconomically ranked localities. The improvements in response to third trimester sirens are also consistent with the majority of studies on stress resulting from conflict and birth outcomes, which find adverse effects primarily in response to conflict exposure during early pregnancy. Thus, the adverse effects of stress during the third trimester may be sufficiently weak, enabling a positive effect of the conflict due to decreased work attendance to arise.

We acknowledge that Figure 4 also shows improved birth outcomes for mothers from low socioeconomically ranked localities in response to low sirens counts during the third trimester, despite Table 3's results suggesting a null - or even a negative coefficient estimate - for low socioeconomically ranked localities pregnant women. However, Table 3 assesses the correlation between sirens and work attendance, which indeed does not seem to exist for pregnant women from low socioeconomically ranked localities; this does not rule out the possibility that improved birth outcomes for mothers from low socioeconomically ranked localities are due to decreased work attendance in response to OPE more generally, as Figure 5 subtly suggests in the bars for "Low Socio". We note that in Figure 4, most predicted values indicating improved birth outcomes during the third trimester are statistically distinguishable from zero but they are not statistically distinguishable from each other. Thus, we cannot rule out that the beneficial siren effect remains constant in response to higher siren counts. Finally, it may still be the case that for a very large amount of sirens during the third trimester disadvantaged mothers are experiencing some anxiety - even with the offsetting effects of decreased work attendance - which in turn attenuates the improvements in birth outcomes or even negatively affects birth outcomes, as is observed with regards to low birth weight.

Our third trimester responses to sirens indicate improvements in birth outcomes. While this is surprising, it is actually consistent with some of the evidence presented in Torche and Shwed (2015). Torche and Shwed (2015) evaluate an event similar to the setting of our study - the second Lebanon War in Israel in 2006, which also resulted in rockets targeted towards civilian populations primarily in northern Israel over several weeks. Unlike our study, the authors do not utilize regional variation in terms of the sirens each mother experienced in her locality of residence during her pregnancy.[16] Interestingly, results that estimate separate effects of exposure to the Second Lebanon War by month of gestation exhibit greater birth weight for mothers in month 7 of gestation during the conflict and a decreased probability of low birth weight for mothers in month 8 during the conflict. During the Second Lebanon War, work attendance decreased substantially (Bucksbaum and Abramovitch (2007)). This reduction in work attendance may have resulted in positive effects on birth weight among third trimester pregnancies in this setting as well.

[16]The authors in Torche and Shwed (2015) do employ a sibling fixed effects regression specification.

Table 4: Placebo Analysis - Assigning OPE to Summer 2011 Births

	Birth Weight	LBW	Gestation Length	Preterm
Sirens - Trimester 1	3.349	-0.002	-0.004	-0.001
	(2.587)	(0.001)	(0.108)	(0.002)
Sirens - Trimester 2	-1.619	-0.000	-0.044	-0.003***
	(1.014)	(0.000)	(0.039)	(0.001)
Sirens - Trimester 3	0.830	0.000	-0.027	-0.000
	(1.009)	(0.000)	(0.045)	(0.001)
Sirens Sq - Trimester 1	-0.054	0.000	0.001	0.000
	(0.054)	(0.000)	(0.002)	(0.000)
Sirens Sq - Trimester 2	0.029*	-0.000	0.001	0.000*
	(0.017)	(0.000)	(0.001)	(0.000)
Sirens Sq - Trimester 3	-0.031	-0.000	0.000	0.000
	(0.022)	(0.000)	(0.001)	(0.000)
Observations	9,999	9,999	9,999	9,999
R-squared	0.05	0.03	0.06	0.05
Mean of Dependent Variable	3207	0.0706	272.3	0.141
Conception Month Fixed Effects	✓	✓	✓	✓
Birth-Specific Controls	✓	✓	✓	✓
Locality-Conception Year Fixed Effects	✓	✓	✓	✓

Notes: Number of localities is 85. The coefficient estimates presented are $\beta_1 - \beta_6$ from equation (2). Birth-specific control include: mother's age at birth (categorical), mother's age (categorical), child sex, maternal abortion history, birth parity (categorical), high fertility, past cesarean delivery, late pregnancy loss in the past, and infertility treatment. Mean of Dependent Variable is the mean for non-OPE births in the sample, in the above case births not assigned OPE treatment based on the placebo OPE. Standard errors are clustered at the locality level. *** p<0.01, ** p<0.05, * p<0.1

6 Robustness Checks

6.1 Placebo Analysis

We examine whether the results in Section 5 are due to pre-existing trends. For this, we run the specification in equation (2) but on data that ends in 2012 and assigns the OPE exposure and siren variables as if OPE occurred in Summer 2011 rather than Summer 2014. The results are mostly reassuring. While the coefficient estimate for second trimester sirens is statistically significant for pre-term birth, and for birth weight it is on the verge of being statistically significant, they are in opposite directions in terms of consistently indicating improvements or detrimental effects due to sirens. Thus, this result may be by chance.

