The Effect of Birth Timing Manipulation around Carnival on Birth Indicators in Brazil

Carolina Melo* Naercio Menezes-Filho†

June 29, 2023

Abstract

This paper studies the patterns and consequences of birth timing manipulation around the carnival holiday in Brazil. We document how births are displaced around carnival and estimate the effect of displacement on birth indicators. We show that there is extensive birth timing manipulation in the form of both anticipation and postponement and find an increase in gestational length and a reduction in neonatal and early neonatal mortality. We show that these results are consequences of the postponed births that would otherwise happen through scheduled c-sections, but end up happening through vaginal deliveries. Therefore, restrictions on usual delivery procedures due to the carnival holiday increase the children survival rates.

***Keywords*: birth timing manipulation, carnival holiday, gestational length, neonatal mortality**

***JEL Codes*: I14, I15, I18**

---

*C. Melo: Insper Institute of Education and Research (INSPER); address: Rua Quatá, 300, São Paulo-SP, Brazil, 04546-042; phone: +55(11)98937-7007; e-mail: carolinapgm1@insper.edu.br.

†N. Menezes Filho: Insper Institute of Education and Research (INSPER) and University of São Paulo (USP); address: Rua Quatá, 300, São Paulo-SP, Brazil, 04546-042; phone: +55(11)99990-6866; e-mail: naercioamf@insper.edu.br. We thank Paulo Furquim, Rudi Rocha, Rodrigo Soares, Bladimir Carrillo, seminar participants at Insper and Ridge/Lacea for their helpful comments and suggestions. This work was supported by Grants number 2021/05978-5 and 2019/12553-0, Sao Paulo Research Foundation (FAPESP).

1 Introduction

Birth timing manipulation exists for reasons beyond health. Under certain circumstances, it can characterize obstetric violence and generate negative consequences for the health of mothers and infants. The World Health Organization has pointed to the necessity of advancing in research to document problems of health institutions related to obstetric violence, so to help improve the quality of birth care around the world (Zanardo et al., 2017). In this paper, we document the existence of extensive birth timing manipulation around carnival festivity days in Brazil, and study its dynamics and consequences for gestational length and health outcomes at birth.

We define an optimal holiday manipulation window (Jacobson et al., 2021) and, by comparing outcomes on days that surround carnival Tuesday with outcomes on other days of the year, not affected by this holiday, we perform descriptive exercises. We quantify the missing mass of births during the festivity days and the excess mass of births on days before and after carnival festivities, and we also describe birth displacement patterns, in terms of delivery method, maternal characteristics, and gestational length. Our main analysis, however, focuses on estimating the carnival effects on delivery methods and health outcomes by comparing births that happened within the carnival manipulation window with those that happened outside of it, on counterfactual days. Because the optimal carnival window comprises all births that would happen in the carnival period regardless of maternal profile, we argue that these effects are consistent, net of selection in maternal characteristics.

Our results show that there is extensive birth timing manipulation around carnival festivity days, manifested by both anticipation and postponement of births. The missing mass of births during carnival festivity days are composed mainly by missing c-sections, which configure the most convenient delivery type when it comes to timing manipulation. The excess mass of births on days that precede carnival festivities is made of c-sections only, but the excess mass on the days after the holiday is composed also by spontaneous and induced vaginal deliveries. Descriptive evidence also shows that the more educated, less vulnerable mothers, are the ones most likely to engage in birth timing manipulation, and that gestational length is lower (higher) on the days that precede (succeed) festivities.

Our main results reveal that carnival increases gestational length by 0.06 day, and decreases neonatal mortality and early neonatal mortality rates by 0.30 and 0.26 per 1,000 live births, respectively. Implied instrumental variable estimates, obtained by dividing estimated coefficients by an estimated fraction of the displaced births within the optimal window, give an increase in gestational age of 3.41 days, a decrease in neonatal mortality of 17.51 deaths per 1,000 live births, and a decrease in early neonatal mortality of 15.23 deaths per 1,000 live births. With regards to mechanisms, we show that carnival increases the daily number of vaginal deliveries, especially the spontaneous ones. We argue that this evidence indicates that some births that would otherwise be c-sections or induced vaginal deliveries during carnival end up being postponed and becoming spontaneous deliveries.

To verify whether our main results are driven by selection in maternal profile, we estimate the effects of the carnival window on the number of births to mothers of different characteristics, but find no meaningful effect. We thus conclude that our results on gestational age and (early) neonatal mortality can be in fact attributed to the carnival holiday. In terms of policy recommendations, our results show that richer mothers, more likely to engage in birth anticipation and have their babies suffer from lower gestational length and birthweight, could have their babies' health improved through the waiting a little longer to schedule birth or try going into spontaneous labor.

In terms of heterogeneity, we find that the increase in the number of spontaneous vaginal deliveries and the resulting net increases in gestational length and birthweight are observed only in the cases of white mothers. Moreover, the pattern of birth displacement differs for the different hospital types. In private and mixed units, we observe both anticipation and postponement of births, while in public units no anticipation is observed. Taken together, the evidence suggests that carnival effects are concentrated in births to white mothers that deliver in mixed units. Therefore, policy efforts should be focused on this profile.

Previous studies have documented the existence of birth timing manipulation with regards to both the day of birth and the time of birth throughout the day (Cohen, 1983; Brown-III, 1996; Spetz et al., 2001; Gans et al., 2007; Gans and Leigh, 2009; Neugart and Ohlsson, 2012; Fabbri et al., 2016; Rocha and Spinola, 2016). These studies suggest that doctors may be willing to manipulate the timing of birth due to their demand for leisure or convenience (Cohen, 1983; Brown-III, 1996; Spetz et al., 2001; Gans et al., 2007; Rocha and Spinola, 2016), and/or due to their risk aversion (Fabbri et al., 2016). And pregnant women may be willing to manipulate the timing of birth to avoid inauspicious dates, such as April 1st and the Day of the Dead (Gans and Leigh, 2012; Lo, 2003), and/or to receive some financial benefit, such as a "baby bonus" or a tax credit (Dickert-Conlin and Chandra, 1999; Gans and Leigh, 2009; Schulkind and Shapiro, 2014; Borra et al., 2019).

A strand of the literature specifically concerns the effects of holidays on the displacement of births (Cohen, 1983; Lefevre, 2013; Martin et al., 2018). Jacobson et al. (2021) use California data to look at how holiday births are displaced over time and examine the consequences of this displacement for delivery or birth outcomes. We contribute to this literature by focusing on a long holiday, which could bring more pronounced effects, and by using data from a large developing country, where the health effects could potentially be larger.[1] Moreover, since the carnival holiday takes place at different dates across

[1] Rocha and Spinola (2016) present evidence of birth timing manipulation in the Brazilian health

years, we use an empirical strategy that also controls for day-of-year effects, on top of day-of-week and year effects, which lends an additional layer of credibility to our results.

The rest of the paper is organized as follows. In section 2, we provide brief background information on carnival in Brazil and present a conceptual framework to guide our empirical analyses. In section 3, we present our data along with summary statistics. In section 4, we present our empirical strategy. In sections 5 and 6, we present our main results and heterogeneity analysis, respectively. In section 7, we present robustness tests. And section 8 concludes.

2 Background and Conceptual Framework

In Brazil, carnival is the most popular festivity. It occurs in February or March, but there is no fixed date for it. Carnival day is set to be 40 days before the Palm Sunday[2] and, although it always falls on a Tuesday, festivities in Brazil start on the preceding Saturday and are extended to the following Wednesday – known as Ash Wednesday – at noon. Carnival is an official holiday in some, but not in all, Brazilian states and cities (Ministério da Economia, 2019); however, it is celebrated throughout the whole country and taken as a holiday by most. For this reason, in this paper, we refer to carnival as a holiday.

We are interested in learning how carnival affects the dynamics of birth timing and delivery method choice and, consequently, gestational length and health outcomes at birth. There is a strand of the literature that documents the existence of birth timing manipulation around holidays. Timing manipulation can be manifested by either anticipation or postponement of deliveries, consequently affecting the gestational length of births involved (Cohen, 1983; Lefevre, 2013; Rocha and Spinola, 2016; Martin et al., 2018; Jacobson et al., 2021). Previous research has shown that gestational length can affect birthweight and other health indicators, including neonatal mortality. In special, the relationship between gestational length/birthweight and other health outcomes has been vastly documented in the literature.[3] Particularly relevant for this paper are the results of Butler and Alberman (1969), Susser et al. (1972), and Hoffman et al. (1974), mentioned by Goldstein and Peckham (1976), showing that neonatal mortality and gestational length (birthweight) have a non-linear, U-shaped, relationship, with mortality falling up to a 40 week gestational length (3500-4000 grams of birthweight) and increasing afterwards.

system, showing that there is a lower number of births on weekdays in between holidays as compared to regular weekdays, for both private and public hospitals.

[2]Palm Sunday is a date originally celebrated by the Catholics.

[3]See, for instance, Westphal and Joshi (1964); Susser et al. (1972); Hoffman et al. (1974); Goldstein and Peckham (1976); Almond et al. (2005); Black et al. (2007); Oreopoulos et al. (2008); Spong (2013); American College of Obstetricians and Gynecologists (2013); Carrillo and Feres (2017).

To provide a more complete conceptual framework for our work, however, besides considering the literature on birth timing manipulation in face of holidays and the effects of birth displacement on health outcomes at birth, we need to contextualize the institutional birth setting in Brazil. We, therefore, provide an overview of the Brazilian health system in what it involves birth care in the following paragraphs, and then discuss the potential effects of carnival in this specific context.

The Brazilian health system comprises both a privately funded system and a publicly funded unified system (*SUS*), with universal coverage. Health units in the country can be of three types: [i] 100% privately funded (private units), [ii] 100% publicly funded (public units), and [iii] privately and publicly funded at the same time (mixed units). While private (public) units serve only the private (public) system, mixed units although privately managed have a share of their (physical and human) capacity dedicated to *SUS* (Rocha and Spinola, 2016). Over 98% of births in Brazil happen in hospitals (Magalhaes et al., 2019), 54% in public, 29% in mixed, and 17% in private ones.[4]

Under the service of *SUS*, obstetricians and other health professionals are hired on a fixed-hour, fixed-pay contract to serve in shifts on duty, and all people have care access free of charge (Rocha and Spinola, 2016). The first contact a pregnant woman has with the system is through the basic health unit (BHU), where prenatal care is provided in cases of a regular risk pregnancy. The catchment area of a BHU is served by one or more hospitals, to where pregnant women are referred to deliver. Therefore, under regular risk conditions, the doctor that follows a pregnant woman during pregnancy is usually not the one who assists her delivery. Women are advised to go to referred hospitals when reaching a certain frequency of contractions in the labor process. Only when medical reasons are present, according to the Ministry of Health's guidelines, a c-section or labor induction should be scheduled (Ministério da Saúde (Brasil), 2015). In fact, more than 80% of all deliveries that happen in public hospitals involve women going into labor. Of those, only less than 20% are induced.[5] Hence, birth timing manipulation under the public service is likely to happen within doctor shifts, after the pregnant woman's admission into the hospital.

Under the private service, obstetricians can be hired to perform shifts on duty (in private or mixed hospitals) or are paid per procedure by the private health insurer, the patient, or both. When under the private system care, pregnant women can choose their doctor and develop a relationship of confidence with her/him. In these cases, the doctor that provides prenatal care is usually the same one that assists the delivery. Frequently, the delivery type is defined and planned early by the doctor and the patient together, before women reach the last weeks of the gestational period. When obstetricians are

[4]Statistics obtained from 2012-2019 DATASUS/SINASC. Available at: http://datasus.saude.gov.br/transferencia-de-arquivos/.

[5]Statistics obtained from 2019 DATASUS/SINASC. Available at: http://datasus.saude.gov.br/transferencia-de-arquivos/.

paid per procedure, there exists a high incentive for them to (convince their patients to) schedule c-sections, for the pay is higher, time demanded is shorter, and they can more conveniently plan a work schedule (Ministério da Saúde (Brasil), 2001; Pasche et al., 2010). In addition, on the demand side, besides convenience, there is a national culture of birth that associates surgical deliveries with higher quality of care (Dias et al., 2008; Ministério da Saúde (Brasil), 2014; Leal et al.). In private hospitals, over 80% of deliveries are c-sections and, of those, nearly 70% are scheduled procedures.[6]

Given the setting of birth care in Brazil, we rationalize how the long carnival holiday can affect birth timing manipulation. Under the *SUS* service, in face of the holiday, doctors may avoid scheduling c-sections and/or labor inductions that are medically justified on festivity days, because hospitals (which can be public or mixed) might be understaffed, operating at lower capacity. The low fraction of deliveries that would be scheduled to be performed during the holiday[7] can be, therefore, either anticipated or postponed. In the case of postponement, there is a risk that women go into spontaneous labor anytime before the expected new date of delivery.

Under the private service, however, pregnant women and their doctors of choice can freely agree in advance not to schedule deliveries on festivity days. The alternative for them is, then, to anticipate birth to days that precede carnival or to postpone it to days that succeed it. Given that, most of those births were anyhow meant to be c-sections,[8] we expect that many surgical procedures are anticipated to the weekdays before carnival. Due to the limited capacity of doctors (or even hospitals) to accommodate so many birth anticipations, and because it would not be medically advisable to anticipate deliveries by so many days, only a limited number of c-sections can be scheduled to days that precede carnival. Births that are not (or cannot) be anticipated are subject to postponement, again, under the risk of pregnant women going into spontaneous labor before the new date on which their c-sections were scheduled to be performed. When that happens, it is possible that women are assisted by a different doctor than that with who they went through prenatal care, either under the emergency service of *SUS* or the private system, and end up having a vaginal delivery instead (even though their initial preference was to have a c-section). We, nonetheless, cannot rule out the possibility that some births that would happen vaginally during carnival are also anticipated by women that do not want to risk delivering with another doctor. We, therefore, anticipate that the holiday may not not only result in birth timing manipulation, but also in a disproportionate change in the number of births that happen in different health unit types and in the number of different delivery types performed.

