A bundle of joy? Evaluating bundled payments for maternity care in the Netherlands

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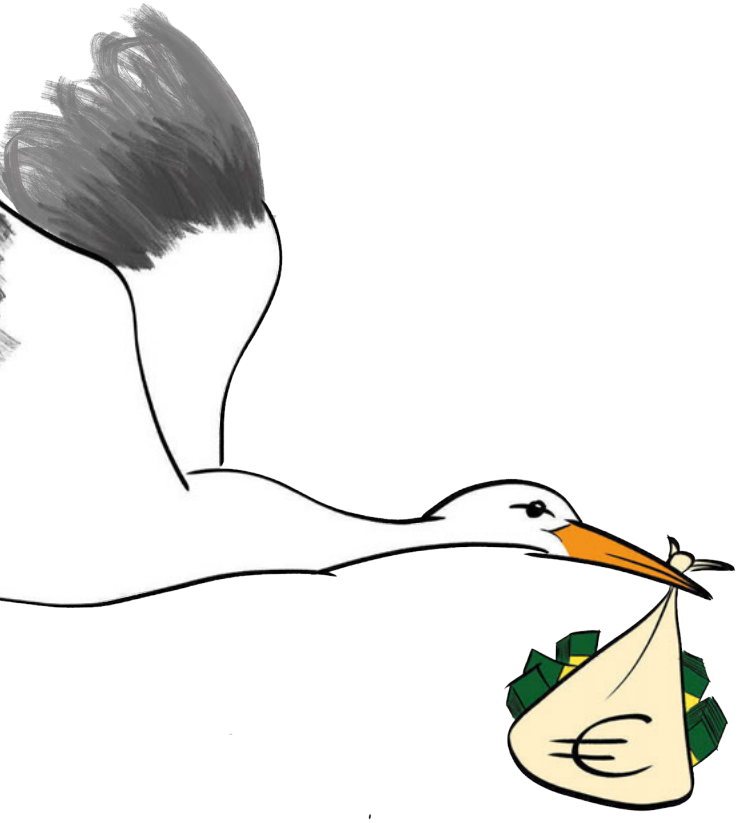

Chapter 3

Integrating maternity care through bundled payments in the Netherlands: early results and policy lessons

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Abstract

Bundled payments are increasingly used globally to move health care delivery in a value-based direction. However, evidence remains scant in key clinical areas. We evaluated bundled payments for maternity care in the Netherlands during the period 2016–18. We used a quasi- experimental difference-in-differences design to measure the association between the bundled payment model and changes in key clinical and economic outcomes. Bundled payments were associated with an increase in outpatient, midwife-led births and a reduction in in-hospital, obstetrician-led births, along with changes in the use of labor inductions and planned versus emergency cesarean deliveries. Total spending on maternity care decreased by US$328 (5 percent) per pregnancy. No changes in maternal or neonatal health outcomes were observed. Several policy lessons emerged. First, bundled payments appeared to help affect providers' behavior in the maternity care setting. Second, bundled payments seemed to exert heterogeneous effects across participating maternity care networks, as the same financial incentive translated into different changes in clinical practices and outcomes. Third, alternative payment models should be designed with clear goals and definitions of success to guide evaluation and implementation.

Introduction

Across the globe, bundled payment models are increasingly being implemented in an effort to slow health care spending and improve the value of care (1). Bundled payment is an alternative payment model in which providers are paid a prospectively determined fee or budget for an episode of care (for example, pregnancy and delivery) and thus share in potential losses and savings. The theory of bundled payment models is that providers are best positioned to work together to deliver higher-value care and reduce the use of lower-value services by sharing financial incentives to save money and earn part of the savings under the bundled payment (1–4). Achieving this—ideally with improved health or no detrimental effects on health—could make the health care system more efficient and sustainable and would support transitions toward integrated and value-based care. However, empirical evidence on the effects of bundled payment on spending and outcomes has been broadly mixed to date (1). Importantly, such evidence has also been scant in many important clinical areas.

Bundled payment models have been implemented in various health care settings and countries during the past twenty-five years—for example, the PROMETHEUS and Bundled Payments for Care Improvement initiatives in the US (5–9) and initiatives in Taiwan (10), Denmark (11), and Portugal (12,13). About two-thirds of the evaluations on these bundled payment models that examined changes in spending reported spending (growth) reductions (1). Associated changes in quality of care were generally favorable, although they were modest or not statistically significant. Two studies reported a negative effect on quality (1).

Maternity care is an important clinical area in which bundled payments are gaining increased traction (14–18) as childbirth is often the most common reason for inpatient spending in the population under age sixty-five. Still, empirical evidence on the effects of bundled payments remains particularly scarce in maternity care (19) with only two US studies to date. One study reported a reduction in neonatal intensive care unit admissions and increased screening and prevention activities (17) and the other reported reduced spending and no changes in health (18).

In 2006, managed competition was introduced in the Netherlands, alongside a package of reforms to reinforce market mechanisms within the health care system (20). Every citizen is obliged to take up basic health insurance. All health insurers are obliged to offer a fixed package of basic health insurance coverage (annually determined by the Ministry of Health, Welfare, and Sport) and are not allowed to deny anyone this basic health plan (by law). Health insurers can compete with each other in terms of price for the basic health plan, but prices may not differentiate between consumers of one health insurer. Citizens are free to choose from which health insurer they want to buy their basic health plan each year. This system gives health insurers the incentives and tools to act as proactive buyers and to steer the providers they contract with toward providing high-quality care for a reasonable price. Part of the expense of this system of mandatory health insurance is covered by the premiums paid by consumers and citizens, and the other part is covered through centrally collected income-related taxes, which are redistributed to health insurers as risk-adjusted capitation payments (20).

In the Netherlands, bundled payments for maternity care were experimentally introduced in 2017 as part of a series of policy interventions to improve the coordination and quality of maternity care and lower perinatal mortality, which was relatively high in the Netherlands compared with other European countries (21–29). Maternity care is mainly provided by midwives, obstetricians, and postpartum care providers who operate within regions called maternity care networks. The Netherlands has a strong history and culture of home births, which has strengthened the position of midwives. However, at present, roughly 14 percent of births take place at home and 86 percent in the hospital (either obstetrician led as an inpatient or midwife led as an outpatient) (30). The bundled payment model for maternity care includes all prenatal, natal, and postnatal care services delivered by midwives, obstetricians, and postpartum care providers (23). A price distinction is made between regular and complex care. Care for the newborn, outside of standard postpartum care, is not included in the bundle. Adoption of the bundled payment model requires the establishment of a new provider-led entity, the integrated maternity care organization, in which midwives, obstetricians, a hospital, and postpartum care providers are united. The organization negotiates contracts with insurers and subcontracts with providers to provide the contracted care. Six regions with a history of interdisciplinary collaboration voluntarily adopted this bundled payment model in 2017. More details on the health and maternity care system in the Netherlands and the bundled payment model are in the appendix.

We evaluated the Dutch maternity care bundled payment model through its first two years, studying the six regions that adopted the model. We focused on changes in maternity care use, spending, and maternal and neonatal health outcomes attributable to the payment reform, using a quasi-experimental, difference-in-differences approach.

Study Data And Methods

Data Sources And Study Period

This study used data from the Data-Infrastructure for Parents and Children, in which multiple nationwide Dutch administrative data sets are linked (32). This source combines data from several sources, including an all-payer claims database (Vektis) (33); data on maternal and neonatal health, quality of maternity care, and clinical information (Perined) (30); and the System of Social Statistical Datasets provided by Statistics Netherlands, containing sociodemographic characteristics (34).

The three linked data sources in the Data-Infrastructure for Parents and Children cover 92 percent of all pregnancies in the Netherlands during the study period (appendix table A2). We checked the characteristics of the sample in our linked data set with the characteristics in the complete registry of Statistics Netherlands, to make sure that the sample in the Data-Infrastructure for Parents and Children was not a selective sample of the general population (appendix table A3). More details are in appendix 2.

The study period spanned 2016–18, with 2016 as the preintervention period and the third quarter of 2017 through 2018 as the postintervention period. The first two quarters of 2017 were excluded from the postintervention period (a washout period), given the early phases of implementation. For our spending outcome, data from Vektis were not yet available for the third and fourth quarters of 2018 at the time of this study, and therefore the postintervention period was the third quarter of 2017 through the second quarter of 2018 for the spending analysis.