6.2 Testing for Selection of Mothers Giving Birth during Operation Protective Edge

One can argue that our results for the third trimester of pregnancy are driven by mothers with different characteristics who came to give birth in Soroka Hospital during OPE. If the composition of mothers giving birth during OPE changed such that mothers with healthier pregnancies came to Soroka, then this can explain the improvements observed in birth outcomes following sirens during the third trimester. With this in mind, we note that Soroka Hospital is the only hospital serving southern Israel. The closest hospital to Soroka is located nearly an hour drive away in the city of Ashkelon, a city that also experienced substantial rocket attacks during OPE. In order to get to a hospital that is in a city that experienced significantly less sirens during OPE than Soroka did, minimal travel time from Soroka is more than 75 minutes, a substantial trip when in labor.

If different mothers came to give birth in Soroka during OPE, then the distribution of birth months over the course of the year of OPE - 2014 - should be different in comparison to other years. We would expect less births during July-August 2014 when OPE was taking place. We test for this in Table 5 by running regressions with the dependent variable being an indicator for a birth occurring during July-August. These regressions are run for the sample of births occurring in 2007-2009, 2011-2012, and 2014 during January through October, in order to not include births during other military operations (see Section 3 on sample restrictions due to this). Two alternative specifications explore two different explanatory variables of interest. The first is an indicator for a birth taking place during 2014, thus comparing the probability of birth during July-August 2014 to that of all other years in the regression sample. The second is the total amount of sirens in the mother's locality during OPE divided by 20.[17] The latter regression specification controls also for year-of-birth fixed effects. All regression specifications for Table 5 control for locality fixed effects, linear time trends and birth-specific controls. Standard errors are clustered in the year of birth level in the former regression and at the locality level in the latter regression.

The results in Table 5 do not show a statistically significant change in the probability of a birth during July-August 2014, in comparison to other years - both in general (first column) and as a function of the number of sirens in the mother's locality (second column). Furthermore, these results hold when examining only the sample of birth from mothers either from disadvantaged or more advantaged localities. Thus, the evidence does not suggest more or less births in Soroka during OPE.[18]

6.3 Different Gestation Length Thresholds

In Section 3, we explain that the number of sirens assigned to each mother in constructing the sirens treatment variable is based on the mother's due date rather than her child's birth date. This addresses the potential endogeneity of the birthdate, given that our variables of interest affect gestational length. Our sample is limited to births with a gestational length of at least 180 days. This results in a small amount of mothers - those who gave birth substantially earlier than their due date - having a large amount of sirens

[17] The number of sirens is divided by 20 so that the coefficient estimates and their standard errors do not appear as zero.

[18] We note that while the results of Figure 3 do suggest increases in gestation length for the vast majority of mothers experiencing OPE during their third trimester of pregnancy, for the mean number of sirens the difference is equivalent to roughly 2.5 days. Thus, the results of Table 5 are still consistent with this increase, as we would not expect that mothers giving birth a few days later would alter the entire probability of a birth occurring during July-August in a statistically meaningful way.

Table 5: Testing for Different Probability of Births during July-August 2014

	Dependent Variable: July-August Birth					
	All Localities		Disadvantaged Localities		More Advantaged Localities	
Year of Birth is 2014	-0.002		-0.004		-0.002	
	(0.007)		(0.007)		(0.007)	
Multiple of 20 Sirens		0.002		0.010		0.003
		(0.003)		(0.015)		(0.006)
Observations	20,881	20,881	4,839	4,839	15,874	15,874
R-squared	0.01	0.01	0.01	0.01	0.01	0.01
Mean of Dependent Variable	0.207	0.207	0.197	0.197	0.211	0.211
Locality Fixed Effects	✓	✓	✓	✓	✓	✓
Year of Birth Fixed Effects		✓		✓		✓
Birth-Specific Controls	✓	✓	✓	✓	✓	✓