We also conjecture that a lower (higher) gestational age due to birth anticipation

[6] Statistics obtained from 2019 DATASUS/SINASC. Available at: http://datasus.saude.gov.br/transferencia-de-arquivos/.

[7] Recall that, under the public service, over 80% of deliveries involve women going into labor.

[8] Recall that, under the private service, the share of c-section births in Brazil is greater than 80%.

(postponement) can directly result in a lower (higher) birthweight, which, in turn, can have further consequences for the health of the infant. Because the average gestational length of Brazilian women is below 39 weeks,[9] putting them in the declining part of the U-shaped curve – originated by results of Butler and Alberman (1969), Susser et al. (1972), and Hoffman et al. (1974), mentioned by Goldstein and Peckham (1976) –, we expect neonatal mortality to increase (decrease) with birth anticipation (postponement). We note, however, that studies have documented that health consequences of timing manipulation are usually a result of the combination of a change in gestational age with a change in delivery method, with the exact mechanism being very hard to disentangle (Borra et al., 2016). Thus, any effect we may observe cannot only be attributed to changes in gestational length, as changes in delivery method may also be into play.

3 Data

To perform our empirical analysis, we use three datasets that are made publicly available by the Brazilian Ministry of Health:[10] [i] a dataset that contains information on all live births that occurred in Brazil, DATASUS/SINASC; [ii] a dataset that contains information on all active health units in the country, DATASUS/CNES; and [iii] a dataset that contains information on all deaths that occurred in the country, DATASUS/SIM.

The DATASUS/SINASC dataset contains unidentified data at the individual birth level, with the health unit code (CNES code), the birth date, and several maternal and birth characteristics, including: age, race, marital status and years of education of the mother, gestational length in weeks, delivery method (cesarean section or vaginal delivery), and birthweight in grams.

The DATASUS/CNES dataset contains monthly information on active health units in the country, identified by a health unit code (CNES code). From this dataset, we obtained information on the total number of beds and the percentage of obstetric beds of each hospital dedicated to serving the public and the private health systems. We then defined three types of health units: [i] private, those that have 100% of their obstetric beds dedicated to the private health system; [ii] public, those that have 100% of their obstetric beds dedicated to the public unified health system; and [iii] mixed, those that have some obstetric beds dedicated to the private system and others dedicated to the public system.[11] Using the health unit code (CNES code), we merged the DATASUS/CNES dataset with the DATASUS/SINASC dataset. With the resulting merged dataset, we collapsed our data to obtain a panel at the day-by-year level. To perform heterogeneity analysis, in which we estimate carnival effects for each unit type separately, we restricted

[9] Statistics obtained from 2012-2019 DATASUS/SINASC. Available at: http://datasus.saude.gov.br/transferencia-de-arquivos/.

[10] Available at: http://datasus.saude.gov.br/transferencia-de-arquivos/.

[11] We follow Rocha and Spinola (2016) in defining private, public, and mixed health units.

the data to births that happened in private, public, or mixed units before collapsing.

The DATASUS/SIM dataset contains unidentified data at the individual death level, with both the death date and the birth date that corresponds to each entry. We identified all neonatal and early neonatal deaths,[12] collapsed this dataset at the birthday level and merged it with our main dataset. With the resulting dataset, we were able to create neonatal death and early neonatal death rate variables.[13]

A summary of our final dataset, which includes 8 years of data (2012-2019),[14] is presented in table 1. The table shows summary statistics for all variables used in our empirical analyses, for the following periods: [i] all days of the year, [ii] days contained within a window of 20 days before up to 14 days after carnival Tuesday (our optimal holiday manipulation window), and [iii] carnival festivity days (going from carnival Saturday up to Ash Wednesday).

The statistics presented in table 1 yield an interesting descriptive analysis. We note that the average number of births on carnival festivity days is considerably lower than the average on other days of the year. The overall percentage of births that happen in private and mixed hospitals is lower than that of births that happen in public hospitals. In fact, more than half (55%) of the country's births happen in public units. Furthermore, the percentage of of births to mothers with a more vulnerable profile (less educated, non-white, with no partner, and/or aged less than 18) is higher during carnival, and health outcomes at birth are, on average, worse during these days.

[12]Neonatal deaths are defined to be those that happen before the baby reaches his/her 28th day of life; and early neonatal deaths are defined to be those that happen before the baby reaches his/her 7th day of life (Ministry of Health).

[13]It is worth noting that the DATASUS/SIM dataset does not contain information on the health unit in which the individual was born nor a reliable identifier that allows one to perfectly match its entries with DATASUS/SINASC entries.

[14]We do not use years before 2012 because critical variables are only available starting from this year.

	Whole Year			**Carnival Window**			**Carnival Festivity Days**		
	Mean	SD	N	Mean	SD	N	Mean	SD	N
# of births	8,037.13	1,188.89	2,688	8,304.93	1,154.02	280	6,901.69	563.9	32
% of births in private units	16.79	2.52	2,688	16.95	2.66	280	13.13	1.87	32
% of births in public units	54.56	3.73	2,688	53.68	3.80	280	58.51	2.66	32
% of births in mixed units	28.65	1.66	2,688	29.36	1.60	280	28.37	1.62	32
# of c-sections	4,503.23	1,070.46	2,688	4,639.88	1,090.09	280	3,302.13	514.86	32
# of spontaneous vaginal deliveries	2,381.59	230.94	2,688	2,430.92	225.34	280	2,411.44	220.95	32
# of induced vaginal deliveries	963.29	142.12	2,688	1,022.27	126.87	280	984.63	133.09	32
% of c-sections	55.27	6.22	2,688	55.10	6.25	280	47.62	3.78	32
% of spontaneous vaginal deliveries	30.96	5.05	2,688	30.62	5.02	280	36.14	3.41	32
% of induced vaginal deliveries	12.49	2.37	2,688	12.89	2.44	280	14.84	2.58	32
% of mothers aged less than 18	8.64	1.35	2,688	8.60	1.27	280	9.53	1.30	32
% of mothers aged more than 35	10.38	1.58	2,688	10.22	1.50	280	9.30	1.28	32
% of mothers w/ $\leq$8 years of educ.	22.06	4.45	2,688	22.35	4.60	280	24.20	5.11	32
% of non-white mothers	63.49	2.36	2,688	62.78	2.40	280	65.32	1.86	32
% of mothers with no partner	44.09	2.43	2,688	43.88	2.31	280	45.85	1.97	32
Gestational length (in days)	269.35	0.97	2,688	267.94	0.68	280	267.83	0.72	32
Birthweight (in grams)	3,183.07	14.73	2,688	3,179.44	13.62	280	3,166.31	11.87	32
Neonatal death rate	8.83	1.34	2,688	8.95	1.27	280	9.83	1.40	32
Early neonatal death rate	6.68	1.13	2,688	6.77	1.16	280	7.57	1.35	32

Table 1: Summary Statistics

Notes. The sample includes 8 years of data (2012-2019). The *carnival window* period comprises 35 days, going from 20 days before up to 14 days after carnival Tuesday. The *carnival festivity days* period comprises 5 days, going from carnival Saturday up to Ash Wednesday.

4 Empirical Strategy

To assess the carnival effects on birth outcomes, we need to first determine the days around carnival Tuesday that were impacted by the holiday. To do so, we follow the literature and use the idea that, in a manipulation region, the missing mass (defined in our context as *births* minus *expected births* < 0) should be equal to the excess mass (defined in our context as *births* minus *expected births* > 0).[15] Applying this idea to the context of this paper, we have that the drop in births during the days in which carnival festivities occur should be equal to the increase in births in the days that precede and succeed the festivities. The carnival manipulation window, therefore, is defined as the set of days (around carnival Tuesday) for which the sum of missing and excess masses is closest to zero.

In order to estimate the missing/excess mass for each day within a holiday window, we need to find counterfactual days, so that we can compare the actual number of births on a given window day with the expected number of births for that day had carnival not existed. We use days of the year that fall outside the carnival window as counterfactuals for carnival window days, controlling for holiday, day-of-week, day-of-year, and year effects. The empirical strategy we use to estimate the missing/excess mass on each holiday window day is summarized by the regression equation below:

$$Y_{dt} = \alpha + \sum_{j=-i}^{k} \beta_j Dist_{jdt} + \nu Holiday_{dt} + \lambda_{dt} + \rho_{dt} + \mu_t + u_{dt} \tag{1}$$

where d indexes the day and t indexes the year; i and k are positive integers; Y_{dt} is the outcome of interest (the number of births) on day d and in year t; $Dist_{jdt}$ is a binary variable that indicates whether day d of year t is j days away from carnival Tuesday; $Holiday_{dt}$ is a binary variable that indicates whether day d of year t is a national holiday other than carnival; λ_{dt}, ρ_{dt}, and μ_t represent day-of-week, day-of-year, and year fixed effects respectively; and u_{dt} is the robust error for day d and year t. Our parameters of interest are the β_j's, which give the difference between the number of births on day j before/after carnival Tuesday and the number of births on days of the year not impacted by carnival festivities – i.e. the β_j's give the missing/excess mass of births on each holiday window day.

After estimating regression equation 1 for each combination of window before and after the carnival Tuesday, we sum the β_j's found in each estimation and identify the one for which this sum has the smallest magnitude. Results, presented in table A.1, reveal that the optimal carnival manipulation window is the one that goes from 20 days before up to 14 days after carnival Tuesday. We use this optimal window to study the dynamics

[15] This methodology is used by Jacobson et al. (2021), Kleven (2016); Diamond and Persson (2017); Dee et al. (2019). Although we use this same methodology, we estimate the missing and excess masses of births around the holiday through the application of a different empirical strategy.

and describe the patterns of birth displacement around the holiday, as well as to estimate the carnival effects on birth indicators.[16]

Because the optimal carnival window, by construction, contains all the births that would happen during carnival festivities irrespective of selection into birth timing manipulation, including those displaced to a neighborhood around carnival Tuesday, the difference between the outcome of interest on the average window day and the outcome of interest on a day outside the window should capture the carnival effect net of selection bias. Therefore, to assess the effects of the carnival holiday on gestational length and health outcomes, including birthweight and neonatal mortality, we stick to the optimal window and estimate the following equation:[17]

$$Y_{dt} = \alpha + \beta Window_{dt} + \nu Holiday_{dt} + \lambda_{dt} + \rho_{dt} + \mu_t + u_{dt} \tag{2}$$

where $Window_{dt}$ is a binary variable that indicates whether day d of year t is within the carnival window. Our parameter of interest is β, which gives the average difference in the outcome of interest between a day within the carnival window and a day not impacted by carnival festivities. Our identification hypothesis, in this case, relies on the nonexistence of selection into the manipulation window. We are primarily interested in assessing carnival effects on delivery methods and health outcomes at birth, but we also look at carnival effects on maternal characteristics, so to check the balance between observations within the holiday manipulation window and those outside of it, used as counterfactuals.

Not all births that occur within the manipulation window are affected by carnival festivities. Thus, following Jacobson et al. (2021), we scale our estimates of equation 2's β by the (estimated) fraction of births that were in fact subject to timing manipulation – the ratio of the estimated number of missing births during carnival festivity days to the total number of births within the optimal manipulation window – so to obtain implied instrumental variable (IV) estimates. These implied IV estimates can give us a sense of the size of the effects of birth timing manipulation (anticipation and postponement), rather than a "reduced form" effect.

Jacobson et al. (2021) discuss how timing manipulation due to the holiday could have a domino effect, in which not only births that would otherwise happen during the holiday are rescheduled but also births that would happen on days around it. In our case, for

[16] In practice, we find the optimal manipulation window in three steps. First, we estimate the missing and excess masses for a combination of different windows before and after carnival Tuesday. We run estimations for a window of 4 days before combined with 4, 5, ..., and 20 days after; then, for a window of 5 days before combined with 4, 5, ..., and 20 days after; then, we repeat the same procedure for up to 20 days before combined with 4, 5, ..., and 20 days after. Second, for each of these estimations, we sum the missing mass with the excess masses (before and after festivity days). And, third, we search for the sum that is closest to zero to determine the optimal window.

[17] See Jacobson et al. (2021) and Diamond and Persson (2017) for previous applications of this idea of assessing effects of the window as a whole.

instance, there could be a birth that would be originally scheduled to happen on Thursday before (after) carnival which, due to the holiday, was scheduled to another date. If this were the case, the estimated fraction of affected births would be underestimated and, consequently, the implied IV estimates would be overestimated.[18]

5 Results

In this section, we present the results of our empirical analysis. We start by describing the dynamics of birth around the carnival Tuesday and quantifying birth displacement. Then, we engage in learning the profile of births involved in timing manipulation; that is, the profile of mothers engaged in such practice and the delivery methods adopted. Still in the descriptive world, we document gestational length on days that surround Carnival Tuesday, so to learn whether they are associated with patterns of birth displacement and profile.

We then move to the main results, by estimating carnival effects on gestational length, birthweight, neonatal mortality, and early neonatal mortality rates. With regards to mechanisms, we examine the effect of carnival on the number of c-sections, spontaneous vaginal deliveries, and induced vaginal deliveries. Finally, we close the section with the presentation of balance tests on maternal characteristics to test for selection.