Study Sample

The six maternity care networks that implemented bundled payments in 2017 (integrated maternity care organizations) made up the intervention group, and the non-participating maternity care networks were potential controls.

Our initial, linked data set contained 616,615 pregnancies in total. Applying exclusion criteria led to a study sample of 493,415 pregnancies (see appendix 2.3 and figure A4). We derived matched controls for the intervention groups at the maternity care network level, using k-means clustering, based on the urbanization degree of patients' households and the annual number of pregnancies served by the maternity care networks (see appendix 3 for details on the matching procedure and appendix figure A2 for the result of the match). The final sample contained 139,849 pregnancies: 26,763 in the intervention group and 113,086 in the matched control group. A flow chart (CONSORT diagram) of the sample derivation is in appendix figure A4.

Outcomes

We focused on key clinical and economic outcome variables in three categories: maternity care use, maternity care spending, and maternal and neonatal health outcomes. These were based on the literature (35-38), advice of our Scientific Guidance Committee (consisting of senior researchers and health care professionals in maternity and perinatal care and health economics), and data availability.

Maternity care use measures consisted of place of birth, labor induction, and planned and emergency cesarean delivery. Place of birth was divided into three categories: as an inpatient in the hospital (obstetrician-led), as an outpatient in the hospital (midwife-led), and home (midwife- led). Maternity care spending reflected total spending on maternity care, measured in euros and converted to US dollars. Maternal and neonatal health outcome measures included an Apgar score below 7 after five minutes, low birthweight, preterm birth, postpartum hemorrhage, and perineal rupture. Maternal and perinatal mortality were not examined, as these outcomes were very rare.

Covariates

Based on covariates from previous studies (37, 39-41) and data availability, we considered the characteristics shown in exhibit 1, to assess balance between the intervention and control groups—before and after matching at the maternity care network level.

Descriptive Analyses

We first examined descriptive statistics of the outcomes in the intervention and control groups. We plotted unadjusted trends over time to assess the pre-intervention trends. Next, we compared the population characteristics of

the intervention and control groups, both before and after matching, using standardized differences. We also looked at the population characteristics of the intervention and matched control groups in the pre- and postintervention periods (appendix table A5). This enabled us to assess whether the groups were comparable and to determine that potential outside factors (for example, changes in the population composition) likely did not exert a large influence.

Quasi-Experimental Analyses

To measure the association between the bundled payment model and changes in our key clinical and economic outcomes, we used a quasi-experimental, difference-in-differences design. We focused on the interaction of the treatment indicator and postintervention period for each outcome. We estimated the average treatment effect for the treated for our study population (not the average treatment effect, as this was a voluntary payment reform and the intervention group was non-random). Details on the model are in appendix 4.

It was not feasible to statistically test the parallel trend assumption with annual outcomes, as there was only one annual data point in the pre-intervention period (that is, 2016). However, we showed unadjusted preintervention trends at the quarterly level in 2015 and 2016 for each of our outcomes, to aid visual inspection of the extent to which the intervention and control maternity care networks exhibited parallel or divergent trends before the bundled payments. We found that, in general, unadjusted preintervention trends for most outcomes were largely parallel for most of the preintervention period, with some suggestion of possible anticipatory behavior but no sustained divergence of pre-intervention trends (appendix figure A5). A 2018 study also examined whether the intervention regions differed in terms of utilization, spending, and health outcomes relative to the other regions in the period before the introduction of the bundled payments (22).

In adjusted analysis, we estimated the difference-in-differences model (appendix 4) within each cluster of participating maternity care networks with matched nonparticipating maternity care networks, and we pooled each subclass-specific difference-in-differences estimate to derive an overall difference-in-differences estimate for each outcome.

Sensitivity Analyses

To test the robustness of our results, we performed three sensitivity analyses. We first assessed the robustness of findings to alternative control groups. Instead of the matched control group, we used a different control group that comprised the top ten non-participating maternity care networks with a high level of collaboration, plausibly similar to maternity care networks in the intervention group, based on expert opinion. The level of collaboration is potentially associated with both the establishment of an integrated maternity care organization and the outcomes. By using this alternative control group, we were able to test whether the observed changes in outcomes in our main analysis were associated with the bundled payment model or with the high level of collaboration in the participating maternity care networks.

Second, we evaluated the associations between bundled payments and outcomes for each participating maternity care network individually to understand whether effect estimates were driven by outlier maternity care networks.

Third, we examined heterogeneity in the estimated treatment effects of the bundled payment model in different segments of the postintervention period. This provides more insight into the stability of estimates over time, and notably the pace at which this payment model may lead to changes in clinician behavior. We looked at the associations in the third and fourth quarters of 2017 (T1), the first and second quarters of 2018 (T2), and the third and fourth quarters of 2018 (T3) compared with the third and fourth quarters of 2016 (T0).

Limitations

We note several limitations. First, despite our matching strategy, our estimates may have been susceptible to unobserved confounding. Participating maternity care networks may have been different on unobserved attributes, such as culture and collaboration, relative to the nonparticipating maternity care networks. Participants are regions that consider themselves as innovators and early adopters, and they voluntarily participated in bundled payments. To limit the possible influence of unobserved confounding, we carefully selected the matching variables and checked the population characteristics of both groups in our sample to make sure that these were comparable. In addition, we performed the sensitivity analysis with an alternative control group to confirm that the high level of collaboration in participating maternity care networks was not driving our estimates.

A second limitation was the relatively short follow-up period of two years. At the end of the study period, the implementation process was still active in the participating maternity care networks, and not all potential implications were measurable yet. As of January 1, 2023, the bundled payment model was permanently implemented as part of the regular payment system for maternity care in the Netherlands, alongside the traditional fee-for-service model. Providers together with health insurers jointly decide which payment model they want to adopt. Furthermore, it is unknown to what extent each individual professional experiences exposure to the incentives of the bundled payment model in daily practice. Despite this limitation, understanding the initial results of payment reform remains important, especially given that reductions in spending and changes in utilization appeared fairly early in the implementation. Early lessons from this study can provide relevant feedback for this experiment and can inform decisions regarding other payment reform initiatives.

Third, we lacked data on patients' experiences with maternity care and the quality of postpartum care at home. The experiences of mothers (to-be) and their partners are an important indicator for the quality of maternity care. Unfortunately, there is no standardized measure available for this in the Netherlands that could have been included in this study. This seems to be a common issue, as patients' experiences are rarely included in evaluations of bundled payment models (1). Given the importance of patients' experiences and the quality of postpartum care within maternity care, it would be preferable to be able to include these data in future evaluations.

Study Results

Population Characteristics

After matching, the study population consisted of 139,849 pregnancies (26,763 in the intervention group and 113,086 in the control group). Characteristics of the participating maternity care network populations and those in the matched control maternity care networks were generally comparable (exhibit 1). Imbalance was evident in household urbanization degree (4.2 percent highly urbanized in the intervention group, 11.7 percent in the control group). This was among the variables that we adjusted for in the analysis (see appendix 3 and figure A3).

Exhibit 1. Characteristics of pregnant women and their partners among maternity care networks (MCNs) participating and not participating in the bundled payment model for maternity care in the Netherlands, before and after matching, 2015-18

	Before matching			After matching		
	Participating MCNs	Nonparticipating MCNs	Standardized difference (unadjusted)	Participating MCNs	Nonparticipating MCNs	Standardized difference (unadjusted)
Number of MCNs	6	64	—[a]	6	24	—[a]
Average pregnancies per MCN[b]	7,368	8,763	—[a]	4,461	4,712	—[a]
Mother						
Age (years)	30.8	31.2	−0.1	30.8	31.0	−0.3
Educational level (%)						
Low	5.2	4.8	0.0	4.9	4.4	0.0
Middle	54.0	49.6	0.0	54.1	52.1	0.0
High	40.9	45.6	0.0	40.9	43.5	0.0
Country of origin (%)						
Dutch	74.5	68.9	0.0	74.3	74.0	0.0
Other Western	11.0	10.7	0.0	11.0	9.6	0.0
Non-Western	14.6	20.5	0.0	14.7	16.3	0.0
Health spending 2 years before delivery ($)	2,229.9	2,284.7	46.4	2,207.4	2,195.3	−20.8
Father						
Age (years)	33.7	34.2	−0.2	33.7	33.9	−0.3
Educational level (%)						
Low	5.1	5.4	0.0	4.9	4.9	0.0
Middle	60.4	54.0	0.0	60.8	57.3	0.0
High	34.5	40.7	0.0	34.3	37.8	0.0