Notes: The sample includes birth occurring during Jan.-Oct. in 2007-2009, 2011-2012, and 2014. Birth-specific controls include: mother's age at birth (categorical), mother's age (categorical), child sex, maternal abortion history, birth parity (categorical), high fertility, past cesarean delivery, late pregnancy loss in the past, and infertility treatment. Columns (3)-(4) limit the sample to maternal localities that are ranked socioeconomically at level 4 (the lowest rank for Jewish localities in southern Israel). Columns (5)-(6) limit the sample to maternal localities that are ranked socioeconomically at level 5 or more. Standard errors in columns (1), (3), and (5) are clustered at the year of birth level, while in columns (2), (4), and (6) at the locality level. *** p<0.01, ** p<0.05, * p<0.1

Table 6: Operation Protective Edge and Birth Outcomes - Different Gestational Length Thresholds for Sample

	Gestational Length (Days)				Pre-Term Delivery (Indicator)		
Minimal Gest. Length Threshold	200 Days	220 Days	240 Days	260 Days	200 Days	220 Days	240 Days
Sirens - Trimester 1	-0.051	-0.091	-0.061	-0.060	0.004**	0.005**	0.004**
	(0.061)	(0.062)	(0.046)	(0.056)	(0.002)	(0.002)	(0.002)
Sirens - Trimester 2	-0.170***	-0.150**	-0.147**	-0.222***	-0.005***	-0.005***	-0.005***
	(0.055)	(0.058)	(0.059)	(0.072)	(0.001)	(0.001)	(0.001)
Sirens - Trimester 3	0.150***	0.151***	0.119***	0.065***	-0.007***	-0.007***	-0.006***
	(0.042)	(0.041)	(0.041)	(0.022)	(0.002)	(0.002)	(0.002)
Sirens Sq - Trimester 1	0.003*	0.003**	0.003**	0.003**	-0.000	-0.000	-0.000
	(0.001)	(0.002)	(0.001)	(0.001)	(0.000)	(0.000)	(0.000)
Sirens Sq - Trimester 2	0.004***	0.004***	0.003**	0.005**	0.000***	0.000***	0.000***
	(0.001)	(0.001)	(0.001)	(0.002)	(0.000)	(0.000)	(0.000)
Sirens Sq - Trimester 3	-0.002*	-0.002	-0.001	-0.001	0.000***	0.000**	0.000**
	(0.001)	(0.001)	(0.001)	(0.001)	(0.000)	(0.000)	(0.000)
Observations	9,197	9,154	9,037	8,057	9,197	9,154	9,037
R-squared	0.08	0.07	0.08	0.08	0.08	0.08	0.07
Mean of Dependent Variable	272.4	272.7	273.3	275.6	0.133	0.128	0.116
Conception Month Fixed Effects	✓	✓	✓	✓	✓	✓	✓
Birth-Specific Controls	✓	✓	✓	✓	✓	✓	✓
Locality-Conception Year Fixed Effects	✓	✓	✓	✓	✓	✓	✓

Notes: The number of localities is 85. See Section 3 for information on the sample. The coefficient estimates presented are $\beta_1 - \beta_6$ in equation (2). The first row indicates the dependent variable, and for each dependent variable, the second row indicates the minimal gestational length threshold for the sample in the regression. Birth-specific controls include: mother's age at birth (categorical), mother's age (categorical), child sex, maternal abortion history, birth parity (categorical), high fertility, past cesarean delivery, late pregnancy loss in the past, and infertility treatment. Mean of Dependent Variable is the mean for non-OPE births in the sample. Regressions with pre-term delivery as the dependent couldn't run on the 260 days threshold as all births at that threshold are full-term. Standard errors are clustered at the locality level. *** p<0.01, ** p<0.05, * p<0.1

assigned to them despite not experiencing these sirens during their pregnancy. This distortion would primarily be relevant to the number of sirens assigned during the third trimester.