5.1 Description of the Birth Displacement Dynamics

We start the empirical analysis by describing the dynamics of birth displacement and the profile of births involved in timing manipulation around carnival Tuesday. In doing so, we assume the optimal holiday window and re-estimate regression equation 1 using other outcome variables of interest, with the following regression equation:

$$Y_{dt} = \alpha + \sum_{j=-20}^{14} \beta_j Dist_{jdt} + \nu Holiday_{dt} + \lambda_{dt} + \rho_{dt} + \mu_t + u_{dt} \tag{3}$$

where we specify that $i = 20$ and $k = 14$, and Y_{dt} can represent the number or percentage of births to mothers with certain characteristics, or gestational length (in days). For instance, Y_{dt} can be the total number of births in the country or the percentage of births to teenage mothers (aged less than 18) on day d of year t. Our parameters of interest are the β_j's, which (again) give the difference between the outcome of interest on the day j before/after carnival Tuesday and the outcome of interest on days of the year not impacted by carnival festivities.

[18] Jacobson et al. (2021) also discuss how the timing manipulation of some births can impose externalities on other non-retimed births, due to congestion effects. Nonetheless, our "reduced form" estimates can capture these overall carnival effects.

In figure 1 and table B.1, we describe the pattern of births for each day within the holiday manipulation window, that is, we present estimates of the β_j's of equation 3, where the outcome variable is the total number of births. We note that there is an expressive missing mass of births on carnival festivity days,[19] especially on carnival Tuesday, which sums up to 5,084 less births, and an excess mass of births both before and after festivity days. Overall, displaced births represent 1.7% of all births that happen within the carnival window.

These results suggest that births that would happen during carnival days in the absence of the holiday are about half anticipated and half postponed. We observe a significant excess mass of births on Tuesday (day -7), Wednesday (day -6), Thursday (day -5), and Friday (day -4) that precede festivities and also on the Friday of the week before (day -11). We also observe a significant excess mass of births on the Thursday (day 2), Friday (day 3), and Saturday (day 4) that come right after Ash Wednesday and on those same days of the week after (days 9, 10, and 11).

Although it is tempting to think that mothers and doctors engage in an anticipation or postponement of up to 11 days, it is important to note that it may not be the case, since there is likely a "domino effect" on the line of displaced births. For instance, births that would otherwise happen on Tuesday that precedes carnival festivities (day -7) might be anticipated to the previous Friday (day -11), so to free up space for other anticipations on the week that precedes carnival. Hence, the significant excess mass of births that show up on day -11 can be mostly made of births that would otherwise happen on day -7, configuring an anticipation of 4 days only, not 11. When we later look at dynamic effects on gestational length and divide these effects by the fraction of displaced births on each window day (presented on column 4 of table B.1), we can get a sense of the length of anticipation (postponement) on the days that precede and succeed carnival festivities.

[19]Recall that carnival festivity days comprise the Saturday, Sunday, and Monday that precede carnival Tuesday, carnival Tuesday itself, and the Wednesday that comes right after it.

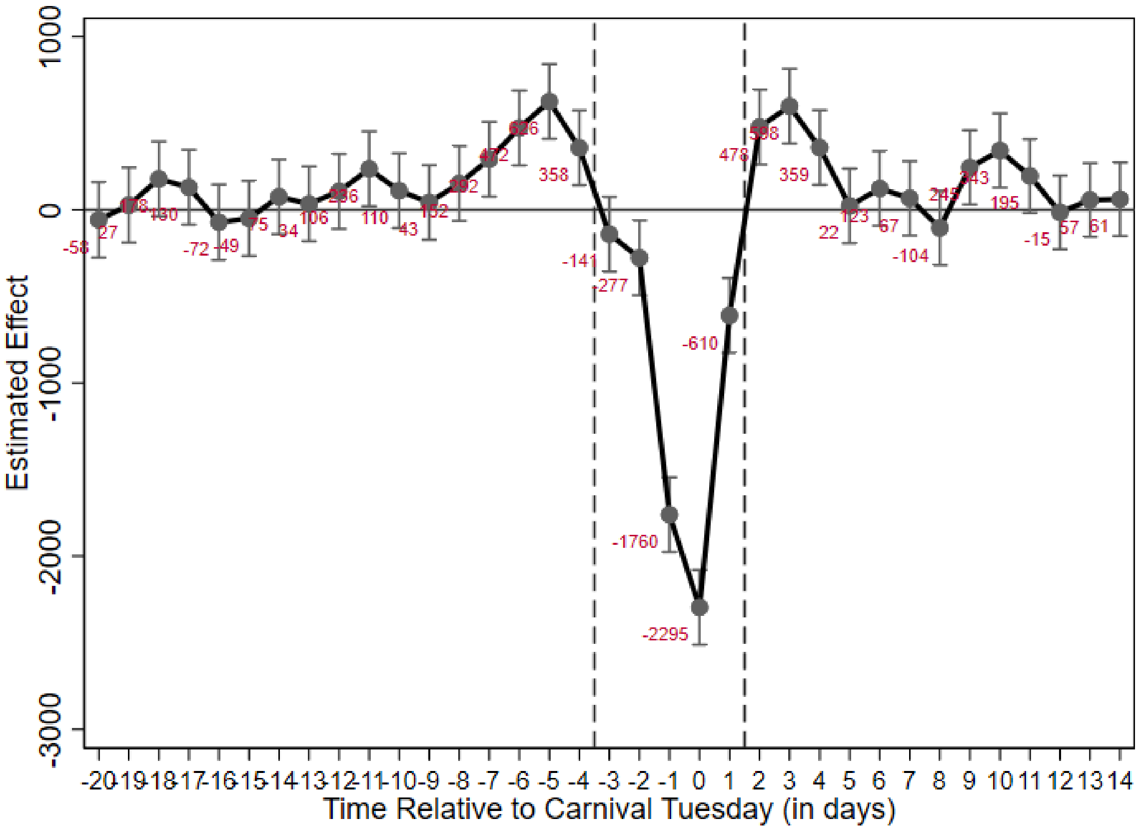


Figure 1: Patterns of birth displacement

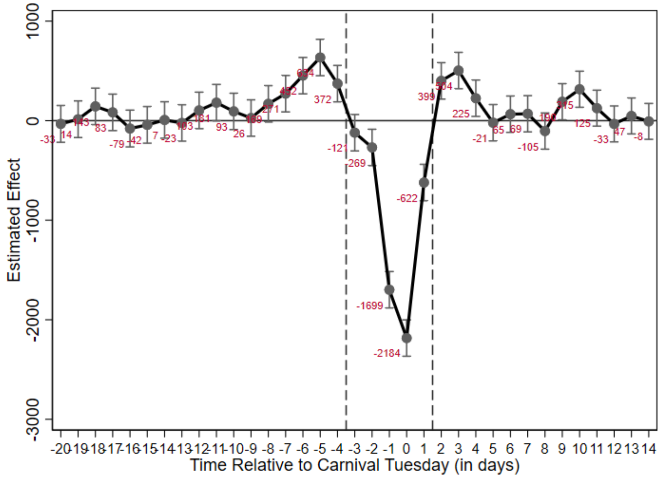
Notes. This figure shows plots of estimates for β_j's of equation 3 and corresponding 95-percent confidence intervals, using the total number of births as the outcome variable. Vertical dashed lines indicate the carnival festivity period, which starts on the Saturday that precedes carnival Tuesday (day 0) and ends on the Wednesday that succeeds it, the Ash Wednesday. The sample comprises all live births that happened within the period of 34 days before carnival Tuesday up to 301 days after it, in years 2012-2019.

We now turn to the evaluation of delivery method patterns. Figure 2 depicts the number of c-sections, spontaneous vaginal deliveries, and induced vaginal deliveries for each day within the holiday manipulation window. By looking at figure 2a, we note that the missing and excess masses of c-sections follow a pattern very similar to that of all birth types combined. There is an expressive missing mass of c-sections on carnival festivity days, which is compensated for by a significant excess mass of surgeries before and after carnival. There are 4,895 births whose timing is manipulated via c-sections, corresponding to 96% of the total number of displaced deliveries. This result is expected, because c-sections configure the most convenient way to manipulate the timing of birth.

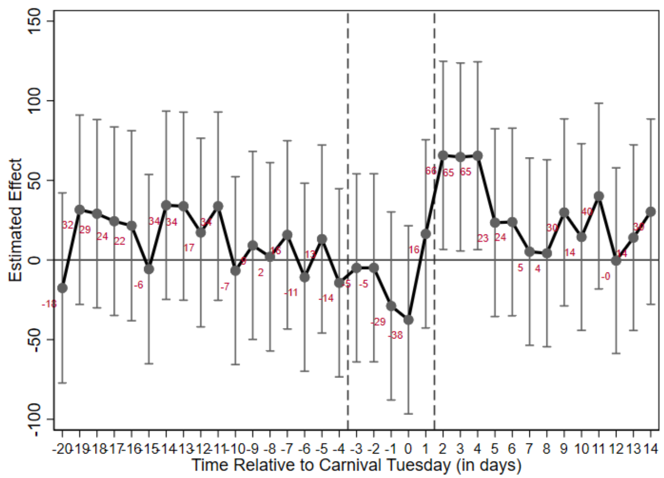
As for spontaneous vaginal deliveries, the pattern is different, since there is technically no way to anticipate the natural labor process. Results presented in figure 2b show that there is no missing mass of spontaneous vaginal births during carnival festivity days, nor there is an excess mass of spontaneous vaginal births on days that precede carnival festivities. However, we note a significant excess mass of this delivery type on the Thursday (day 2), Friday (day 3), and Saturday (day 4) right after Ash Wednesday. These findings suggest that some of the mothers whose births would otherwise be scheduled to earlier days within the carnival window, as either c-sections or induced vaginal deliveries, end up waiting longer, going into natural labor, and having a vaginal delivery.

While spontaneous vaginal deliveries do not allow for timing manipulation, induced vaginal deliveries do. Unlike c-sections, however, induced labor processes do not allow one to choose the exact time of birth, which explains why this delivery type is not preferred by those willing to have a fine control of birth timing. In line with these arguments, results presented in figure 2c show that there is only a small missing mass of induced vaginal deliveries on carnival festivity days, yet only significant on carnival Tuesday. During the whole period of festivities, only 106 births have their timing manipulated via induced labor, which make only 2% of the total number of displaced deliveries.

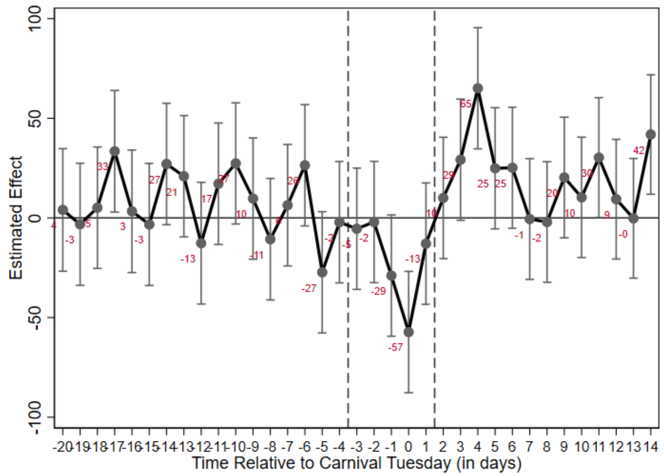
We note also a small excess mass of induced vaginal deliveries on the days that succeed carnival festivities, especially on the Saturday after Ash Wednesday (day 4). It is not clear, however, that this excess mass of induced births is made of induced vaginal deliveries that would otherwise happen during the carnival days. It could be, for instance, that induced births that would be scheduled to carnival festivity days are anticipated via c-sections and the excess mass of induced deliveries compensate for some of the c-sections that would otherwise happen during festivity days.