	Before matching			After matching		
	Participating MCNs	Nonparticipating MCNs	Standardized difference (unadjusted)	Participating MCNs	Nonparticipating MCNs	Standardized difference (unadjusted)
Country of origin (%)						
Dutch	75.5	70.6	0.0	75.3	74.7	0.0
Other Western	9.5	9.2	0.0	9.4	8.5	0.0
Non-Western	15.0	20.3	0.0	15.3	16.7	0.0
Health spending 2 years before delivery ($)	731.8	757.3	22.9	721.9	704.3	0.0
Household						
Standardized household income (percentile)						
1–20	14.6	16.4	0.0	14.4	15.6	0.0
21–40	11.7	12.4	0.0	11.6	12.4	0.0
41–60	18.8	18.1	0.0	18.5	19.0	0.0
61–80	27.4	24.8	0.0	27.3	26.6	0.0
81–100	27.5	28.3	0.0	28.1	26.3	0.0
Urbanization degree						
1 (highly urban)	4.1	29.0	−0.1	4.2	11.7	−0.1
2	53.6	28.5	0.2	53.1	36.2	0.2
3	8.8	16.9	−0.1	8.9	21.3	−0.1
4	27.2	18.1	0.1	27.7	21.5	0.1
5 (rural)	6.2	7.5	0.0	6.2	9.3	0.0

Source: Authors' analysis of the matched study sample derived from the Data-Infrastructure for Parents and Children at the pregnancy level. The Data-Infrastructure for Parents and Children is described in the text, with its components described in notes 30 and 32-34.
Notes: Participating MCNs were matched to nonparticipating MCNs through k-means clustering based on urbanization degree of the region and number of pregnancies served annually. Standardized differences are shown to compare the population characteristics of the intervention (participating MCNs) and control (nonparticipating MCNs) groups before and after matching (described in the text). According to the standardized differences after matching displayed here, population characteristics were deemed comparable for the main analysis, and additional matching at the pregnancy level was not necessary. Spending was measured in euros and converted to US dollars. [a]Not applicable. [b]After matching, exclusion criteria were applied, which led to a smaller study sample, as described in appendix 2.3 (see note 31 in text).

Maternity Care Use

In adjusted analysis, participants in the bundled payment program exhibited a statistically significant increase in outpatient in-hospital (midwife-led) deliveries of 2.74 percentage points relative to control (adjusted difference-in-differences estimate in log scale: 0.03; 95% confidence interval: 0.02, 0.04). This was offset by a similar, significant decrease in in-hospital (obstetrician-led) deliveries of −3.52 percentage points relative to control (difference-in-differences estimate in log scale: −0.03; 95% CI: −0.05, −0.02) (exhibits 2 and 3). No relative change in home deliveries was observed in association with the intervention. In addition, the share of deliveries with induced labor decreased by 1.41 percentage points in participating maternity care networks relative to control (difference-in-differences estimate in log scale: −0.01; 95% CI: −0.03, 0.00), as well as the share of deliveries by planned cesarean delivery, which decreased by 1.16 percentage points relative to control (difference-in-differences estimate in log scale: −0.01; 95% CI: −0.02, 0.00). The share of deliveries by emergency cesarean delivery increased by 1.33 percentage points in participating maternity care networks relative to control (difference-in-differences estimate in log scale: 0.01; 95% CI: 0.01, 0.02).

Maternity Care Spending

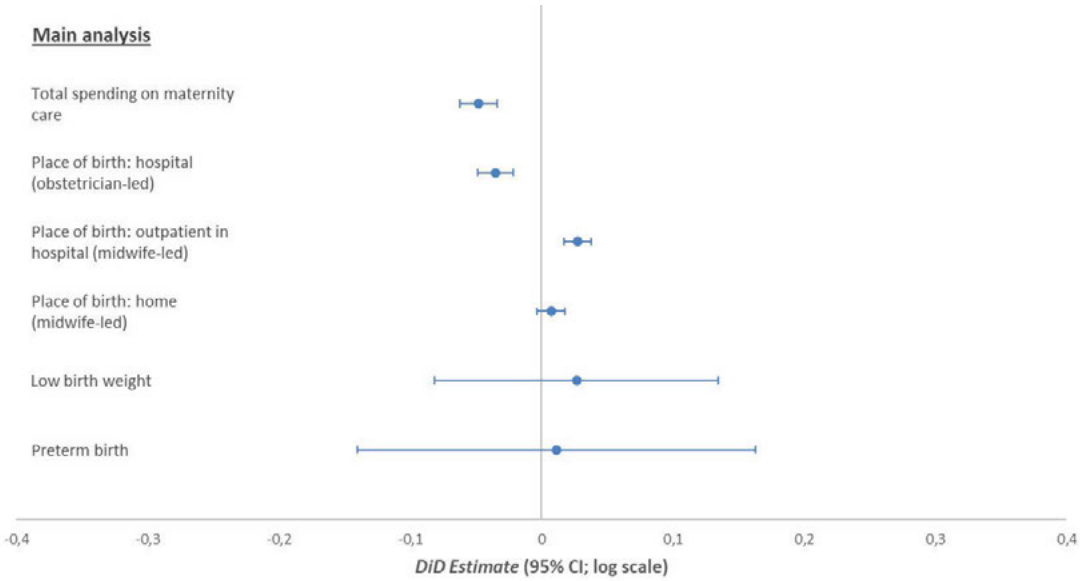
Participating in the bundled payment program was significantly associated with a relative decline of US$328 (€311) per pregnancy, or 5 percent, in total spending on maternity care (adjusted difference-in-differences estimate in log scale: −0.05; 95% CI: −0.06 to −0.03) (exhibits 2 and 3). Specifically, total spending on maternity care grew in both the intervention and control groups, but spending growth was slower in the intervention group. To the extent that there was some anticipatory behavior attributable to the intervention in the latter part of 2016 (the beginning of more outpatient deliveries coinciding with less spending), the estimated effect here would be more conservative.

Health Outcomes For Mother And Child

Participation in the bundled payment model was not significantly associated with any changes in health outcomes such as Apgar score below 7 after five minutes, low birthweight, preterm birth, postpartum hemorrhage, or perineal rupture (exhibits 2 and 3, appendix figure A6).

Forest plots of the adjusted difference-in- differences estimates in log scale with corresponding 95% confidence intervals for the main analysis and sensitivity analyses for all outcomes are in appendix figure A6.

Exhibit 2. Changes in total spending on maternity care, place of birth, and neonatal health outcomes in the Netherlands associated with participation in the bundled payment model for maternity care in 2017 and 2018



Source: Authors' analysis of the matched study sample derived from the Data-Infrastructure for Parents and Children at the pregnancy level. The Data-Infrastructure for Parents and Children is described in the text, with its components described in notes 30 and 32-34.
Notes: The figure is a forest plot displaying changes in outcomes associated with participation in the bundled payment model for maternity care, for the main analysis. Changes in outcomes are presented in adjusted difference-in-differences estimates in log scale; whiskers indicate 95% confidence intervals.

Exhibit 3. Associations between maternity care network (MCN) participation in the bundled payment model for maternity care and changes in utilization, spending, and health outcomes in the Netherlands, 2017 and 2018

Outcome variables	Participating MCNs		Nonparticipating MCNs		Difference-in-differences	
	Baseline period	Treatment period	Baseline period	Treatment period	Point estimate	*P* value
Utilization						
Labor induction	22.42	21.97	21.03	21.99	-1.41	0.030
Cesarean delivery	13.31	14.09	14.89	15.47	0.19	0.696
Planned	6.75	6.41	7.00	7.83	−1.16	0.004
Emergency	6.56	7.65	7.89	7.64	1.33	0.001
Place of birth						
Home (midwife-led)	14.56	14.67	16.44	15.85	0.70	0.184
Outpatient in hospital (midwife-led)	15.07	17.55	14.15	13.90	2.74	0.000
Hospital (obstetrician-led)	70.38	67.71	69.37	70.23	−3.52	0.000
Spending						
Total spending on maternity care ($)	$6,440	$6,459	$6,618	$6,966	−328	0.000
Health outcomes						
Apgar score <7 after 5 minutes	1.03	1.07	1.24	1.24	0.04	0.749
Perineal rupture	1.60	2.00	1.69	1.81	0.29	0.138
Postpartum hemorrhage	5.00	5.17	4.65	5.20	−0.39	0.193
Preterm birth	4.28	4.25	4.43	4.34	0.06	0.884
Low birthweight	8.44	8.46	8.70	8.54	0.19	0.630

Source: Authors' analysis of the matched study sample derived from the Data-Infrastructure for Parents and Children at the pregnancy level. The Data-Infrastructure for Parents and Children is described in the text, with its components described in notes 30 and 32-34.
Notes: Table shows adjusted standardized means (measured in euros and converted to US dollars) for spending and percentages for utilization and health outcomes. Point estimates are based on a standardized population (that is, if the entire sample would take up treatment or not) and show the absolute change in dollars for spending and the absolute change in percentages for utilization and health outcomes. Point estimates are adjusted. *p* values are based on the regression model with the difference-in-differences coefficients.