To test whether assignment of sirens based on the mother's due date affected our results in any way, we present regression results in Table 6 for the same specification as in Table 2, only the minimal gestation length threshold varies. We do this for the two birth outcomes that exhibited improvements in response to sirens during the third trimester - gestation length and a pre-term delivery. The advantage of this more strict sample criterion is that the number of sirens more precisely captures the actual number of sirens mothers experienced in their locality during their third trimester. The disadvantage of this sample restriction is reduced variation in our outcomes of interest. Despite this disadvantage, the results in Table 6 still show statistically significant benefits in terms of gestation length and the probability of a pre-term delivery in response to sirens during the third trimester. This is even true for gestation length at the 260 days threshold and for pre-term delivery at the 240 days threshold.

6.4 Additional Robustness Checks

In the Appendix, we present results for two additional robustness checks.

In Table 10, we present results for our quadratic regression specification, as outlined in equation (2) and presented in Table 2, for all dependent variables, without limiting the birth years in the sample to 2014 and 2015. These results thus utilize all birth years in the sample beginning in 2007. The results are for the most part consistent with the findings presented in Table 2 and Figure 3.

We investigate an alternative mechanism for the improvements in birth outcomes due to exposure to OPE - solidarity or possibly community assistance that pregnant women received during OPE. For this, we ran the same regressions as the one producing the results in Figure 4, but rather than estimating differential siren effects based on localities' socioeconomic ranking, these were estimated based on localities' population. The idea is to test whether improvements in birth outcomes following sirens are greater in smaller localities, where the community may be more closely knit and assistance or solidarity during OPE may have been greater. In these regressions, the results - presented in Table 11 in the Appendix - indicate that the statistically significant improvements in birth outcomes following third trimester sirens are found more among mothers from larger localities, thus not lending support to the solidarity or community assistance hypothesis.

7 Concluding Remarks

As the economics literature has progressed from demonstrating the importance of birth weight for long-term adult outcomes (Black et al. (2007); Behrman and Rosenzweig (2004)) to establishing the central role intrauterine shocks play in determining birth weight and other birth outcomes (Almond and Currie (2011)), an abundant research has emerged that evaluates various potential intrauterine shocks and their effect on birth outcomes. When possible, these studies also evaluate the effect of these shocks on long-term adult outcomes or even offspring outcomes. This study evaluates one such shock - Operation Protective Edge in Israel - which resulted in the civilian population experiencing dozens of sirens warning of rocket attacks over a two-month period. Our results show that the effect of a conflict on birth outcomes can be difficult to interpret, given multiple channels through which the conflict can affect birth outcomes - stress, reduced work attendance, and prenatal care being just a few of these potential channels and the ones that we establish in our analysis.

While a large and growing literature has managed to establish the adverse effects of stress on birth outcomes, and for prenatal care there is a large literature showing positive effects - albeit not always causally - the literature on work attendance and birth outcomes is less concise. We hope our results can prompt additional research and study designs that are more capable of isolating the effect of work attendance during pregnancy on birth outcomes and address this potential channel that may affect birth outcomes and has important policy implications.

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Appendix

A Migration Balance following Operation Protective Edge

As discussed in Section 3, our data has the limitation of observing maternal locality only during birth, as opposed to when OPE actually occurred. To verify that this does not bias our results due to potential migration across localities in the aftermath of OPE, we test whether locality migration balances following OPE - during 2015 - were correlated with the number of sirens experienced in each locality. Table 7 presents regression results for a sample of localities with the migration balance per 1000 residents in 2015 as the dependent variable and the number of sirens during OPE as the explanatory variable. The first column presents results for all Jewish localities and the second column presents results for localities that had non-zero sirens during OPE.

The source for migration balance data is from the Israel CBS. We note that the CBS migration balance data was only available for towns and cities and not smaller localities in Israel, which represent a large fraction of the localities in our data for southern Israel. As such, we tested for the correlation across all towns in Israel, rather than just towns from southern Israel, as this would have reduced the sample to solely 12 towns and cities. We only used Jewish towns and localities because of the large amount of Arab towns and cities in northern Israel that both experienced no sirens during OPE and have extremely low migration balances due to the Arab population being largely immobile in terms of migration in Israel.

The results in Table 7 do not show a statistically significant relationship between locality migration balances during 2015 and the number of sirens during OPE. The p-value for the coefficient estimates are 0.21 and 0.38 for the first and second columns of Table 7, respectively.