(a) Number of c-sections



(b) Number of spontaneous vaginal deliveries

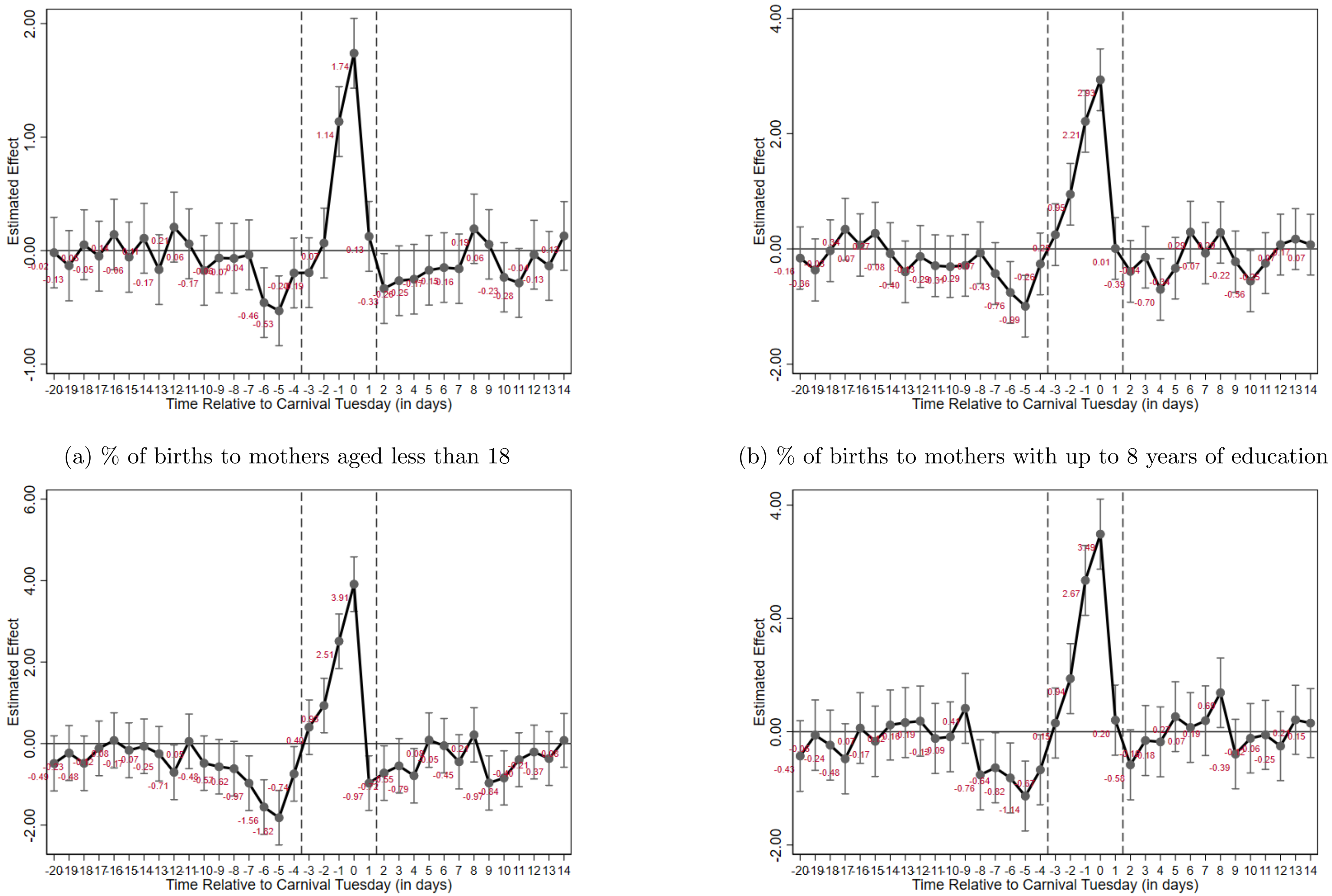


(c) Number of induced vaginal deliveries

Figure 2: Patterns of delivery types

Notes. This figure shows plots of estimates for β_j's of equation 3 and corresponding 95-percent confidence intervals. Outcome variables are specified below each subfigure. Vertical dashed lines indicate the carnival festivity period, which starts on the Saturday that precedes carnival Tuesday (day 0) and ends on the Wednesday that succeeds it, the Ash Wednesday. The sample comprises all live births that happened within the period of 34 days before carnival Tuesday up to 301 days after it, in years 2012-2019.

In continuing to describe the dynamics of birth displacement around carnival festivities, we now describe the profile of displaced births around the carnival Tuesday. We focus on the share of births to mothers of the following characteristics: young (aged less than 18), poorly educated (with up to 8 years of education), non-white (black, brown, indigenous, or Asian), and with no partner (single, divorced, or widowed). Results, presented in figure 3, show that on days that precede (succeed) carnival festivities, the percentage of births to young, poorly educated, non-white and without-a-partner mothers is lower than on counterfactual days, controlling for day-of-week, day-of-year, and year effects. In contrast, on festivity days, the percentage of births to young, poorly educated, non-white and without-a-partner mothers is higher. Clearly, these results suggest that the more educated, less vulnerable, mothers are those (disproportionately) engaged in birth anticipation and postponement.



(a) % of births to mothers aged less than 18

(b) % of births to mothers with up to 8 years of education

(c) % of births to non-white mothers

(d) % of births to mothers with no partner

Figure 3: Patterns of maternal characteristics

Notes. This figure shows plots of estimates for β_j's of equation 3 and corresponding 95-percent confidence intervals. Outcome variables are specified below each subfigure. Vertical dashed lines indicate the carnival festivity period, which starts on the Saturday that precedes carnival Tuesday (day 0) and ends on the Wednesday that succeeds it, the Ash Wednesday. The sample comprises all live births that happened within the period of 34 days before carnival Tuesday up to 301 days after it, in years 2012-2019.

Given the patterns of birth timing and delivery methods during carnival festivities observed, it is natural for one to expect that a given pattern of gestational length should follow. Figure 4 presents the patterns of gestational length around carnival.

Results show that gestational length is lower (higher) on days that precede (succeed) carnival festivities. In particular, on the Tuesday, Wednesday, and Thursday before carnival (days -3, -4, and -5), gestational length is 0.15, 0.13, and 0.26 day lower, giving implied IV estimates of 2.6, 4.2, and 3.9 days less of a gestational period, respectively.[20] Therefore, results suggest that marginal births that happened on Tuesday (day -7) were supposed to happen on Thursday or Friday (day -5 or -4); marginal births that happened on Wednesday (day -6) were supposed to happen on Sunday (day -3); and marginal births that happened on Thursday (day -5) were supposed to happen on Monday (day -1). Hence, a domino pattern seems reasonable to consider.

On days after carnival Tuesday, a higher gestational length is observed, starting from Ash Wednesday. On Ash Wednesday (day 1) and the Thursday, Friday, and Saturday that succeed it (days 2, 3, and 4), daily average gestational length is higher by 0.21, 0.23, 0.48, and 0.40 day. These coefficients translate into implied IV estimates of 2.9, 4.5, 7.5, and 8.5 days, suggesting that it was actually some of the births that would have happened during festivity days that were postponed. We emphasize that, while (roughly) one half of the displaced births was anticipated by 3-4 days, the other half was postponed by 3-8 days. That is, while birth anticipation decreased gestational age by about half a week, birth postponement could have, in some cases, increased gestational age by a whole week.

5.2 Main Results

We now look at carnival effects estimated through regression equation 2. Estimated effects on gestational length and health outcomes at birth, presented in table 2, reveal that the increase in gestational length associated with birth postponement prevails over the decrease associated with birth anticipation. In net terms, carnival increases gestational age by 0.06 day, on average, which yields an implied IV estimate of 3.41 more days of gestation for the displaced births. Although the estimated net carnival effect on birthweight is non-significant, it is positive and it gives an implied IV estimate of 60 more grams for the marginal births. Importantly, carnival has a negative and significant effect on neonatal death rate and early neonatal death rate of a 0.30 and 0.26 magnitude, resulting in strikingly high implied IV estimates of 17.51 and 15.23 less deaths per 1,000 live births, respectively.

[20] To obtain the implied IV estimate for each day, we divide the estimated coefficient by the fraction of displaced births on each specific day, presented in table B.1.

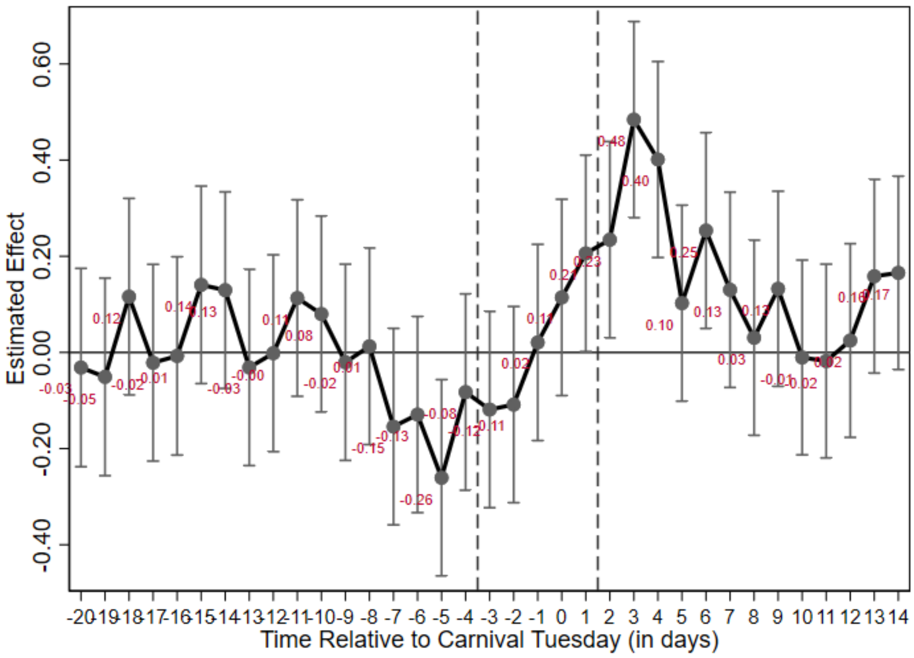


Figure 4: Patterns of gestational length

Notes. This figure shows plots of estimates for β_j's of equation 3 and corresponding 95-percent confidence intervals, using gestational length (in days) as the outcome variable. Vertical dashed lines indicate the carnival festivity period, which starts on the Saturday that precedes carnival Tuesday (day 0) and ends on the Wednesday that succeeds it, the Ash Wednesday. The sample comprises all live births that happened within the period of 34 days before carnival Tuesday up to 301 days after it, in years 2012-2019.

	(1) Gestational length (days)	(2) Birthweight (grams)	(3) Neonatal death rate	(4) Early neonatal death rate
Carnival window	0.06*	1.02	-0.30**	-0.26**
	(0.06)	(0.25)	(0.02)	(0.02)
Daily mean	269.35	3,183.07	8.83	6.68
Fraction displaced	0.017	0.017	0.017	0.017
Implied IV estimate	3.41	60.09	-17.51	-15.23
Obs.	2,684	2,684	2,684	2,684

Table 2: Carnival effects on gestational length, birthweight, and neonatal mortality

Notes. This table presents results of least squares estimation of equation 2. P-values are presented in parentheses, underneath β estimates. The sample comprises all live births that happened within the period of 34 days before carnival Tuesday up to 301 days after it, in years 2012-2019. *Significant at the 10% level. **Significant at the 5% level. ***Significant at the 1% level.

To improve the credibility of our analysis, we check whether estimated effects are contaminated by selection bias, by estimating the carnival effects on the number of births to mothers of certain characteristics. Results, presented in table 3, point to no significant net change in the number of births to mothers aged less than 18, aged more than 35, with up to 8 years of education, nor to those with no partner. Overall, our evidence is convincing that the estimated carnival effects are not driven by selection bias.

	(1) Mothers aged <18	(2) Mothers aged >35	(3) Non-white mothers	(4) Mothers w/ ≤8 yrs of educ.	(5) Mothers w/ no partner
Carnival window	-1.22	2.67	-0.57	0.51	12.04
	(0.73)	(0.69)	(0.98)	(0.95)	(0.38)
Daily mean	686.31	840.57	4,841.95	1,731.22	3,485.5
Obs.	2,684	2,684	2,684	2,684	2,684

Table 3: Selection tests: Carnival effects and mothers' characteristics

Notes. This table presents results of least squares estimation of equation 2. P-values are presented in parentheses, underneath β estimates. The sample comprises all live births that happened within the period of 34 days before carnival Tuesday up to 301 days after it, in years 2012-2019. *Significant at the 10% level. **Significant at the 5% level. ***Significant at the 1% level.

Finally, we try to disentangle mechanisms by estimating carnival effects on the number of births by the different delivery methods. Results, presented in table 4, show that carnival has a significant net positive effect on the number of spontaneous and induced vaginal deliveries, by 15.89 and 9.47 births per day respectively. These effects suggest that at least some of the surgical births that would happen in the absence of carnival end up being vaginal deliveries. Furthermore, most of them end up being of the spontaneous kind, corroborating with the story that some mothers end up waiting longer, going into natural labor, and switching away from c-sections.

	(1) Total births	(2) C-sections	(3) Spontaneous Vag. Deliveries	(4) Induced Vag. Deliveries
Carnival window	17.26	-6.36	15.89*	9.47**
	(0.65)	(0.85)	(0.07)	(0.04)
Daily mean	8,037.13	4,503.23	2,381.59	963.29
Obs.	2,684	2,684	2,684	2,684

Table 4: Mechanisms: Carnival effects on the number of births by delivery type

Notes. This table presents results of least squares estimation of equation 2. P-values are presented in parentheses, underneath β estimates. The sample comprises all live births that happened within the period of 34 days before carnival Tuesday up to 301 days after it, in years 2012-2019. *Significant at the 10% level. **Significant at the 5% level. ***Significant at the 1% level.

6 Heterogeneity Analysis

We now focus on the understanding of where these carnival effects are concentrated. Do these findings apply to all three – private, public, and mixed – types of health units? Do they apply to all types of mothers or are they concentrated in an specific profile? By answering these questions we can provide a hint on how to more assertively design birth care policies.

6.1 Maternal Race

We start by looking at heterogeneity in carnival effects by maternal race. In table 5, we present carnival effects on gestational length and birthweight for white and non-white mothers separately. We find that carnival festivities increase gestational length by 0.09 day and increases birthweight by 2.55 grams for babies of white mothers, which give us implied IV estimates of 3.99 days and 116.06 grams, respectively. No significant effects are observed for births to non-white mothers.[21]

As for the number of births by delivery method, significant effects are also observed only for births to white mothers. Results, presented in table 6, show that, for births to white mothers, carnival increases the number of both spontaneous and induced vaginal deliveries, with the increase in spontaneous vaginal deliveries being doubled the size of the increase in the induced ones.

[21] Please, recall that our data does not allow us to perfectly match DATASUS/SIM entries with DATASUS/SINASC entries, limiting our ability to accurately estimate heterogeneous effects on (early) neonatal death rates.

	(1) Gestational length (days)	(2) Birthweight (grams)
White: Carnival window	0.09**	2.55*
	(0.04)	(0.07)
Daily mean	268.27	3,169.33
Fraction displaced	0.022	0.022
Implied IV estimate	3.99	116.06
Non-white: Carnival window	0.05	0.08
	(0.18)	0.94)
Daily mean	269.89	3,190.81
Fraction displaced	0.014	0.014
Implied IV estimate	3.39	5.96
Obs.	2,684	2,684

Table 5: Carnival effects on gestational length and birthweight for each maternal race type

Notes. This table presents results of least squares estimation of equation 2. P-values are presented in parentheses, underneath β estimates. The sample comprises all live births that happened within the period of 34 days before carnival Tuesday up to 301 days after it, in years 2012-2019. *Significant at the 10% level. **Significant at the 5% level. ***Significant at the 1% level.