Sensitivity Analyses

Robustness to alternative control group

Comparing the participating maternity care networks with a control group of the top ten maternity care networks with a high level of collaboration yielded results similar to those of the main analysis (exhibit 4, appendix figure A6).

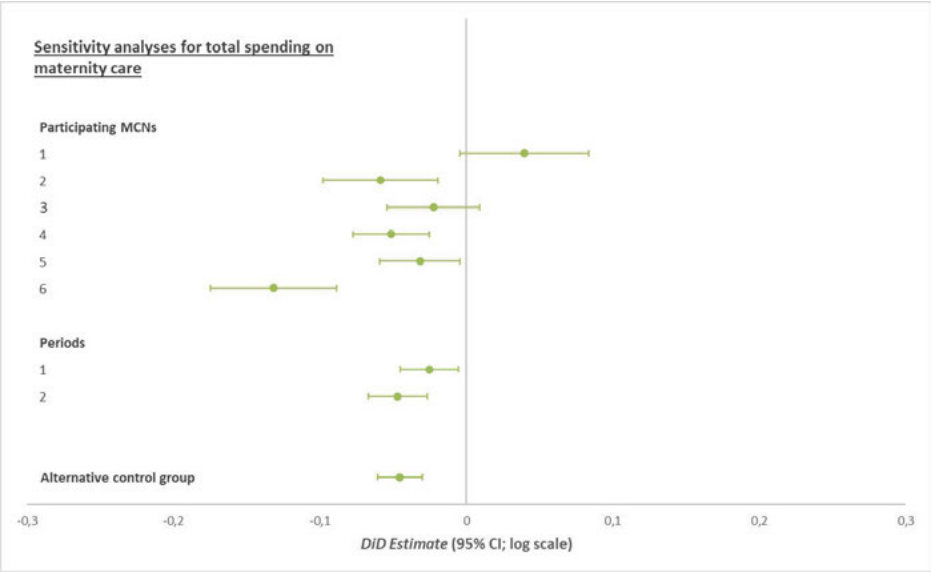
Heterogeneity across participants

Associations between the bundled payment model and outcomes displayed small differences across the participating maternity care net- works. For example, estimates for labor inductions demonstrated some variability across the participating maternity care networks (appendix figure A6). For planned cesarean deliveries, a significant decrease was observed in one maternity care network, and for emergency cesarean deliveries, a significant increase was observed in one maternity care network (not the same region). The other five regions showed no change in planned or emergency cesarean deliveries (appendix figure A6). For total maternity spending, the aggregate slowdown relative to control was driven by four of the six participating maternity care networks (exhibit 4). For health outcomes, the results in sensitivity analyses were generally similar to those of the main analysis (appendix figure A6).

Heterogeneity by postintervention period

Estimated treatment effects of the bundled payment model in different segments of the postintervention period showed similar results for most outcomes (for example, place of birth, emergency cesarean deliveries, and spending) and variation in results for some (for example, planned cesarean deliveries and labor inductions) (exhibit 4, appendix figure A6).

Exhibit 4. Changes in total spending on maternity care in the Netherlands associated with participation in the bundled payment model for maternity care in 2017 and 2018, compared with an alternative control group, across participating maternity care networks (MCNs), and over time



Source: Authors' analysis of the matched study sample derived from the Data-Infrastructure for Parents and Children at the pregnancy level. The Data-Infrastructure for Parents and Children is described in the text, with its components described in notes 30 and 32-34.
Notes: The figure is a forest plot displaying changes in total spending on maternity care associated with participation in the bundled payment model, for the sensitivity analysis in which we used an expert-based control group based on the level of collaboration; one in which we looked at the participating maternity care networks individually (as opposed to the pooled associations in the main analysis) to assess participant heterogeneity; and one in which we looked at changes earlier and later in the postintervention period (represented by periods 1 and 2 in the figure, which correspond to T1 and T2 in the text). For 'Participating MCNs' numbers correspond with the six MCNs that adopted bundled payments in 2017. Changes in outcomes are represented in adjusted difference-in-differences estimates in log scale; whiskers indicate 95% confidence intervals.

Discussion

In the first two years of the maternity care bundled payment model in the Netherlands (2017– 18), participation in the model was associated with a shift from obstetrician-led, hospital-based deliveries to midwife-led, outpatient deliveries; a decrease in labor inductions; and a decline in planned cesarean deliveries that was partly offset by an increase in emergency cesarean deliveries.

In aggregate, these changes in utilization corresponded to reduced maternity spending growth by about 5 percent, with no associated decrements in health outcomes for the mother or the child. Sensitivity analyses largely supported the findings of the main analysis, with variability between maternity care networks and, for some outcomes, over time.

Comparison With Other Studies

Our findings add novel evidence and generally support the results of other studies evaluating bundled payment models, both in maternity care (19) and in other areas of health care (1, 9). Similar to most other studies on the association between bundled payments and spending (1, 9), we found a reduction in spending among participants in the bundled payment model. Estimates in these studies varied widely, from low, single-digit reductions in spending to roughly 30 percent decreases. However, studies looking at spending effects in the first one to three years generally found estimates closer to the 5 percent reduction that we found in this study (1, 9). Studies looking at longer follow-up periods generally found an increase in savings over time (42, 43). It is important to note that the savings we measured may have been an underestimate. This is because the additional overhead that participating maternity care networks received to set up and manage their organizations was included in their total spending. Our finding that health outcomes did not change after two years is also consistent with the results of other studies that found no effects of bundled payment models on quality. Two prior studies reported a negative effect on quality (1), which we specifically did not find.

Future Research

Future research on bundled payments in maternity care should focus on longer-term effects and investigate heterogeneity by subpopulation and provider context. Given that the effects of the bundled payment model may be different for low-risk and high-risk pregnancies, as well as for regions with different characteristics, assessing treatment effect heterogeneity will likely yield important new insights. This should also improve understanding of the mechanisms behind the bundled payment model's plausible effects. For example, in one participating maternity care network, we observed an increase in emergency cesarean deliveries, whereas in another maternity care network, we observed a decrease in planned cesarean deliveries (appendix figure A6). At this point, it is unclear what caused these findings, as this did not seem to be the result of a policy change regarding cesarean deliveries in

one maternity care network. An increase in emergency cesarean deliveries could, however, negatively affect health outcomes and should therefore be investigated further in the future.

It is also important to consider other methods of evaluation in the future. Evaluation methods are currently focused on quantitative methods, whereas qualitative methods may better assess changes in collaboration, joy in the workforce, patient experience, and changes in care practices. Along with these factors, evaluations should also pay attention to possible undesired and potentially harmful effects and how they can be explained (for example, the observed increase in emergency cesarean deliveries in this study).

Policy Implications

These results offer three important lessons for policy makers, payers, and providers who are considering alternative payment models in health care. First, bundled payments seem to be an effective tool to guide providers' behavior in the maternity care setting, even after a limited follow-up period of two years. In previous qualitative studies that we conducted, care professionals reported positive experiences and stated that collaboration intensified through shared accountability and commitment to shared goals (22-25). Professionals also reported task shifting from obstetricians to midwives as a focal point of the transition toward integrated maternity care. These changes in care practices as a direct result of the bundled payment model may explain the observed changes in utilization and spending outcomes. Adding more nonfinancial supports alongside the financial and quality incentives of the bundled payment model might further stimulate provider behavior change (44). This is relevant for both the Dutch initiative and payment reform initiatives around the world.