B Linear and Non-Zero Indicator Variable Regressions for the Relationship between Sirens and Birth Outcomes

Table 8 presents results from regressions that specify either an indicator variable for non-zero sirens for each of the pregnancy trimesters (top panel) or simply the number of sirens during each pregnancy trimester (bottom panel) as the main explanatory variables. The rest of the regression is as in equation (1) without the main variables of interest. The non-zero indicator regression results suggest mixed effects for first trimester sirens, a beneficial effect of second trimester sirens but only in terms of the probability of a pre-term delivery, and a beneficial effect of third trimester sirens for all birth outcomes, with the exception of the probability of a low birth weight. In the bottom panel, which presents results for a specification assuming a linear relationship between sirens and birth outcomes, all statistically significant coefficient estimates suggest improved birth outcomes in response to sirens. The results of this specification appear to be misleading, given the results in Figure 2, which show also adverse effects in response to sirens during

Table 7: Migration Balances following Operation Protective Edge and Sirens

	Dependent Variable: Locality Migration Balance per 1000 Residents	
	All Localities	Localities with Non-Zero Sirens
Number of Sirens During Operation Protective Edge	0.096 (0.076)	0.047 (0.053)
Observations	123	89
Mean of Dependent Variable	2.455	4.826

Notes: Migration balance data is from the Israel CBS for the year 2015. The sample of localities is all Jewish localities with 2015 migration balance data available in all of Israel. The coefficient estimates are from OLS regressions.

the first trimester.

C Regressions with Maternal Fixed Effects

As stated in Section 4, our data enable us to run regressions with maternal fixed effects. Maternal fixed effects are advantageous in terms of alleviating concern for maternal selection for pregnancies during OPE. However, the decreased variation through which the coefficients are estimated can inflate the standard errors such that the results become non-informative. Unfortunately, the maternal fixed effects regression results presented in Table 9 do not allow us to conclude meaningfully concerning the effect of sirens on birth outcomes, due to large standard errors. While we still observe an adverse effect of first trimester sirens on low birth weight, other coefficient estimates are not statistically significant and their standard errors are quite large. We stress that many of the coefficient estimates are of a similar magnitude to those presented in Table 2 in the final column of each dependent variable, which is reassuring. However, these coefficient estimates are not statistically significant given that the standard errors for these estimates are 2-3 times the size of the standard errors for the same estimates in Table 2.

D Response to Sirens - C-Section, Birth Defects, Early Water and Apgar Score

We further lend support to our results regarding the effect of sirens on birth weight, gestational length, low birth weight, and a per-term delivery in the main analysis of the paper by presenting results for other

Table 8: Birth Outcomes and Sirens Exposure - Linear and Non-Zero Indicator Variable Regressions

	Birth Weight	LBW	Gestation Length	Preterm
	Non-Zero Indicator Specification			
Non-Zero Sirens - Trimester 1	16.737	0.020**	0.906***	-0.009
	(12.030)	(0.008)	(0.288)	(0.012)
Non-Zero Sirens - Trimester 2	-14.476	-0.002	-0.165	-0.033***
	(19.622)	(0.007)	(0.527)	(0.011)
Non-Zero Sirens - Trimester 3	19.265*	-0.002	1.457***	-0.038***
	(11.067)	(0.006)	(0.396)	(0.010)
	Linear Specification			
Sirens - Trimester 1	1.902***	0.000	0.052***	0.000
	(0.489)	(0.000)	(0.008)	(0.000)
Sirens - Trimester 2	0.388	-0.000**	0.014**	-0.001***
	(0.271)	(0.000)	(0.007)	(0.000)
Sirens - Trimester 3	1.014***	-0.000	0.060***	-0.002***
	(0.325)	(0.000)	(0.007)	(0.000)
Observations	9,214	9,214	9,214	9,214
Mean of Dependent Variable	3223	0.0641	272.3	0.134
Conception Month Fixed Effects	✓	✓	✓	✓
Birth-Specific Controls	✓	✓	✓	✓
Conception Year-Locality Fixed Effects	✓	✓	✓	✓

Notes: Number of localities is 85. Sample is births conceived during 2013-2014. See Section 3 for information on the sample. The first panel presents results for regression specifications as in equation (1) but with a measure for the number of sirens in each trimester as the main variables of interest. The second panel presents results for regression specifications as in equation (1) but with a indicators for non-zero sirens in each trimester as the main variables of interest. Birth-specific control include: mother's age at birth (categorical), mother's age (categorical), child sex, maternal abortion history, birth parity (categorical), high fertility, past cesarean delivery, late pregnancy loss in the past, and infertility treatment. Mean of Dependent Variable is the mean for non-OPE births in the sample. Standard errors are clustered at the locality level. *** p<0.01, ** p<0.05, * p<0.1