	(1) Total births	(2) C-sections	(3) Spontaneous Vag. Deliveries	(4) Induced Vag. Deliveries
White: Carnival window	30.03	11.36	11.67***	6.41***
	(0.12)	(0.53)	(0.00)	(0.01)
Daily mean	2,818.04	1,885.91	568.92	334.83
Non-white: Carnival window	-0.57	-9.73	7.73	2.56
	(0.98)	(0.54)	(0.27)	(0.46)
Daily mean	4,841.95	2,405.45	1,728.44	602.39
Obs.	2,684	2,684	2,684	2,684

Table 6: Mechanisms: Carnival effects on the number of births by delivery type for each maternal race type

Notes. This table presents results of least squares estimation of equation 2. P-values are presented in parentheses, underneath β estimates. The sample comprises all live births that happened within the period of 34 days before carnival Tuesday up to 301 days after it, in years 2012-2019. *Significant at the 10% level. **Significant at the 5% level. ***Significant at the 1% level.

6.2 Health Unit Type

We now look at heterogeneity with regards to health unit type. In figure C.1, we present the dynamics of birth displacement by health unit type. By looking at figures C.1a and C.1c, we note that the pattern of birth displacement in private and mixed units is very similar to that observed for all health unit types combined, with an expressive missing mass of births during carnival festivities and excess masses on days that precede and succeed the holiday. Figure C.1b reveals, however, that, in public units, no significant excess mass of births before carnival festivities is observed, suggesting that only birth postponement is present in these units.

We recognize, nonetheless, that births that would otherwise happen in public units during carnival festivities may have been anticipated in other health unit types. Or, really, that any birth that would originally happen in a given unit type, because of the holiday, may have moved to units of other types. To test whether this is the case, we estimate net carnival effects on the number of births that happened in each health unit type. Results, presented in table C.1, show no significant effects, suggesting that no meaningful change in the participation of the different health unit types is observed due to carnival.

Since no evidence of births happening in different unit types due to carnival is observed, we look at net effects on gestational length, birthweight, and the different delivery methods separately for each type of unit. In table C.2, we show carnival effects on gestational age and birthweight by each health unit type. We note a significant increase in gestational length only in mixed units. Implied IV estimates suggest that displaced births experience a net increase in gestational length of 4.95 days in these units.

When we look at the estimated effects on the number of births by each delivery method, so to learn about mechanisms, presented in table C.3, we note that there is a significant increase in the number of spontaneous vaginal deliveries in mixed health units and no significant effects are observed for births that happen in private or public units.

Overall, we note that carnival effects are mainly concentrated in births to white mothers and those that happen in mixed health units. Since mixed units serve both the private and the public sectors, we cannot affirm precisely in which sector carnival effects are being experienced.

6.3 Births to White Mothers in Mixed Hospitals

Finally, to provide extra confidence in our findings that effects are concentrated in births to white mothers that happen in mixed units, we restrict our sample to them and re-estimate the net effects of interest. Results are presented in tables C.4 and C.5. We confirm that, for this group of births, the holiday increases gestational length and birthweight by about 4 days and 112 grams (according to our implied IV estimates) for the marginal displaced births. Additionally, carnival results in an increase in vaginal deliveries, especially in the spontaneous ones.

7 Robustness Checks

To assess the robustness of our main results, we perform a test which consists in using an alternative set of counterfactual days, one made up of days closer to the carnival window, inspired by the empirical strategy used by Jacobson et al. (2021), who argue that good counterfactual days are those not affected by the holiday, but close to the manipulation window.[22] Instead of including in the sample all live births that happened within the period of 34 days before up to 301 days after carnival Tuesday (a total of 48 full weeks), we now include only the births that happened within the period of 34 days before up to 35 days after (a total of 10 full weeks). Results are presented in appendix section D.

After careful examination of results, one should note that our main conclusions are robust to these tests, as they reveal that using an alternative holiday manipulation window and an alternative set of counterfactual days still give that: [i] there exists birth timing manipulation, in the form of both anticipation and postponement, around carnival festivity days; [ii] timing manipulation is mainly driven by c-sections; [iii] birth postponement leads some mothers (that would otherwise schedule a c-section) to wait longer, go into spontaneous labor, and end up having a vaginal delivery; [iv] gestational length and birthweight are lower (higher) before (after) carnival festivities, and (early) neonatal mortality rates are lower on days that succeed festivities; [v] carnival has a positive net effect on gestational age and birthweight, and a negative net effect on (early) neonatal mortality; and [vi] the more educated, less vulnerable, mothers are disproportionately engaged in birth timing manipulation, yet evidence goes against selection bias confounding our main carnival effect results.

8 Concluding Remarks

Birth timing manipulation for non-medical reasons can be problematic as it may configure obstetric violence and have negative consequences to maternal and infant health. The identification and documentation of the dynamics and consequences of birth timing manipulation, therefore, is critical for the improvement of birth care quality around the world.

[22] It is worth noting that, although we take this argument seriously and check whether our results are robust to this idea, because our empirical strategy allows us to control for day-of-year effects, choosing days closer to the optimal holiday window to serve as counterfactuals should not improve our estimates in terms of selection bias. Furthermore, we argue that including all other days of the year in our sample is superior, for it yields superior power.

In this paper, we study the dynamics and consequences of birth timing manipulation around carnival festivities in Brazil. In the first part of our empirical analysis, we run descriptive exercises to evaluate the dynamics of birth displacement in the neighborhood of carnival festivity days; that is, we look at average holiday effects on each day within a neighborhood around carnival Tuesday. This strategy allows us to examine how births are displaced around the holiday, patterns of delivery methods adopted, the profile of mothers engaged in birth timing manipulation, and the behavior of gestational length on the days that surround carnival Tuesday. We document the existence of birth timing manipulation in the form of both anticipation and postponement, mostly performed through c-sections.

In what concerns selection with regards to maternal profile, we find that less vulnerable mothers (more educated, white, with a partner, and/or aged over 18) are more likely to be involved in birth timing manipulation, concentrating their deliveries on days that either precede or succeed the holiday. Results also show that daily average gestational length significantly drops on weekdays before the holiday and significantly increases on the week after the holiday.

In a second moment, we focus our empirical analysis on carnival effects net of selection in the profile of mothers. We compare daily average outcomes within a window around carnival Tuesday with daily average outcomes within a counterfactual window. Our main results show that carnival increases gestational length and decreases neonatal mortality significantly. With regards to mechanisms, carnival increases the daily number of vaginal deliveries, indicating that some births that would otherwise happen via c-sections during carnival end up being postponed and becoming spontaneous deliveries.

We argue that, although there is a higher volume of anticipated births compared to postponed births within the holiday window, the effects of birth postponement and the consequent increased gestational length are powerful enough to reduce neonatal mortality. In fact, we interpret our main results as confirmatory evidence of birth postponement being the driver of a lower neonatal mortality. Given that the literature shows that neonatal mortality and gestational length have a non-linear, U-shaped, relationship, in which mortality falls up to a 40 week gestational length point and increases after then (Butler and Alberman, 1969; Susser et al., 1972; Hoffman et al., 1974; Goldstein and Peckham, 1976), these results indicate that the usual practice in Brazil is to perform birth deliveries at a sub-optimal gestational length point. That is, neonatal mortality rates could be improved if gestational length were increased – even by a small amount – in both the private and the public health systems.

Besides shedding light on the country's potential to reduce neonatal mortality – perhaps by the waiting a little longer to schedule birth or go into spontaneous labor –, our work has yet another contribution to policy making. We show that there is a double-sided aspect of selection in maternal profile that should be addressed. While the more educated mothers are more likely to engage in birth anticipation and have their babies suffer from lower gestational length and birthweight, they are also more likely to engage in postponement and have their babies enjoy higher gestational length and birthweight, as well as lower chance of neonatal death. More vulnerable mothers, however, have a higher likelihood of delivering in less prepared hospitals during the holiday – which may increase risks of yet other complications.

Overall, we note that the displacement of births around carnival can have both negative and positive consequences, depending on the nature of timing manipulation, the type of hospital, and the profile of mothers involved. We emphasize the need for policymakers to address the different aspects of the displacement dynamics so to improve birth care.

In conclusion, our work contributes to the economics literature on the study of birth timing manipulation, especially in what concerns the effects of holidays, by providing new evidence on the dynamics of birth displacement and its consequences for the health of babies in a new context. In addition, our work has a more practical contribution, by informing policy making in health.

References

D. Almond, K. Chay, and D. Lee. The costs of low birth weight. *The Quarterly Journal of Economics*, 120:1031–1083, Aug 2005.

American College of Obstetricians and Gynecologists. Definition of term pregnancy. *Obstet Gynecol*, 122:1139–1140, 2013. Committee Opinion No. 579.

S. E. Black, P. J. Devereux, and K. G. Salvanes. From the cradle to the labor market? the effect of birth weight on adult outcomes. *The Quarterly Journal of Economics*, 122 (1):409–439, 2007. doi: 10.1162/qjec.122.1.409.

C. Borra, L. Gonzalez, and A. Sevilla. Birth Timing and Neonatal Health. *American Economic Review: Papers & Proceedings*, (106):329–332, 2016.

C. Borra, L. Gonzalez, and A. Sevilla. The Impact of Scheduling Birth Early on Infant Health. *Journal of the European Economic Association*, (17):30–78, 2019. doi: 0.1093/jeea/jvx060.

H. S. Brown-III. Physician Demand for Leisure: Implications for Cesarean Section Rates. *Journal of Health Economics*, (145):223–242, 1996.

N. R. Butler and E. D. Alberman. In *Perinatal Problems*. E. & S. Livingston, Edinburgh and London, 1969.

B. Carrillo and J. G. Feres. Low Birth Weight and Infant Mortality: Lessons from Brazil. Working paper, 2017.

A. Cohen. Seasonal Daily Effect on the Number of Births in Israel. *Journal of the Royal Statistical Society - Series C (Applied Statistics)*, (32):228–235, 1983.

T. S. Dee, W. Dobbie, B. A. Jacob, and J. Rockoff. The Causes and Consequences of Test Score Manipulation: Evidence from the New York Regents Examinations. *American Economic Journal: Applied Economics*, 11(3), 2019. doi: 10.1257/app.20170520.

R. Diamond and P. Persson. The long-term consequences of teacher discretion in grading of high-stakes tests. *NBER Working Paper*, (22207), 2017.

M. Dias, R. M. Domingues, A. P. Pereira, S. Fonseca, S. Gama, M. Theme-Filha, S. Bittencourt, P. M. Rocha, A. Schilithz, and M. d. C. Leat. Trajetória das mulheres na definição pelo parto cesáreo: estudo de caso em duas unidades do sistema de saúde suplementar do estado do rio de janeiro. *Ciência e Saúde Coletiva*, 15:1521–1534, 2008. doi: 10.1590/S1413-81232008000500017.

S. Dickert-Conlin and A. Chandra. Taxes and the timing of births. *Journal of Political Economy*, 107(1):161–177, 1999.

D. Fabbri, I. Chiara & Castaldini, C. Monfardini, and A. Protonotari. Caesarean section and the manipulation of exact delivery time. *Health Policy*, 120:780–789, 2016. doi: 10.1016/j.healthpol.2016.05.001.

J. S. Gans and A. Leigh. Born on the first of July: An (un)natural experiment in birth timing. *Journal of Public Economics*, (93):246–263, 2009.

J. S. Gans and A. Leigh. Bargaining over labor: Do patients have any power? *Economic Record*, 88(281):182–194, 2012.

J. S. Gans, A. Leigh, and E. Varganova. Minding the shop: the case of obstetrics conferences. *Social Science and Medicine*, 6(7):1458–1465, 2007.

H. Goldstein and C. Peckham. Birthweight, gestation, neonatal mortality and child development. In D. F. Roberts and A. M. Thomson, editors, *The biology of human fetal growth*, pages 81–102. Taylor and Francis, London, 1976.

H. J. Hoffman, C. R. Stark, and F. E. Lundin. Analysis of birth weight, gestational age, and fetal viability, u. s. births, 1968. *Obstetrical amp; Gynecological Survey*, 29(9):651, 1974. doi: 10.1097/00006254-197409000-00029.

M. Jacobson, M. Kogelnik, and H. Royer. Holiday, Just One Day out of Life: Birth Timing and Postnatal Outcomes. *Journal of Labor Economics*, 39(S2), April 2021. doi: 10.1086/712493.

H. J. Kleven. Bunching. *Annual Review of Economics*, (8), 2016.

M. d. Leal, A. P. Pereira, R. M. Domingues, M. M. Filha, M. A. Dias, M. Nakamura-Pereira, M. H. Bastos, and S. G. Gama. Intervenções obstétricas durante o trabalho de parto e parto em mulheres brasileiras de risco habitual. *Cadernos de Saúde Pública*, 30(suppl 1). doi: 10.1590/0102-311x00151513.

M. Lefevre. Physician Induced Demand for C-Sections: Does the Convenience Incentive Matter? August 2013. doi: 10.2139/ssrn.2310646.

J. C. Lo. Patients' attitudes vs. Physicians' determination: implications for cesarean sections. *Social Science and Medicine*, 57:91–96, 2003.

M. Magalhaes, C. Melo, N. Menezes Filho, and B. Komatsu. Os Determinantes da Realização de Cesáreas no Brasil. *Insper Centro de Políticas Públicas - Policy Paper*, (41), 2019. URL https://www.insper.edu.br/wp-content/uploads/2019/08/Policy-Paper-41-Ces%C3%A1reas.pdf.

P. Martin, M. Cortina-Borja, M. Newburn, G. Harper, R. Gibson, M. Dodwell, N. Dattani, and A. Macfarlane. Timing of singleton births by onset of labour and mode of birth in nhs maternity units in england, 2005–2014: A study of linked birth registration, birth notification, and hospital episode data. *PLOS ONE*, 13(6), 2018. doi: 10.1371/journal.pone.0198183.