Second, bundled payments seemed to exert heterogeneous effects across participating maternity care networks. Heterogeneity in outcomes can be explained by the ways in which the incentives from the bundled payment model were translated differently into practice, which seems to be influenced by contextual factors. Although each participating maternity care network was exposed to the same financial incentive and all reported intensified collaboration among providers, they implemented different interventions (for example, a multidisciplinary electronic patient record, a joint consultation hour, and projects regarding task shifting). It remains unclear through which mechanisms maternity care networks decide what interventions to implement and how these interventions affect outcome heterogeneity. This motivates

further research into the role of contextual differences across participating maternity care networks (23), which is relevant for payment reform initiatives around the globe.

Third, alternative payment models should be designed with clear goals, ideally defined before implementation, with all parties involved. Moreover, it is important to define when the reform will be considered successful (45)—for example, if quality is not affected, but spending is contained. In the Dutch experiment, the rationale was clear (that is, enhance multidisciplinary collaboration to improve quality), but the policy goals were not formulated explicitly (enough). This lack of explicit goals has led to a situation in which policy makers and other stakeholders all have a (slightly) different expectation of the experiment and can select results to support their given positions. This complicates drawing clear, broadly agreed-on conclusions on whether or not the experiment has been successful. In turn, this hinders policy decisions on whether the uptake of the bundled payment model should be stimulated or, ultimately, become mandatory for all maternity care networks. Thus, we emphasize the importance of early evaluations such as this one, as explicit goals can still be formulated at this stage that can inform future evaluations and policy decisions regarding the Dutch experiment. New payment reform initiatives could benefit from stating the goals and defining success from the beginning.

Conclusion

In this first quasi-experimental evaluation of maternity care bundled payments in the Netherlands with a two-year follow-up period, participation in the intervention was associated with small changes in maternity care use and slower spending, with no observed changes in maternal and neonatal health outcomes at this point.

Although the results reported here were early and modest, our evaluation of this experiment yielded several lessons for policy makers, payers, and providers considering alternative payment models. First, bundled payments appeared to be capable of affecting providers' behavior in the maternity care setting. Second, bundled payment incentives played out differently in different contexts; more insight is needed into the mechanisms behind this treatment effect heterogeneity. Third, explicitly formulating reform goals and defining success before payment reform is helpful for determining whether the reform is successful, which in turn is key for policy decisions.

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Appendix Chapter 3

Appendix 1: The Dutch health care system, maternity care and the experiment with bundled payments for maternity care

The Dutch health care system

In 2006, managed competition was introduced in the Netherlands alongside a package of reforms to reinforce market mechanisms within the healthcare system (Schut & Varkevisser, 2017). Every citizen is obliged to take up basic health insurance. All health insurers are obliged to offer a fixed package of basic health insurance coverage (annually determined by the Minister of Health, Welfare and Sport) and are not allowed to deny anyone for this basic health plan (by law). Health insurers can compete with each other in terms of price for the basic health plan, but prices may not differentiate between consumers of one health insurer. Citizens are free to choose from which health insurer they want to buy their basic health plan each year. This system gives health insurers the incentives and tools to act as proactive buyers and to steer the providers they contract towards providing high quality care for a reasonable price. Part of the expenses of this system of mandatory health insurance is covered by the premiums paid by consumers/citizens and the other part is covered through centrally collected income-related taxes which are redistributed to health insurers as risk-adjusted capitation payments (Schut & Varkevisser, 2017).

Maternity care

Historically, independent midwives and home births are a fundamental part of maternity care in the Netherlands (Perdok et al., 2016a; Boesveld et al., 2017). Obstetricians and midwives in the Netherlands have a long but also complicated history as providers of maternity care. Whilst midwives tend to consider pregnancy and delivery as predominantly physiological processes that require limited medical care and interventions in most cases, obstetricians tend to view pregnancy and delivery as more high-risk and requiring more medical guidance (Perdok et al., 2016a; Perdok et al., 2016b; Amelink-Verburg et al., 2010; Boesveld et al., 2017, Cronie et al., 2018). This fundamental difference in perspective and care approach has been the root for a decades long rift between the two disciplines. Hierarchical issues have added to the complexity of this relationship between midwives and obstetricians (Scheefhals et al., 2024; Cronie et al., 2018). Naturally, there are exceptions to this rule. In some regions the different disciplines work

together very well and respectful collaborations have been established over the years (Cronie et al., 2018). Personal characteristics of individuals or bridging leadership seem to play an important role (Boesveld et al., 2017). The organization of maternity care in the Netherlands is generally as follows (Van Manen et al., 2021; Perdok et al., 2016a; Perdok et al., 2016b; Amelink-Verburg et al., 2010). In early pregnancy (5-6 weeks) women register at a community midwife who establishes whether the pregnancy is low-risk or high-risk using the "List of Obstetric Indications" (LOI) (Amelink-Verburg et al., 2010). The LOI designates the most appropriate care provider for women with defined medical or obstetric conditions. Low-risk pregnant women are cared for by a community midwife, who is usually self-employed. At the onset of labor, these women are attended by their community midwife and have the choice to give birth at home, in a birth center or as an outpatient in a hospital (still under the care and responsibility of the midwife). If the pregnancy is defined as high-risk, women are referred to a hospital to receive care from a obstetrician, either during pregnancy, delivery or postpartum. After birth in the hospital, women usually stay there for a short period of time (a few hours or days). At home, women and their babies are supported by a community midwife and a postpartum care assistant. The postpartum care assistant assists the parents with the care for their baby and with light domestic work during the first eight days after birth (Van Manen et al., 2021; Perdok et al., 2016a; Perdok et al., 2016b; Amelink-Verburg et al., 2010; Scheefhals et al., 2024).

Relatively high perinatal mortality rates in the Netherlands, as compared to other Western-European countries were reported in The European Perinatal Health Report of 2009 (Zeitlin et al., 2009). As a consequence, numerous measures have been taken in recent years to improve collaboration and the quality of maternity care. Examples of the measures that were taken over the past fifteen to twenty years are the implementation of the preconception consultation (2008), the founding of the Pregnancy and Birth Steering Group (2008), the expansion of neonatal screening (2008), the establishment of the Perinatal Audit Netherlands (2011), the institution of the College for Perinatal Care (2011) and the adoption of the Care Standard for Integrated Maternity Care (2016) (Struijs et al., 2020). Next to this, regional Maternity Care Networks (MCNs) were intensified in order to improve collaboration and coordination between all disciplines involved in providing maternity care (i.e., midwives, obstetricians, postpartum care providers, general practitioners, pediatricians and anesthesiologists). There is currently a nationwide network of MCNs in

the Netherlands. In addition to strengthening collaboration between different providers within maternity care, more attention was also paid to prevention and the connection between maternity care and the social domain to further improve the quality of care and health outcomes for mother and child (Struijs et al., 2020).

Experiments with bundled payments for maternity care

As from 2009, stakeholders, including policymakers, payers and providers, also critically examined the existing, monodisciplinary payment model to assess its alignment with the overarching system goals of maternity care, and whether this incentivized the desired collaboration among different maternity care disciplines. It became evident that this was not the case, prompting the need to design a new payment model which would better support collaboration and the overall goals of improving maternity care quality and health outcomes. Although plans for this payment reform began as early as 2013, the experiment was not officially implemented until 2017 (KPMG Plexus, 2016). Delays for implementation were primarily the strong pushback from various stakeholders against the proposed plans to implement bundled payments for maternity care on a national level. This resistance was driven by a fear that this payment reform would lead to phasing out of home births and independent midwives within Dutch maternity care (Struijs et al., 2016; Struijs et al., 2018, Struijs et al., 2020; Scheefhals et al., 2024).

As from January 2017, the Dutch Ministry of Health, Welfare and Sports facilitated the experimental introduction of a bundled payment model for maternity care, on a voluntary basis (Struijs et al., 2016; Struijs et al., 2018, Struijs et al., 2020). The Dutch bundled payment model for maternity care includes all prenatal, natal and postnatal care services delivered by midwives, obstetricians and postpartum care providers. The model is divided into nine modules (Figure A1.1). For each pregnancy either one or four modules are claimed: one module for a pregnancy lasting less than 16 weeks; four modules for all pregnancies of 16 weeks and over. For the full term pregnancies, a separate module is claimed for each stage of the pregnancy and delivery (prenatal, natal, postnatal) and for postpartum care at home (in Dutch: kraamzorg). For the prenatal, natal and postnatal phase there is the option of a regular or a complex module, depending on the level of care that is needed. Care for the newborn is not included in the bundle (at this point).