Table 9: Birth Outcomes and Sirens Exposure - Including Maternal Fixed Effects

	Birth Weight	LBW	Gestation Length	Preterm
Sirens - Trimester 1	-3.889	0.005**	-0.111	0.001
	(5.249)	(0.002)	(0.089)	(0.004)
Sirens - Trimester 2	-2.840	0.000	-0.125	-0.002
	(3.029)	(0.001)	(0.082)	(0.003)
Sirens - Trimester 3	0.493	-0.001	0.067	-0.002
	(3.467)	(0.001)	(0.087)	(0.002)
Sirens Sq - Trimester 1	0.125	-0.000**	0.004*	-0.000
	(0.110)	(0.000)	(0.002)	(0.000)
Sirens Sq - Trimester 2	0.068	-0.000	0.002	0.000
	(0.060)	(0.000)	(0.002)	(0.000)
Sirens Sq - Trimester 3	-0.024	0.000	-0.001	0.000
	(0.081)	(0.000)	(0.002)	(0.000)
Observations	17,180	17,180	17,180	17,180
R-squared	0.73	0.57	0.64	0.59
Mean of Dependent Variable	3220	0.0619	273.2	0.127
Conception Year Fixed Effects	✓	✓	✓	✓
Conception Month Fixed Effects	✓	✓	✓	✓
Birth-Specific Controls	✓	✓	✓	✓
Locality Fixed Effects	✓	✓	✓	✓
Mother Fixed Effects	✓	✓	✓	✓

Notes: Number of localities is 85. Sample is births occurring between Jan. 2007 and August 2015, excluding pregnancies during Israel's two other military operations prior to OPE. See Section 3 for information on the sample. All regressions exclude mothers with single births during the sample period. The coefficient estimates presented are $\beta_1 - \beta_6$ in equation (2). Birth-specific control include: mother's age at birth (categorical), mother's age (categorical), child sex, maternal abortion history, birth parity (categorical), high fertility, past cesarean delivery, late pregnancy loss in the past, and infertility treatment. Mean of Dependent Variable is the mean for non-OPE births in the sample. Standard errors are clustered at the locality level. *** p<0.01, ** p<0.05, * p<0.1

birth outcomes available in our data: the probabilities of a c-section, the child being born with a birth defect, and early water breaking prior to delivery, as well as the Apgar score given to the newborn 5 minutes after birth. Figure 7 presents results as in Figure 4 that plot predicted values for various levels of sirens during each pregnancy trimester based on maternal residence socioeconomic ranking, only the dependent variables vary. Two main conclusions arise from Figure 7. First, mother from towns ranked lower socioeconomically experience greater adverse effects of sirens on their pregnancy outcomes. Second, for these birth outcomes, we observe less beneficial effects of sirens on birth outcomes, although any such effects are still among mother from towns ranked higher socioeconomically - a decrease in the probability of a c-section in response to high first trimester siren counts, and a decrease in the probability of an early water break in response to high third trimester siren counts.

E Regression Results without Limiting to Conception Years 2013-2014

In Table 2, we show results for equation (2) while the sample is limited to births conceived during 2013-2014, the years that produce variation in sirens experienced during pregnancy. In Table 10, we present results from these regressions with the sample including all years we were provided birth data from - January 2007 through August 2015. The adverse effects of first trimester sirens are apparent from Table 10, as are the mixed results concerning second trimester sirens. The third trimester improvements in birth outcomes in response to sirens are only for pre-term delivery.

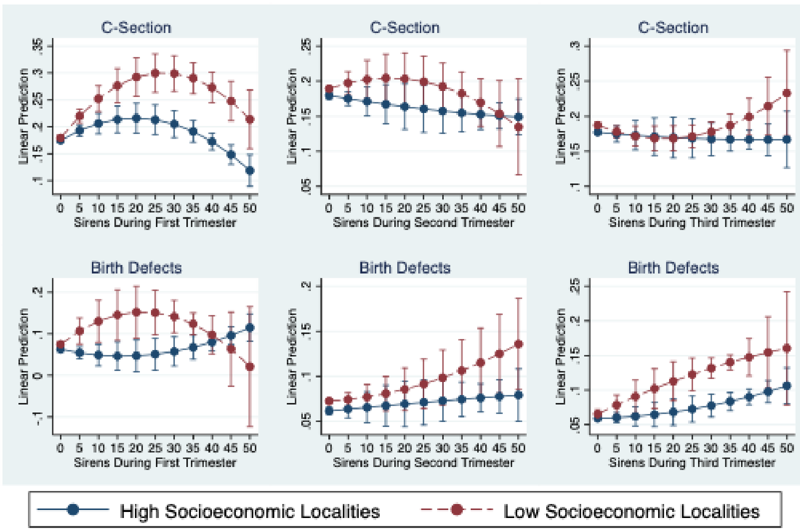
F Differential Effects based on Locality Population