Ministry of Health. Indicadores de mortalidade. URL http://tabnet.datasus.gov.br/cgi/idb2000/mort.htm.

Ministério da Economia. Carnaval não é feriado nacional, Mar 2019. URL https://www.gov.br/economia/pt-br/assuntos/noticias/2019/03/carnaval-nao-e-feriado-nacional.

Ministério da Saúde (Brasil). Parto, Aborto e Puerpério: Assitência Humanizada à Mulher. *Ministério da Saúde*, 2001. URL http://bvsms.saude.gov.br/bvs/publicacoes/cd04_13.pdf.

Ministério da Saúde (Brasil). Cadernos HumanizaSUS, Volume 4: Humanização do parto e do nascimento. 2014. URL https://www.redehumanizasus.net/sites/default/files/caderno_humanizasus_v4_humanizacao_parto.pdf.

Ministério da Saúde (Brasil). Diretrizes de Atenção à Gestante: a operação cesariana. 2015. URL http://conitec.gov.br/images/Relatorios/2016/Relatorio_Diretrizes-Cesariana_final.pdf.

M. Neugart and H. Ohlsson. Economic incentives and the timing of births: evidence from the German parental benefit reform of 2007. *Journal of Population Economics*, 26(1):87–108, 2012. doi: 10.1007/s00148-012-0420-1.

P. Oreopoulos, M. Stabile, R. Walld, and L. L. Roos. Short-, medium-, and long-term consequences of poor infant health: An analysis using siblings and twins. *Journal of Human Resources*, 43(1):88–138, 2008. doi: 10.1353/jhr.2008.0003.

D. Pasche, M. Vilela, and C. Martins. Humanização da atenção ao parto e nascimento no brasil: pressuposto para uma nova ética na gestão e no cuidado. *Revista Tempus Actas Saúde Coletiva*, 4:105–117, 2010. doi: 10.18569/tempus.v4i4.838.

R. Rocha and P. Spinola. Convenience Effect on Birth Timing Manipulation: Evidence from Brazil. *Master's Thesis at UFRJ*, 2016.

L. Schulkind and T. M. Shapiro. What a difference a day makes: quantifying the effects of birth timing manipulation on infant health. *Journal of Health Economics*, 33:139–158, 2014.

J. Spetz, M. W. Smith, and S. F. Ennis. Physician Incentives and the Timing of Cesarean Sections: Evidence from California. *Medical Care*, (39):536–550, 2001.

C. Spong. Defining "term" pregnancy: recommendations from the Defining "Term" Pregnancy Workgroup. *JAMA*, 309(23), June 2013. doi: 10.1001/jama.2013.6235.

M. Susser, F. A. Marolla, and J. Fleiss. Birth weight, fetal age and perinatal mortality1. *American Journal of Epidemiology*, 96(3):197–204, 1972. doi: 10.1093/oxfordjournals.aje.a121448.

M. C. Westphal and C. B. Joshi. The interrelationship of birth weight, length of gestation, and neonatal mortality. *Clinical Obstetrics and Gynecology*, 7(1-3):670–656, 1964. doi: 10.1097/00003081-196409000-00005.

G. L. Zanardo, M. C. Uribe, A. H. Nadal, and L. F. Habigzang. Violência Obstétrica no Brasil: Uma Revisão Narrativa. *Psicologia e Sociedade*, 29, 2017. doi: 10.1590/1807-0310/2017v29155043.

A Empirical Strategy: Optimal Carnival Manipulation Window

Days before Carnival Tuesday	Days after Carnival Tuesday																
	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
4	-4075	-4138	-4142	-4175	-4419	-4218	-3819	-3621	-3686	-3717	-3768	-3984	-3660	-3235	-3180	-3283	-3691
5	-3377	-3438	-3413	-3413	-3654	-3429	-2972	-2720	-2780	-2805	-2811	-2986	-2589	-2147	-2047	-2107	-2501
6	-2873	-2916	-2865	-2862	-3095	-2831	-2320	-2063	-2118	-2110	-2077	-2222	-1811	-1321	-1183	-1229	-1616
7	-2574	-2605	-2551	-2540	-2769	-2475	-1959	-1697	-1736	-1706	-1650	-1791	-1348	-818	-668	-708	-1092
8	-2418	-2448	-2389	-2370	-2602	-2305	-1784	-1499	-1529	-1487	-1427	-1565	-1094	-550	-394	-429	-818
9	-2406	-2436	-2374	-2353	-2586	-2287	-1738	-1435	-1463	-1419	-1354	-1494	-1014	-461	-300	-332	-726
10	-2364	-2394	-2326	-2305	-2539	-2222	-1638	-1313	-1340	-1290	-1216	-1357	-867	-300	-124	-153	-550
11	-2022	-2036	-1966	-1942	-2169	-1813	-1175	-841	-851	-778	-694	-829	-318	303	491	470	78
12	-1893	-1907	-1836	-1803	-2036	-1653	-1006	-652	-654	-577	-488	-622	-77	558	752	736	341
13	-1909	-1922	-1848	-1814	-2060	-1674	-1001	-632	-634	-556	-465	-604	-50	594	793	778	378
14	-1892	-1906	-1826	-1790	-2038	-1636	-933	-557	-558	-475	-377	-517	47	706	912	898	494
15	-2039	-2061	-1985	-1951	-2215	-1803	-1091	-710	-715	-636	-538	-682	-110	561	768	752	322
16	-2163	-2194	-2118	-2087	-2370	-1952	-1230	-845	-855	-777	-680	-830	-248	431	639	616	173
17	-1985	-2014	-1928	-1888	-2172	-1744	-1002	-586	-593	-510	-405	-553	42	733	966	950	505
18	-1636	-1652	-1547	-1499	-1782	-1336	-538	-106	-105	-10	108	-35	574	1323	1575	1566	1123
19	-1629	-1645	-1539	-1490	-1779	-1310	-495	-56	-54	44	166	21	664	1434	1690	1683	1231
20	-1787	-1806	-1700	-1654	-1967	-1491	-665	-218	-220	-122	**-1**	-160	495	1275	1533	1522	1057

Table A.1: Sum of missing/excess mas (sum of β_j's) for different windows around carnival Tuesday

Notes. This table presents results regarding the analysis of the optimal carnival holiday window. Each row of the table corresponds to a number of days before carnival Tuesday and each column corresponds to a number of days after carnival Tuesday. Each cell presents the sum of the β_j's, obtained from estimations of regression equation 1. The result in bold corresponds to the sum that presents the lowest value (in absolute terms), which reveals the optimal window – the one that goes from $d = -20$ up to $d = 14$. The sample comprises all live births that happened within the period of 34 days before carnival Tuesday up to 301 days after it, in years 2012-2019.

B Results

B.1 Quantification of Birth Displacement

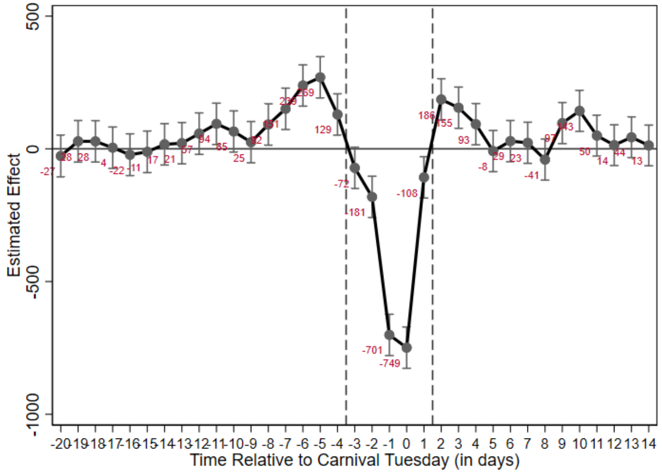
	(1) Number of displaced births	(2) p-value	(3) Total births	(4) Fraction displaced
Day -20 (Wed)	-58	(0.60)	8,739	0.007
Day -19 (Thu)	27	(0.81)	8,651	0.003
Day -18 (Fri)	178	(0.11)	8,552	0.021
Day -17 (Sat)	130	(0.24)	7,008	0.019
Day -16 (Sun)	-72	(0.52)	6,108	0.012
Day -15 (Mon)	-49	(0.66)	9,045	0.005
Day -14 (Tue)	75	(0.50)	8,876	0.008
Day -13 (Wed)	34	(0.76)	8,822	0.004
Day -12 (Thu)	106	(0.34)	8,792	0.012
Day -11 (Fri)	236**	(0.03)	8,687	0.027
Day -10 (Sat)	110	(0.32)	7,116	0.015
Day -9 (Sun)	43	(0.70)	6,238	0.007
Day -8 (Mon)	152	(0.17)	9,355	0.016
Day -7 (Tue)	292**	(0.01)	9,332	0.031
Day -6 (Wed)	472***	(0.00)	9,416	0.050
Day -5 (Thu)	626***	(0.00)	9,468	0.066
Day -4 (Fri)	358***	(0.00)	8,899	0.040
Day -3 (Sat)	-141	(0.20)	7,038	0.020
Day -2 (Sun)	-277**	(0.01)	6,135	0.045
Day -1 (Mon)	-1,760***	(0.00)	7,611	0.231
Day 0 (Carnival Tue)	-2,295***	(0.00)	6823	0.336
Day 1 (Wed)	-610***	(0.00)	8,450	0.072
Day 2 (Thu)	478***	(0.00)	9,397	0.051
Day 3 (Fri)	598***	(0.00)	9,285	0.064
Day 4 (Sat)	359***	(0.00)	7,598	0.047
Day 5 (Sun)	22	(0.84)	6,498	0.003
Day 6 (Mon)	123	(0.26)	9,501	0.013
Day 7 (Tue)	67	(0.54)	9,203	0.007
Day 8 (Wed)	-104	(0.34)	9,014	0.012
Day 9 (Thu)	245**	(0.03)	9,227	0.027
Day 10 (Fri)	343***	(0.00)	9,040	0.038
Day 11 (Sat)	195*	(0.07)	7,479	0.026
Day 12 (Sun)	-15	(0.89)	6,482	0.002
Day 13 (Mon)	57	(0.60)	9,544	0.006
Day 14 (Tue)	61	(0.57)	9,247	0.007
R-squared	0.95			
N	2,684			
Missing mass during holiday	-5,084		290,673	0.017
Excess mass before holiday	2,661		290,673	0.009
Excess mass after holiday	2,429		290,673	0.008

Table B.1: Quantification of birth displacement

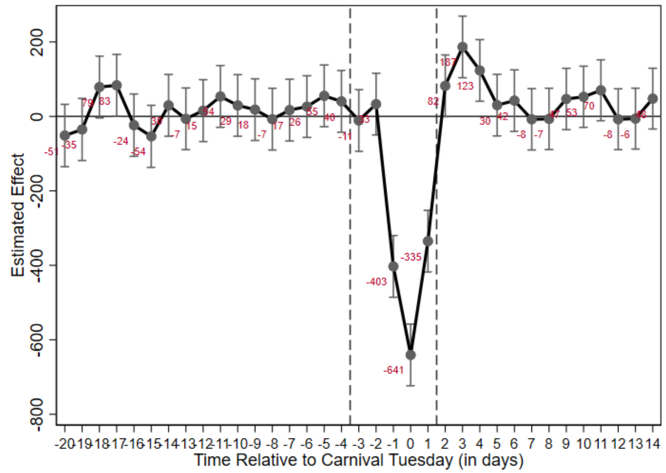
Notes. This table presents results of least squares estimation of equation 3. Columns (1) and (2) present the coefficients of interest and corresponding p-values, respectively. Column (3) presents the average total daily number of births for the corresponding day within the carnival window. And column (4) presents the fraction of displaced births, calculated as the ratio of the estimated number of displaced births to the average total daily number of births. The sample comprises all live births that happened within the period of 34 days before carnival Tuesday up to 301 days after it, in years 2012-2019. *Significant at the 10% level. **Significant at the 5% level. ***Significant at the 1% level.

C Heterogeneity Analysis

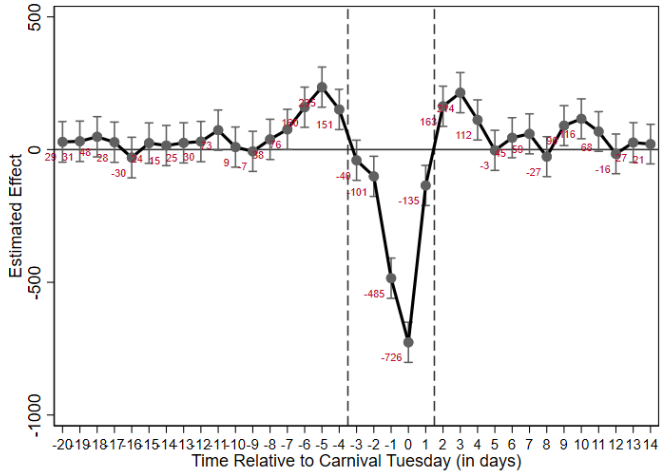
C.1 Health Unit Type



(a) Number of births in private health units



(b) Number of births in public health units



(c) Number of births in mixed health units

Figure C.1: Patterns of birth displacement by health unit type

Notes. This figure shows plots of estimates for β_j's of equation 3 and corresponding 95-percent confidence intervals. Outcome variables are specified below each subfigure. Vertical dashed lines indicate the carnival festivity period, which starts on the Saturday that precedes carnival Tuesday (day 0) and ends on the Wednesday that succeeds it, the Ash Wednesday. The sample comprises all live births that happened within the period of 34 days before carnival Tuesday up to 301 days after it, in years 2012-2019.