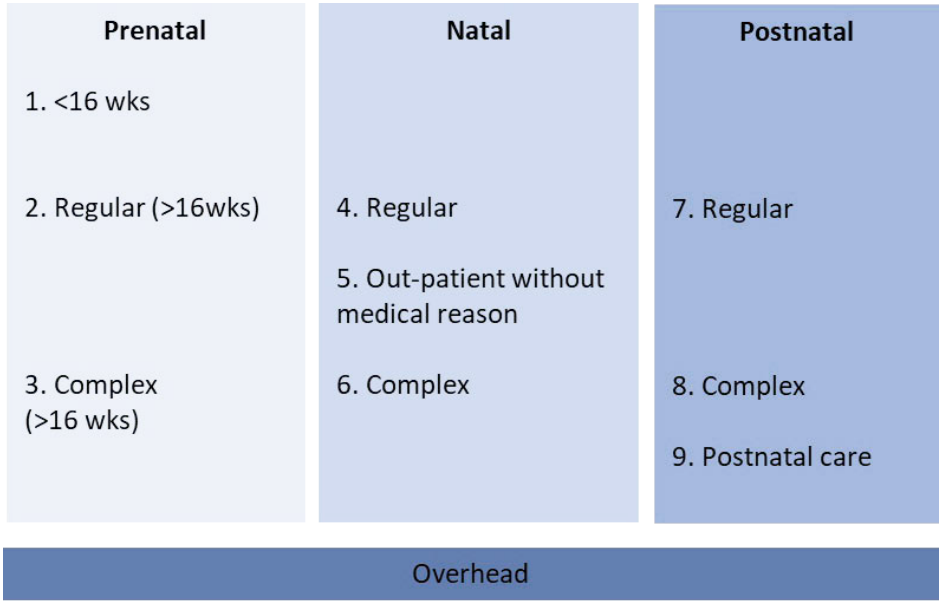


Figure A1.1: Design of the bundled payment model for maternity care in 9 modules

Table A1: Key characteristics of the payment reform in Dutch maternity care (based on De Vries et al., 2021).

Characteristics	Payment reform in Dutch maternity care
Year of implementation	2017
Status	Implemented as an ongoing payment model in 2023, next to the traditional monodisciplinary (fee-for-service) payment model. Providers and payers jointly decide which payment model to use.
Type of APM	Bundled payment (prospective)
Included population	All pregnant women
Included care services	The bundle is divided into four phases: prenatal, natal, postnatal and postpartum care at home. All necessary care related to pregnancy, delivery and the postpartum period is included. Care for newborns is not included.
Risk mitigation strategies	Risk stratification: for each phase (prenatal, natal and postnatal), two tariffs are defined: regular and complex.

Adoption of the bundled payment model requires the establishment of a new provider-led entity, the so-called Integrated Maternity Care Organization (IMCO), in which midwives, obstetricians, a hospital and postpartum care

providers are united. These participating parties are the owners of the IMCO. An IMCO is different from a regular Maternity Care Network (MCN). The traditional MCNs exist since the 80's but became especially important over the last decade. In a MCN, maternity care providers are only determining the regional policies regarding the quality and the implementation of care related to pregnancy and childbirth, not including changes to the payment model and not requiring a legal entity. Therefore, the MCN is a less binding organizational form than an IMCO. When an IMCO is created, the regular MCN usually is included in its entirety in the IMCO. MCNs and IMCOs serve the same areas and populations. Only in a few regions, the IMCO and MCN exist partially next to each other, as not all members of the MCN are participating in the IMCO there. There is currently a nationwide network of MCNs in the Netherlands. Within eight Dutch regions, an IMCO has been formed and bundled payment contracts for maternity care have been signed. These participants are regions that consider themselves as innovators and early adopters and voluntarily participated in bundled payments. All IMCOs have a history of strong collaboration between the disciplines in their regions. Therefore, the intervention group in this study is non-random (which we took into account in the analysis). Six regions started in 2017. Two regions joined in 2019; one of these stopped in 2022. One more region joined in 2021. For the purpose of this study, the IMCO regions are referred to as participating MCNs (i.e., participating in the bundled payment model) and the traditional MCNs are referred to as non-participating MCNs.

The IMCO functions as a general contractor, does not provide care itself, and communicates with both health insurers and participating providers (Figure A1.2). The IMCO takes care of the negotiations with health insurers and signs the bundled payment contract for all maternity care services delivered by its participating providers and subsequently subcontracts the individual providers (see Figure A1.2 below). Prices are freely negotiated between the IMCO and the health insurers and differ between IMCOs and health insurers. IMCOs also receive additional 'overhead' funding from health insurers as an add-on in all claims made. The overhead is needed for the establishment of the organization and setting up the new governance structure, but also for continuous management of the organization. These are new and additional expenses due to the implementation of the bundled payments and the subsequent establishment of a new legal entity. In most cases, the IMCO negotiates with the dominant health insurer (i.e., the health insurer with the biggest market share in their region) and the non-dominant health insurers

follow the agreements made between them (as long as prices do not differentiate more than +/- 10% from their own prices, health insurers copy the prices agreed to by the 'dominant' health insurer). This was agreed upon by health insurers nationally to facilitate the contract negotiation process. Quality measures are part of the contracts, but are general and vary by insurer. IMCOs also collect data on quality measures and use this to benchmark between their providers and for attempts at steering behavior and performance.

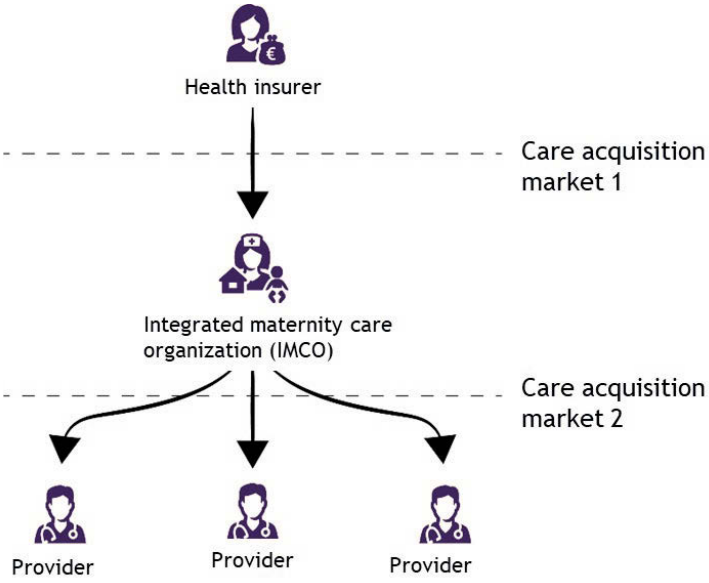


Figure A1.2: Visualization of the two care acquisition markets after introduction of the IMCO

As of January 1, 2023 the bundled payment model was permanently implemented as part of the regular payment models for maternity care in the Netherlands, next to the traditional fee-for-service model (Scheefhals et al., 2024). Providers together with health insurers jointly decide which payment model they want to adopt.

Appendix 2: Data

Appendix 2.1 Data sources and study period

This study uses data from the Data InfrAstructure for ParEnts and childRen (DIAPER), in which multiple nationwide Dutch observational datasets are linked at the pregnancy level. DIAPER contains information about mothers, fathers, pregnancies, and children ranging from 2000 to 2018, at the time of this study, with annual updates. The data-infrastructure combines data from several existing data sources including an all-payer claims database (Vektis), data on maternal and neonatal health, quality of maternity care and clinical information (Perined), and the System of Social Statistical Datasets (SSD) provided by Statistics Netherlands (SN) (Bakker et al., 2014). These linkable microdata provide information on nearly 20 themes — including health and welfare, income and spending, labor and social security, population, and education — and contributes to the coverage of sociodemographic characteristics within DIAPER, such as age, gender, ethnicity, household income, and the highest attained educational level.