Table 11 allows for different siren effects based on the locality's population. The main variables of interest in equation (2) are the trimeter siren variables from equation (2) interacted with either an indicator for a locality population that is less than 3000 residents or an indicator for a locality population that is more than 3000 residents. Thus, Table 11 has 12 coefficients of interest, with small and large localities' effects from sirens represented in the top and bottom 6 coefficient estimates. Table 11s results are similar when larger population thresholds were set to determine small/large localities. With the population threshold set at 3000, the smaller localities consisted of 69 localities (out of 85) but only 740 births. With a population threshold of 8000, the smaller localities consisted of 74 localities and 1,110 observations.

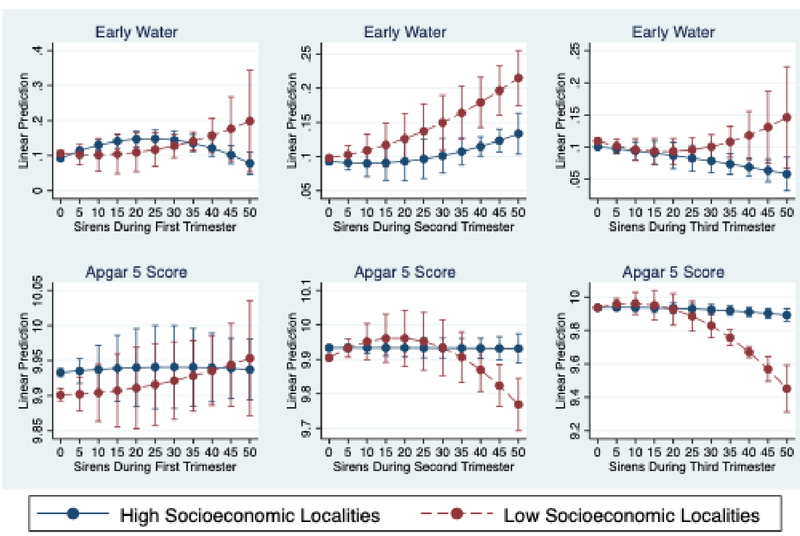
The results of Table 11 suggest that the beneficial effects of third trimester sirens are driven more by the larger localities. If one believes that solidarity or community assistance in times of conflict is greater in smaller communities, then this rules out the potential explanation for the improved birth outcomes observed resulting from this.

Figure 7: Sirens During Pregnancy by Locality Socioeconomic Ranking - Quadratic Specification Predicted Values - C-Section, Birth Defect, Early Water and Apgar Score

(a) Birth Weight and Gestation Length



(b) Low Birth Weight and Pre-Term Delivery



Notes: The figures plot the predictive values and the 95% confidence intervals from results for regression specifications that are similar to equation (2) only they interact the siren variables with dummies for high and low socioeconomically ranked localities. Siren values are listed on the horizontal axis during the first, second and third trimester of pregnancy in the left, middle and right columns, respectively.

Table 10: Sirens and Birth Outcomes - Quadratic Regressions with the Sample including All Years

	Birth Weight	LBW	Gestation Length	Pre-Term
Sirens - Trimester 1	-4.084***	0.003**	-0.089*	-0.001
	(1.500)	(0.001)	(0.045)	(0.001)
Sirens - Trimester 2	-2.188*	0.001	-0.146***	-0.003**
	(1.239)	(0.001)	(0.033)	(0.001)
Sirens - Trimester 3	-0.649	-0.000	0.063	-0.003*
	(1.184)	(0.001)	(0.052)	(0.001)
Sirens Sq - Trimester 1	0.142***	-0.000***	0.003***	0.000
	(0.036)	(0.000)	(0.001)	(0.000)
Sirens Sq - Trimester 2	0.059**	-0.000	0.003***	0.000*
	(0.030)	(0.000)	(0.001)	(0.000)
Sirens Sq - Trimester 3	0.009	0.000	-0.001	0.000
	(0.030)	(0.000)	(0.001)	(0.000)
Observations	33,738	33,738	33,738	33,738
R-squared	0.06	0.03	0.07	0.04
Mean of Dependent Variable	3218	0.0653	273	0.131
Conception Month Fixed Effects	✓	✓	✓	✓
Birth-Specific Controls	✓	✓	✓	✓
Locality-Conception Yeary Fixed Effects	✓	✓	✓	✓