	(1) Private health units	(2) Public health units	(3) Mixed health units
Carnival window	8.74	-5.08	14.08
	(0.52)	(0.70)	(0.27)
Daily mean	1,307.25	4,133.18	2,202.57
Obs.	2,684	2,684	2,684

Table C.1: Carnival effects on the number of births for each health unit type

Notes. This table presents results of least squares estimation of equation 2. P-values are presented in parentheses, underneath β estimates. The sample comprises all live births that happened within the period of 34 days before carnival Tuesday up to 301 days after it, in years 2012-2019. *Significant at the 10% level. **Significant at the 5% level. ***Significant at the 1% level.

	(1) Gestational length (days)	(2) Birthweight (grams)
Private: Carnival window	0.02	-0.78
	(0.77)	(0.72)
Daily mean	266.82	3,156.74
Fraction displaced	0.038	0.038
Implied IV estimate	0.45	-20.44
Public: Carnival window	0.06	1.45
	(0.10)	(0.20)
Daily mean	270.19	3,191.71
Fraction displaced	0.009	0.009
Implied IV estimate	6.98	161.56
Mixed: Carnival window	0.09*	1.20
	(0.05)	(0.43)
Daily mean	269.49	3,186.55
Fraction displaced	0.018	0.018
Implied IV estimate	4.95	66.4
Obs.	2,684	2,684

Table C.2: Carnival effects on gestational length and birthweight

Notes. This table presents results of least squares estimation of equation 2. P-values are presented in parentheses, underneath β estimates. The sample comprises all live births that happened within the period of 34 days before carnival Tuesday up to 301 days after it, in years 2012-2019. *Significant at the 10% level. **Significant at the 5% level. ***Significant at the 1% level.

	(1) Total births	(2) C-sections	(3) Spontaneous Vag. Deliveries	(4) Induced Vag. Deliveries
Private: Carnival window	8.74	6.98	0.28	1.26
	(0.52)	(0.60)	(0.83)	(0.23)
Daily mean	1,307.25	1,132.45	102.07	65.96
Public: Carnival window	-5.08	-11.05	3.27	4.63
	(0.70)	(0.24)	(0.62)	(0.18)
Daily mean	4,133.18	1,774.52	1,648.21	588.61
Mixed: Carnival window	14.08	0.36	10.68***	3.54
	(0.27)	(0.97)	(0.00)	(0.13)
Daily mean	2,202.57	1,350.68	517.18	287.6
Obs.	2,684	2,684	2,684	2,684

Table C.3: Mechanisms: Carnival effects on the number of births by delivery type for each health unit type

Notes. This table presents results of least squares estimation of equation 2. P-values are presented in parentheses, underneath β estimates. The sample comprises all live births that happened within the period of 34 days before carnival Tuesday up to 301 days after it, in years 2012-2019. *Significant at the 10% level. **Significant at the 5% level. ***Significant at the 1% level.

C.2 Births to White Mothers in Mixed Hospitals

	(1) Gestational length (days)	(2) Birthweight (grams)
Carnival window	0.08	2.24
	(0.21)	(0.32)
Daily mean	268.56	3,172.05
Fraction displaced	0.020	0.020
Implied IV estimate	4.08	112.13
Obs.	2,684	2,684

Table C.4: Carnival effects on gestational length and birthweight for births to white mothers in mixed health units

Notes. This table presents results of least squares estimation of equation 2. P-values are presented in parentheses, underneath β estimates. The sample comprises all live births that happened within the period of 34 days before carnival Tuesday up to 301 days after it, in years 2012-2019. *Significant at the 10% level. **Significant at the 5% level. ***Significant at the 1% level.

	(1) Total births	(2) C-sections	(3) Spontaneous Vag. Deliveries	(4) Induced Vag. Deliveries
Carnival window	14.64*	6.45	5.79***	2.45*
	(0.06)	(0.35)	(0.00)	(0.08)
Daily mean	986.91	665.96	188.18	124.65
Obs.	2,684	2,684	2,684	2,684

Table C.5: Mechanisms: Carnival effects on the number of births by delivery type for births to white mothers in mixed health units

Notes. This table presents results of least squares estimation of equation 2. P-values are presented in parentheses, underneath β estimates. The sample comprises all live births that happened within the period of 34 days before carnival Tuesday up to 301 days after it, in years 2012-2019. *Significant at the 10% level. **Significant at the 5% level. ***Significant at the 1% level.

D Robustness Checks

D.1 Alternative Set of Counterfactual Days

D.1.1 Optimal Window

Days before Carnival Tuesday	Days after Carnival Tuesday																
	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
4	-4249	-4199	-4116	-4124	-4307	-4219	-3994	-3800	-3726	-3644	-3666	-3840	-3683	-3457	-3363	-3226	-3456
5	-3645	-3606	-3493	-3482	-3675	-3487	-3218	-3006	-2950	-2859	-2848	-3008	-2658	-2411	-2304	-2165	-2379
6	-3058	-2992	-2857	-2861	-2993	-2765	-2478	-2285	-2220	-2093	-2067	-2104	-1732	-1472	-1361	-1201	-1406
7	-2723	-2644	-2519	-2476	-2597	-2357	-2082	-1885	-1803	-1664	-1551	-1586	-1211	-947	-827	-669	-882
8	-2515	-2442	-2271	-2215	-2334	-2103	-1825	-1610	-1520	-1301	-1184	-1217	-838	-565	-447	-298	-469
9	-2426	-2331	-2147	-2088	-2206	-1973	-1680	-1457	-1320	-1099	-979	-1011	-624	-352	-239	**-13**	-182
10	-2404	-2303	-2116	-2058	-2177	-1934	-1633	-1358	-1219	-996	-876	-907	-519	-254	-95	138	-31
11	-2295	-2191	-2010	-1950	-2070	-1819	-1439	-1159	-1019	-794	-667	-698	-321	45	212	433	260
12	-2293	-2191	-2008	-1946	-2068	-1769	-1384	-1104	-963	-733	-605	-636	-165	210	370	582	409
13	-2177	-2073	-1877	-1811	-1931	-1628	-1242	-958	-812	-580	-457	-463	20	383	535	758	585
14	-2095	-1983	-1781	-1683	-1804	-1498	-1107	-819	-672	-446	-266	-272	190	543	702	921	747
15	-2175	-2063	-1836	-1737	-1858	-1551	-1155	-867	-722	-456	-274	-279	174	533	690	901	679
16	-2189	-2056	-1825	-1725	-1847	-1536	-1141	-858	-679	-409	-231	-236	225	580	729	1007	781
17	-2003	-1865	-1629	-1527	-1648	-1339	-954	-566	-380	-121	48	47	503	832	1090	1388	1157
18	-1945	-1805	-1568	-1464	-1585	-1282	-797	-400	-221	29	205	203	633	1088	1363	1643	1410
19	-2134	-1994	-1756	-1653	-1768	-1432	-942	-551	-373	-120	57	61	577	1044	1311	1579	1339
20	-2062	-1918	-1677	-1576	-1703	-1361	-884	-503	-319	-64	105	122	656	1104	1354	1632	1387

Table D.1: Sum of missing/excess mas (sum of β_j's) for different windows around carnival Tuesday

Notes. This table presents results regarding the analysis of the optimal carnival holiday window. Each row of the table corresponds to a number of days before carnival Tuesday and each column corresponds to a number of days after carnival Tuesday. Each cell presents the sum of the β_j's, obtained from estimations of regression equation 1. The result in bold corresponds to the sum that presents the lowest value (in absolute terms), which reveals the optimal window – the one that goes from $d = -9$ up to $d = 19$. The sample comprises all live births that happened within the period of 34 days before carnival Tuesday up to 35 days after it, in years 2012-2019.

D.1.2 Description of Birth Displacement Dynamics

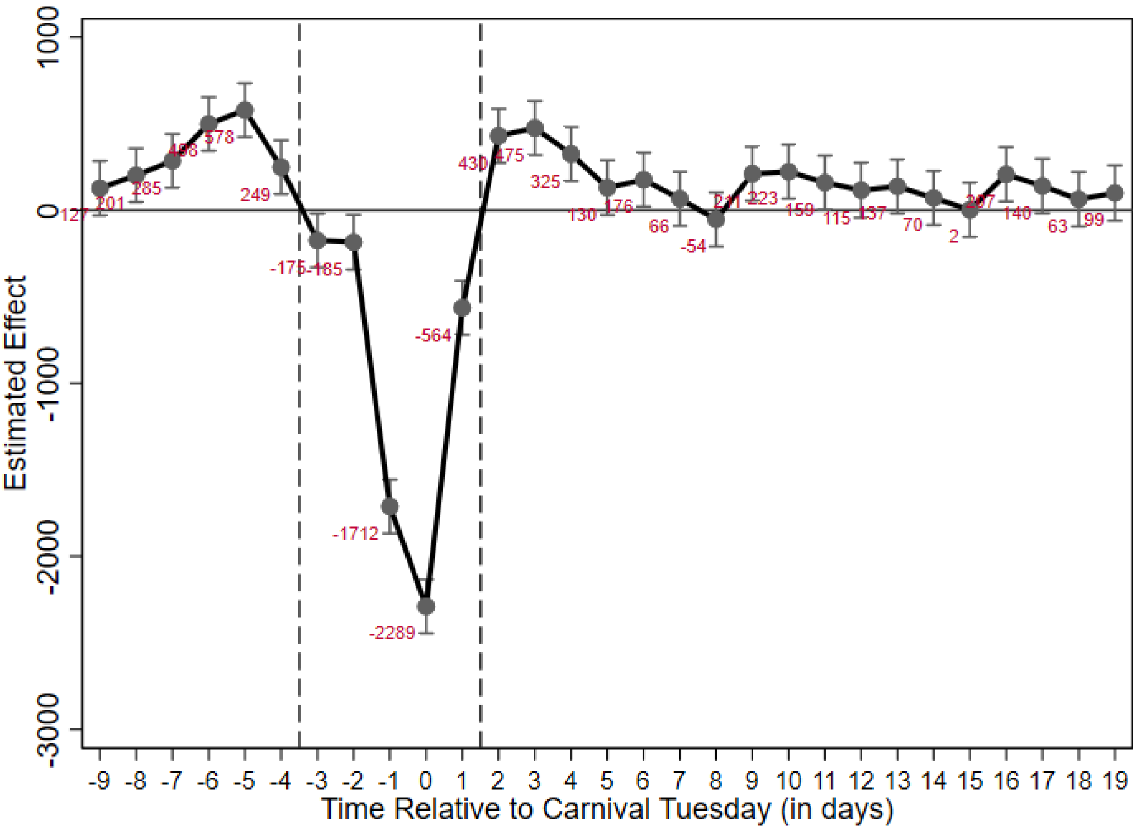


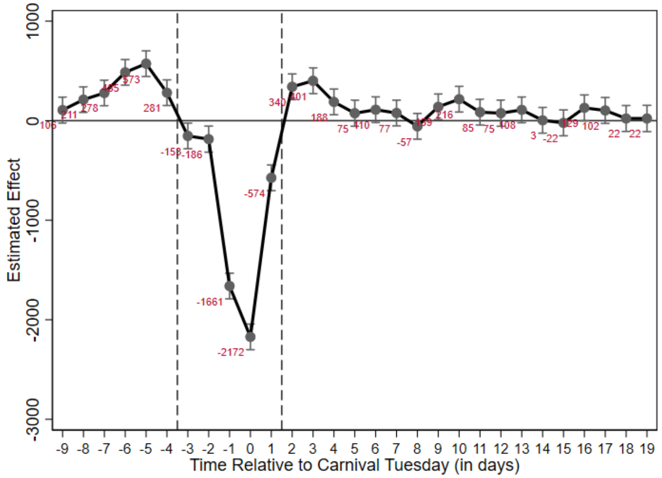
Figure D.1: Patterns of birth displacement

Notes. This figure shows plots of estimates for β_j's of equation 3 and corresponding 95-percent confidence intervals, using the total number of births as the outcome variable. Vertical dashed lines indicate the carnival festivity period, which starts on the Saturday that precedes carnival Tuesday (day 0) and ends on the Wednesday that succeeds it, the Ash Wednesday. The sample comprises all live births that happened within the period of 34 days before carnival Tuesday up to 35 days after it, in years 2012-2019.