The three linked data sources in DIAPER cover the vast majority (92%) of all pregnancies in the Netherlands during the study period (Appendix, Table A2). We checked the characteristics of the sample in our linked dataset with the characteristics in the complete registry of Statistics Netherlands to make sure the sample in DIAPER is not a selective sample of the general population (Appendix, Table A3). Statistics Netherlands provided a highly secured remote access platform to safely manage, analyze, and store data, code, and output. A description of the data preparation process, including linkage of the different data sources and files and the construction of pregnancies within the data, appears in Appendix 2.

The study period spans 2016 through 2018, with 2016 as the pre-intervention period and 2017 Q3 through 2018 as the post-intervention period. The first two quarters of 2017 were excluded from the post-intervention period (a washout period) given the early phases of implementation. For our spending outcome, data from Vektis was not yet available for 2018 Q3-Q4 at the time of this analysis and therefore the post-intervention period was 2017 Q3 through 2018 Q2 for the spending analysis.

Appendix 2.2 Linking the data and constructing pregnancies

(based on Scheefhals et al., 2023)

In order to prepare the data for the analysis, the data from the three different sources (Vektis, Perined, Statistics Netherlands) needs to be transformed, harmonized and linked to each other in the appropriate order and on the correct linkage keys and levels. Firstly, all relevant data from the SSD are harmonized and linked at the individual level of mothers, fathers and children. Secondly, the different Vektis data files are converted to the same level (i.e., the pregnancy level) and linked. After this, all that takes place around one pregnancy can be brought together in the data by grouping all claims related to one pregnancy and relabeling them. Thirdly, the Perined data can be linked to the Vektis data based on the pregnancy-ID (i.e., a unique identifier for each pregnancy of a mother). Finally, the Perined-Vektis combined data can be enriched by linking the relevant SSD data about mothers, fathers and children to the study file on the pregnancy level. Table A2 shows the results of the linkage procedure. Background characteristics of the population in DIAPER were compared to those registered by SN (the official national registry) and were comparable, giving no suggestion that the population in DIAPER is a selective sample of the entire population (see Table A3). This is an important indicator for the quality of the data and for the implications of the results derived from DIAPER.

Table A2. Number of pregnancies in linked dataset from DIAPER (before exclusions were made and matching was performed) compared to all registered pregnancies in the Netherlands

	% (number of) pregnancies				
	2015	**2016**	**2017**	**2018**	**Total**
Statistics Netherlands Statline (national registry)	100% (168.184)	100% (170.323)	100% (167.595)	100% (166.331)	100% (672.433)
Linked dataset for this study	93.0% (156.355)	93.3% (158.933)	92.0% (154.245)	88.4% (147.082)	**91.7%** (616.615)

Table A3. Comparison of the population characteristics in the linked dataset from DIAPER and in the national registry of Statistics Netherlands (years 2015-2018 combined)

Level	Variable	Study file (n = 616.615)		Total pregnancies (n = 672.433)	
		n	%/mean(sd)	n	%/mean(sd)
Mother					
	Age		31.2 (4.734)		31.2 (4.791)
	Education level				
	Low	26.204	4.3	29.684	4.2
	Middle	271.531	44.0	298.008	41.8
	High	246.618	40.0	272.536	38.3
	Ethnicity				
	Dutch without migration background	427.340	69.3	469.955	66.0
	Other western	65.773	10.7	80.627	11.3
	Non-western	123.502	20.0	148.096	20.8
Father					
	Age		32.5 (9.580)		34.2 (5.810)
	Education level				
	Low	26.017	4.2	30.084	4.2
	Middle	265.213	43.0	293.215	41.2
	High	196.070	31.8	218.412	30.7
	Ethnicity				
	Dutch without migration background	417.169	67.7	461.220	64.7
	Other western	54.032	8.8	66.301	9.3
	Non-western	116.863	19.0	139.480	19.6
Household					
	Standardized household income (in percentiles)				
	1-20	98.327	16.0	110.656	15.5
	20-40	74.881	12.1	82.712	11.6
	40-60	109.845	17.8	120.939	17.0
	60-80	151.487	24.6	165.895	23.3
	80-100	171.685	27.8	188.672	26.5
	Household composition				
	Single parent	74.852	12.1	82.262	11.6
	Both parents	524.777	85.1	578.744	81.2
	Other multiperson households	4.814	0.8	5.347	0.8
	Institutions and homes	1.759	0.3	2.493	0.4

Appendix 2.3 Study sample

The six MCNs that implemented bundled payments in 2017 (IMCOs) were the intervention group, and the non-participating MCNs comprised potential controls.

Our initial, linked dataset contained 616,615 pregnancies in total. All pregnancies that were not assigned to the participating or control MCNs were excluded (n=300). In addition, all pregnancies with a duration of less than 24 weeks and all pregnancies that ended in a (spontaneous) abortion or were otherwise nonviable were excluded (n=895). Since twin or multiple pregnancies were considered high risk as compared to singleton pregnancies, all twin and multiple pregnancies were excluded as well (n=10,405). Furthermore, the two MCNs that implemented the bundled payment model in later years (2019 and after) were excluded (n=18,489), because in anticipation of their impending adoption of bundled payments they may have already made some changes prior to 2019 that may bias our results. In addition, all pregnancies in MCNs with a neonatal intensive care unit (NICU) and/or academic medical center (AMC) in their region were excluded (n=93,111). Since there are no IMCOs with a NICU and/or AMC, MCNs with a NICU and/or AMC were excluded from the control group. These exclusion criteria led to a study sample of 493,415 pregnancies.

We derived matched controls for the intervention groups at the MCN level using k-means clustering, based on urbanization degree and annual number of pregnancies served (see Appendix 3 for details on the matching procedure and Appendix Figure A2 for the result of the match). During the matching process, 270,157 pregnancies were dropped because the control MCNs they belonged to were not matched to the participating MCNs. After matching, the study sample comprised 223,258 cases. Some pregnancies had to be removed because they were not in the relevant time periods that were used for the analysis (i.e. 2017 Q1-Q2) (n=83,409). The final sample contained 139,849 pregnancies: 26,763 in the intervention group and 113,086 in the matched control group. A flowchart (CONSORT diagram) of the sample derivation is provided in Appendix Figure A4.

Appendix 2.4 Unobserved confounding

Despite our matching strategy, our estimates may be susceptible to unobserved confounding. For example, participating MCNs may have been different on unobserved attributes relative to the non-participating MCNs, such as culture and collaboration. Participants are regions that consider themselves as innovators and early adopters and voluntarily participated in bundled payments. Additionally, only those maternity care providers (from the original MCN) who wanted to join the new MCN and participate in the bundled payment model did so. The fact that the participants felt ready to take on these incentives and intensify their interdisciplinary collaboration is an indication that they had established trust or working relationships prior to the intervention, which cannot be found in most MCNs (for details on the differences between participating and non-participating MCNs, see Appendix 1). Potentially due to the established collaboration in the participating regions, the quality of maternity care was relatively good before the payment reform. Given these characteristics of the participating MCNs, there is a potential occurrence of Ashenfelter's dip (i.e., performance improvements just prior to the intervention), which may diminish the potential for estimated improvements after the payment reform. On the other hand, it is also possible that the anticipation effect prior to the start of bundled payments could have led to a dip in performance for the participating regions in 2016, as they waited for the start of the intervention in 2017 with new initiatives for quality. The homogenous nature of participating MCNs may also help explain why the intervention and control populations were already comparable after the match at the regional level, as these regions shared traits of medium urbanization degree without NICUs or AMCs. For this reason, we would have preferred to match the intervention and control regions on their level of collaboration. Unfortunately, this data was not available and we carefully selected two proxy variables for the level of collaboration to match on instead (see Appendix 3 for more details on this). Subsequently, we carefully checked the population characteristics of both groups in our sample to make sure these were comparable. In addition, we performed the second sensitivity analysis with an alternative control group to confirm that the high level of collaboration in IMCOs was not driving our estimates. However, our estimates remain susceptible to unobserved confounding.