Notes: See Section 3 for information on the sample - sample years are 2007 through August 2015. Number of localities is 86. The coefficient estimates presented are $\beta_1 - \beta_6$ from equation (2). Birth-specific control include: mother's age at birth (categorical), mother's age (categorical), child sex, maternal abortion history, birth parity (categorical), high fertility, past cesarean delivery, late pregnancy loss in the past, and infertility treatment. Mean of Dependent Variable is the mean for non-OPE births in the sample. Standard errors are clustered at the locality level. *** p<0.01, ** p<0.05, * p<0.1

Table 11: Birth Outcomes and Operation Protective Edge - Differential Effects by Locality Population

		Birth Weight	LBW	Gestation Length	Preterm
Locality Population < 3000	Sirens - Trimester 1	5.345	-0.002**	0.154	-0.007**
		(5.673)	(0.001)	(0.106)	(0.003)
	Sirens - Trimester 2	-5.783	0.003*	-0.212**	0.000
		(4.510)	(0.002)	(0.106)	(0.003)
	Sirens - Trimester 3	4.569	0.001	0.145	-0.004*
		(3.312)	(0.002)	(0.098)	(0.003)
	Sirens Sq - Trimester 1	-0.016	0.000	-0.001	0.000**
		(0.110)	(0.000)	(0.002)	(0.000)
	Sirens Sq - Trimester 2	0.072	-0.000**	0.003**	-0.000
		(0.071)	(0.000)	(0.002)	(0.000)
	Sirens Sq - Trimester 3	-0.026	-0.000	-0.001	0.000
		(0.063)	(0.000)	(0.002)	(0.000)
Locality Population > 3000	Sirens - Trimester 1	-6.469***	0.005***	-0.128***	0.001
		(1.043)	(0.001)	(0.035)	(0.001)
	Sirens - Trimester 2	-6.008***	0.001	-0.258***	-0.003***
		(1.078)	(0.001)	(0.038)	(0.001)
	Sirens - Trimester 3	2.419*	-0.002***	0.202***	-0.006***
		(1.428)	(0.000)	(0.025)	(0.001)
	Sirens Sq - Trimester 1	0.205***	-0.000***	0.005***	-0.000
		(0.025)	(0.000)	(0.001)	(0.000)
	Sirens Sq - Trimester 2	0.156***	-0.000*	0.006***	0.000**
		(0.022)	(0.000)	(0.001)	(0.000)
	Sirens Sq - Trimester 3	-0.030	0.000***	-0.003***	0.000***
		(0.028)	(0.000)	(0.001)	(0.000)
	Observations	9,203	9,203	9,203	9,203
	R-squared	0.06	0.03	0.08	0.05
	Mean of Dependent Variable	3223	0.0641	272.3	0.134
	Conception Month Fixed Effects	✓	✓	✓	✓
	Birth-Specific Controls	✓	✓	✓	✓
	Locality-Conception Year Fixed Effects	✓	✓	✓	✓

Notes: See Section 3 for information on the sample. Number of localities is 85. The coefficient estimates presented are from a variation of equation (2) that interacts all Siren variables with indicator variables for whether the town has a population less than or greater than 3000 residents. Thus, the coefficients $\beta_1 - \beta_6$ from equation (2) are presented for towns with a small population (first 6 coefficient estimates) and larger population (bottom 6 coefficient estimates). Birth-specific control include: mother's age at birth (categorical), mother's age (categorical), child sex, maternal abortion history, birth parity (categorical), high fertility, past cesarean delivery, late pregnancy loss in the past, and infertility treatment. Mean of Dependent Variable is the mean for non-OPE births in the sample. Standard errors are clustered at the locality level. *** p<0.01, ** p<0.05, * p<0.1