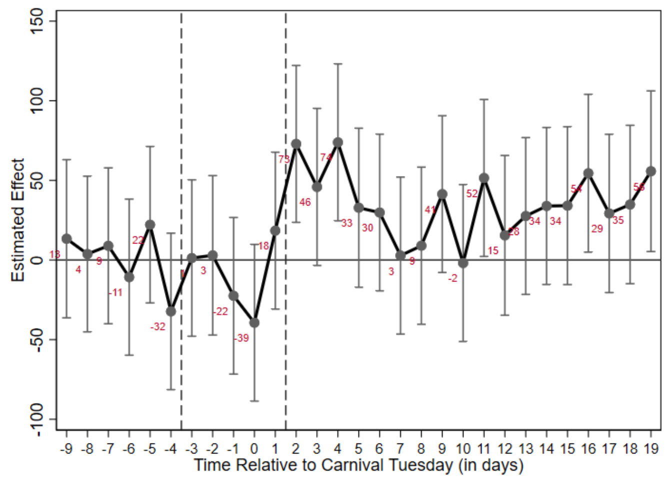
	(1) Number of displaced births	(2) p-value	(3) Total births	(4) Fraction displaced
Day -9 (Sun)	127	(0.11)	8,739	0.015
Day -8 (Mon)	201	(0.01)	8,651	0.023
Day -7 (Tue)	285	(0.00)	8,552	0.033
Day -6 (Wed)	498	(0.00)	7,008	0.071
Day -5 (Thu)	578	(0.00)	6,108	0.095
Day -4 (Fri)	249	(0.00)	9,045	0.028
Day -3 (Sat)	-175	(0.03)	8,876	0.02
Day -2 (Sun)	-185	(0.02)	8,822	0.021
Day -1 (Mon)	-1,712	(0.00)	8,792	0.195
Day 0 (Carnival Tue)	-2,289	(0.00)	8,687	0.263
Day 1 (Wed)	-564	(0.00)	7,116	0.079
Day 2 (Thu)	430	(0.00)	6,238	0.069
Day 3 (Fri)	475	(0.00)	9,355	0.051
Day 4 (Sat)	325	(0.00)	9,332	0.035
Day 5 (Sun)	130	(0.11)	9,416	0.014
Day 6 (Mon)	176	(0.03)	9,468	0.019
Day 7 (Tue)	66	(0.41)	8,899	0.007
Day 8 (Wed)	-54	(0.50)	7,038	0.008
Day 9 (Thu)	211	(0.01)	6,135	0.034
Day 10 (Fri)	223	(0.01)	7,611	0.029
Day 11 (Sat)	159	(0.05)	6,823	0.023
Day 12 (Sun)	115	(0.15)	8,450	0.014
Day 13 (Mon)	137	(0.08)	9,397	0.015
Day 14 (Tue)	70	(0.38)	9,285	0.008
Day 15 (Wed)	2	(0.98)	7,598	0.000
Day 16 (Thu)	207	(0.01)	6,498	0.032
Day 17 (Fri)	140	(0.08)	9,501	0.015
Day 18 (Sat)	63	(0.43)	9,203	0.007
Day 19 (Sun)	99	(0.22)	9,014	0.011
R-squared	0.98			
N	556			
Missing mass during holiday	-4,925		241,727	0.020
Excess mass before holiday	1,938		241,727	0.008
Excess mass after holiday	2,974		241,727	0.012

Table D.2: Quantification of birth displacement

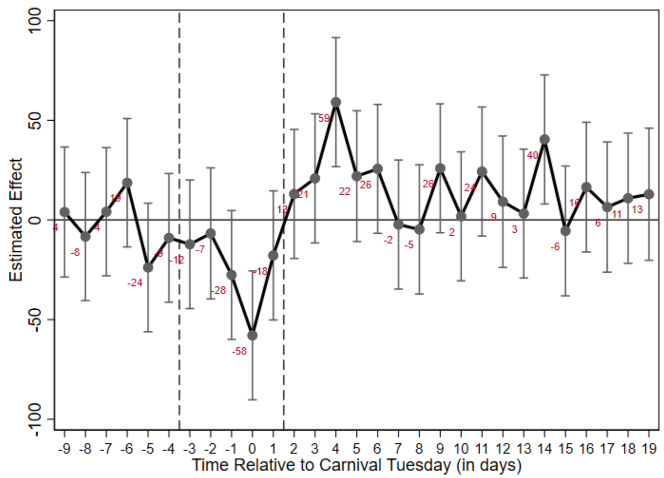
Notes. This table presents results of least squares estimation of equation 3. Columns (1) and (2) present the coefficients of interest and corresponding p-values, respectively. Column (3) presents the average total daily number of births for the corresponding day within the carnival window. And column (4) presents the fraction of displaced births, calculated as the ratio of the estimated number of displaced births to the average total daily number of births. The sample comprises all live births that happened within the period of 34 days before carnival Tuesday up to 35 days after it, in years 2012-2019. *Significant at the 10% level. **Significant at the 5% level. ***Significant at the 1% level.



(a) Number of c-sections



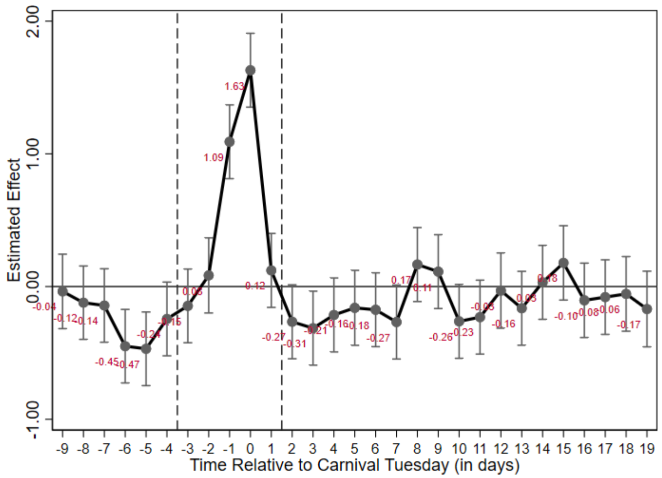
(b) Number of spontaneous vaginal deliveries



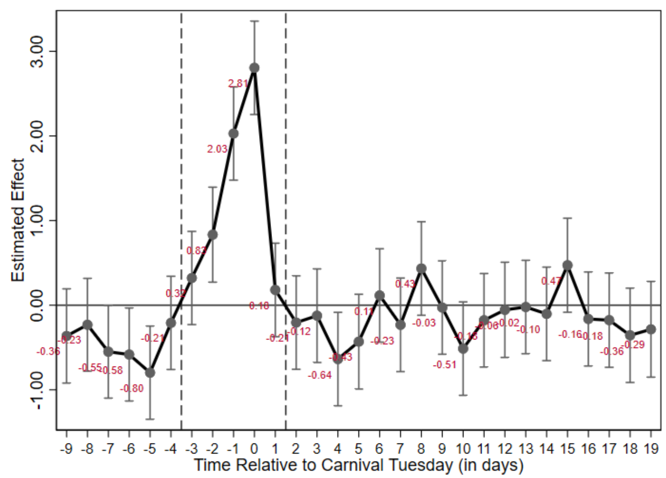
(c) Number of induced vaginal deliveries

Figure D.2: Patterns of delivery types

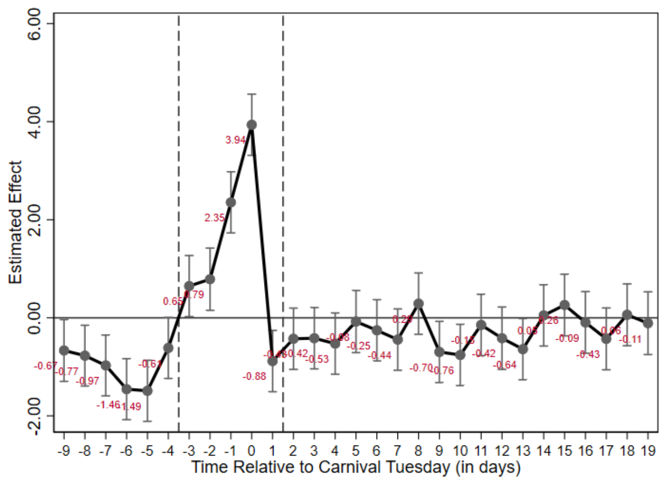
Notes. This figure shows plots of estimates for β_j's of equation 3 and corresponding 95-percent confidence intervals. Outcome variables are specified below each subfigure. Vertical dashed lines indicate the carnival festivity period, which starts on the Saturday that precedes carnival Tuesday (day 0) and ends on the Wednesday that succeeds it, the Ash Wednesday. The sample comprises all live births that happened within the period of 34 days before carnival Tuesday up to 35 days after it, in years 2012-2019.



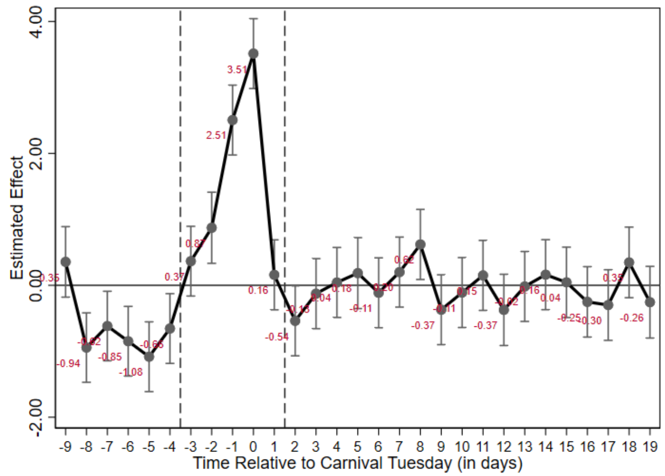
(a) % of mothers aged less than 18



(b) % of mothers with up to 8 years of education



(c) % of non-white mothers



(d) % of mothers with no partner

Figure D.3: Patterns of maternal characteristics

Notes. This figure shows plots of estimates for β_j's of equation 3 and corresponding 95-percent confidence intervals. Outcome variables are specified below each subfigure. Vertical dashed lines indicate the carnival festivity period, which starts on the Saturday that precedes carnival Tuesday (day 0) and ends on the Wednesday that succeeds it, the Ash Wednesday. The sample comprises all live births that happened within the period of 34 days before carnival Tuesday up to 35 days after it, in years 2012-2019.

D.1.3 Main Results

	(1) Gestational length (days)	(2) Birthweight (grams)	(3) Neonatal death rate	(4) Early neonatal death rate
Carnival window	0.08***	1.71*	-0.09	-0.13
	(0.00)	(0.06)	(0.46)	(0.25)
Daily mean	268.22	3,179.39	9.03	6.84
Fraction displaced	0.020	0.020	0.020	0.020
Implied IV estimate	3.97	85.74	-4.57	-6.27
Obs.	556	556	556	556

Table D.3: Carnival effects on gestational length, birthweight, and neonatal mortality

Notes. This table presents results of least squares estimation of equation 2. P-values are presented in parentheses, underneath β estimates. The sample comprises all live births that happened within the period of 34 days before carnival Tuesday up to 35 days after it, in years 2012-2019. *Significant at the 10% level. **Significant at the 5% level. ***Significant at the 1% level.

	(1) Mothers aged <18	(2) Mothers aged >35	(3) Non-white mothers	(4) Mothers w/ ≤8 yrs of educ.	(5) Mothers w/ no partner
Carnival window	-3.57	1.19	-10.5	-0.19	6.93
	(0.31)	(0.88)	(0.66)	(0.98)	(0.68)
Daily mean	708.91	858.57	4,951.36	1,816.8	3,596.4
Obs.	556	556	556	556	556

Table D.4: Selection tests: Carnival effects and mothers' characteristics

Notes. This table presents results of least squares estimation of equation 2. P-values are presented in parentheses, underneath β estimates. The sample comprises all live births that happened within the period of 34 days before carnival Tuesday up to 35 days after it, in years 2012-2019. *Significant at the 10% level. **Significant at the 5% level. ***Significant at the 1% level.

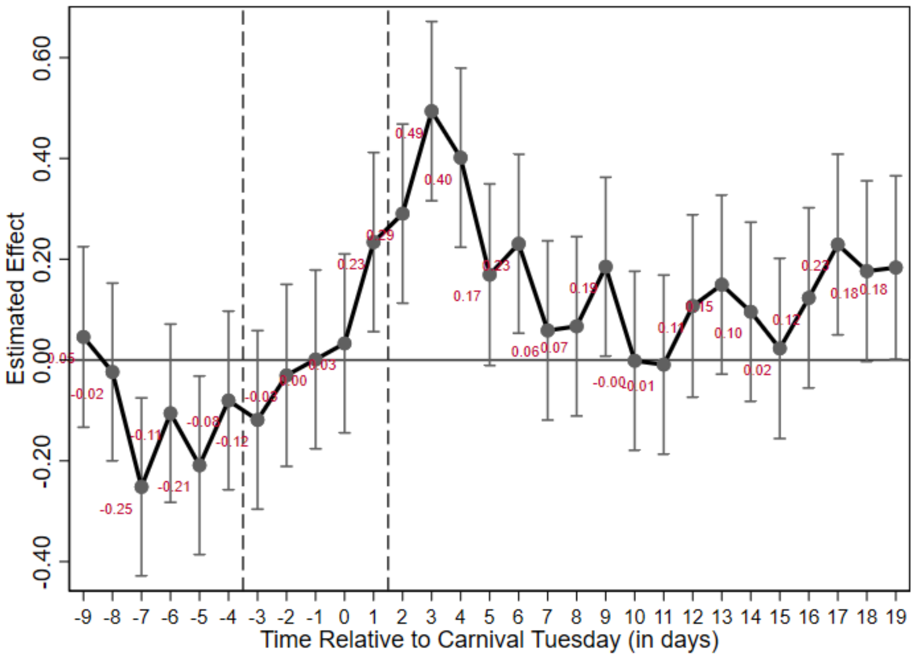


Figure D.4: Patterns of gestational length

Notes. This figure shows plots of estimates for β_j's of equation 3 and corresponding 95-percent confidence intervals, using gestational length (in days) as the outcome variable. Vertical dashed lines indicate the carnival festivity period, which starts on the Saturday that precedes carnival Tuesday (day 0) and ends on the Wednesday that succeeds it, the Ash Wednesday. The sample comprises all live births that happened within the period of 34 days before carnival Tuesday up to 35 days after it, in years 2012-2019.

	(1) Total births	(2) C-sections	(3) Spontaneous Vag. Deliveries	(4) Induced Vag. Deliveries
Carnival window	7.17	-19.2	20.68***	4.75
	(0.88)	(0.67)	(0.00)	(0.31)
Daily mean births	8,325.23	4,656.57	2,437.81	1,018.87
Obs.	556	556	556	556

Table D.5: Mechanisms: Carnival effects on the number of births by delivery type

Notes. This table presents results of least squares estimation of equation 2. P-values are presented in parentheses, underneath β estimates. The sample comprises all live births that happened within the period of 34 days before carnival Tuesday up to 35 days after it, in years 2012-2019. *Significant at the 10% level. **Significant at the 5% level. ***Significant at the 1% level.