Appendix 3: Details on the matching procedure

Matching with k-means clustering

We first matched control groups with the intervention groups at the MCN/IMCO level using k-means clustering, based on urbanization degree and annual number of pregnancies served. Ideally, we would match on the regional level of collaboration as it is known that the level of collaboration in the participating MCNs is high and the level of collaboration in the non-participating MCNs varies widely, and this can have a strong effect on the outcomes under study. Unfortunately, no standardized, nationwide measure is available for this and hence, there is no quantitative data available on this to include in our study. Therefore, we selected the best available proxies for the level of collaboration: urbanization degree and annual number of pregnancies served. Urbanization degree was chosen as a variable to match on because it is more complex to start an IMCO in a metropolitan area with a high density of care providers, where collaboration is more challenging due to this high number of providers. Annual number of pregnancies served was selected as the second matching variable, because this is an indication of the level of professionalization and standardization, and indirectly of the level of collaboration between providers.

The k-means algorithm tries to find clusters of participating MCNs and non-participating MCNs that are as similar as possible to each other based on the two matching characteristics (i.e., urbanization degree and annual number of pregnancies served), this criterium is called ‘similarity within groups’. Simultaneously, it also tries to make clusters that are as distinct as possible from each other and from the unmatched organizations, this criterium is called ‘variation between groups’. Additionally, the algorithm aims to maintain a sufficient amount of controls. We tested all options between 2 and 26 clusters and decided on 15 clusters as the best fit, based on visual inspection and the statistics provided by the k-means algorithm. One outlier MCN was removed during the matching process as the number of pregnancies served annually was much higher than the other regions. The k-means clustering provided 15 clusters with 6 clusters including a participating MCN (Figure A2). These 6 clusters, with the participating MCNs and their matched non-participating MCNs, were used as the 6 subclasses in our analysis. For the main analysis, we fitted the difference-in-differences model for each outcome per subclass and then pooled the subclass-specific estimates for each outcome to form an overall DiD estimate per outcome.

After this first matching on the MCN/IMCO level, we had initially planned to perform a second matching, within each cluster, on the pregnancy level. However, the balance in covariates between the intervention and control groups was already good after the first matching (Table A4).

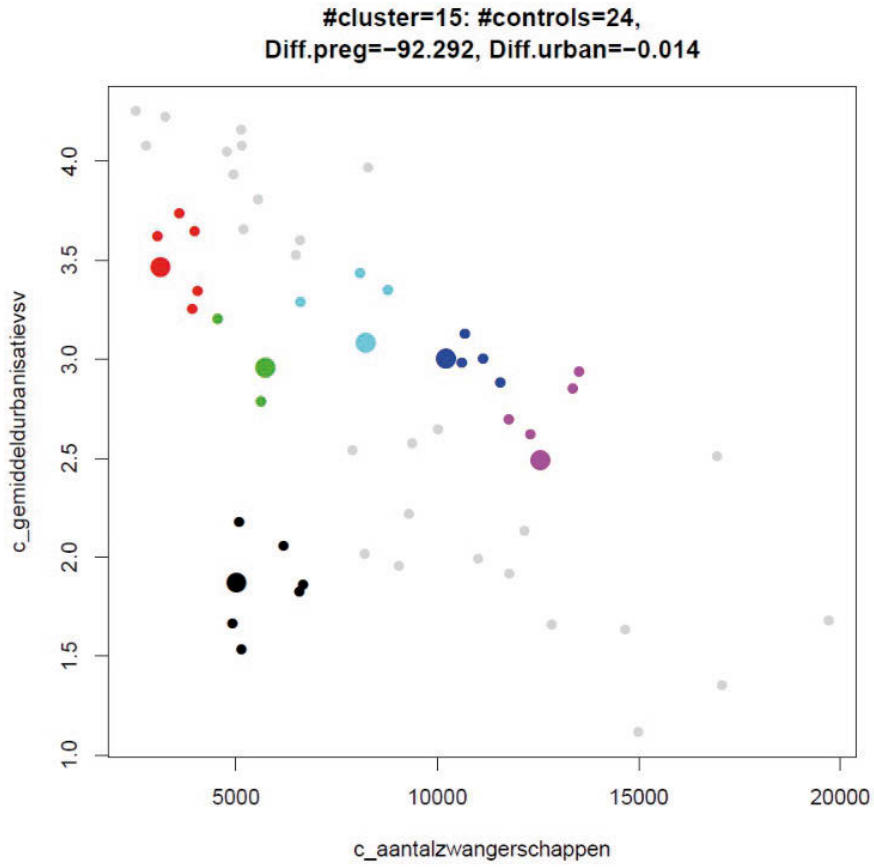


Figure A2. Result of the matching on the organizational level (MCN/IMCO level) using k-means clustering. Each color represents one cluster. Larger points represent the participating MCNs and smaller points represent the non-participating MCNs. Grey points represent non-participating MCNs that were not matched to any of the participating MCNs.

Table A4. Descriptive statistics of the study population before and after matching (extended version of Exhibit 1)

	Before Matching			After Matching		
Variables	**Non-participating MCNs**	**Participating MCNs**	**Standardized difference (unadjusted)**	**Non-participating MCNs**	**Participating MCNs**	**Standardized difference (unadjusted)**
Number of MCNs	**64**	**6**	**NA**	**24**	**6**	**NA**
Average number of pregnancies per MCN	**8763**	**7368**	**NA**	**4712**	**4461**	**NA**
	% / mean (sd)	**% / mean (sd)**		**% / mean (sd)**	**% / mean (sd)**	
Case-mix variables						
Mother						
Age	31.2 (4.8)	30.8 (4.6)	-0.1	31.0 (4.7)	30.8 (4.6)	-0.3
Educational level						
Low	4.8	5.2	0.0	4.4	4.9	0.0
Middle	49.6	54.0	0.0	52.1	54.1	0.0
High	45.6	40.9	0.0	43.5	40.9	0.0
Etnicity						
Dutch	68.9	74.5	0.0	74.0	74.3	0.0
Other Western	10.7	11.0	0.0	9.6	11.0	0.0
Non-Western	20.5	14.6	0.0	16.3	14.7	0.0
Number of distinct medication types used	2.0 (2.2)	1.9 (2.2)	0.0	1.9 (2.1)	1.9 (2.2)	0.0
Health spending two years prior to delivery ($)	2284.7 (4020.1)	2229.9 (3547.0)	46.4	2195.3 (3434.9)	2207.4 (3370.1)	-20.8
Father						
Age	34.2 (5.8)	33.7 (5.6)	-0.2	33.9 (5.7)	33.7 (5.6)	-0.3
Educational level						
Low	5.4	5.1	0.0	4.9	4.9	0.0
Middle	54.0	60.4	0.0	57.3	60.8	0.0
High	40.7	34.5	0.0	37.8	34.3	0.0

Variables	Before Matching			After Matching		
	Non-participating MCNs	Participating MCNs	Standardized difference (unadjusted)	Non-participating MCNs	Participating MCNs	Standardized difference (unadjusted)
Number of MCNs	**64**	**6**	**NA**	**24**	**6**	**NA**
Average number of pregnancies per MCN	**8763**	**7368**	**NA**	**4712**	**4461**	**NA**
	% / mean (sd)	**% / mean (sd)**		**% / mean (sd)**	**% / mean (sd)**	
Etnicity						
Dutch	70.6	75.5	0.0	74.7	75.3	0.0
Other Western	9.2	9.5	0.0	8.5	9.4	0.0
Non-Western	20.3	15.0	0.0	16.7	15.3	0.0
Number of distinct medication types used	1.1 (1.7)	1.1 (1.7)	0.0	1.1 (1.7)	1.1 (1.7)	0.0
Health spending two years prior to delivery ($)	757.3 (3949.3)	731.8 (3357.3)	22.9	704.3 (3341.7)	721.9 (3756.7)	0.0
Household						
Number of persons in household	2.8 (1.1)	2.8 (1.1)	0.0	2.8 (1.1)	2.8 (1.1)	0.0
Standardized household income (pct)						
1-20	16.4	14.6	0.0	15.6	14.4	0.0
20-40	12.4	11.7	0.0	12.4	11.6	0.0
40-60	18.1	18.8	0.0	19.0	18.5	0.0
60-80	24.8	27.4	0.0	26.6	27.3	0.0
80-100	28.3	27.5	0.0	26.3	28.1	0.0
Health insurance payment arrears of one or both parents	4.6	3.7	0.0	3.8	3.5	0.0
Debts of one or both parents	0.5	0.7	0.0	0.6	0.6	0.0

Variables	Before Matching			After Matching		
	Non-participating MCNs	Participating MCNs	Standardized difference (unadjusted)	Non-participating MCNs	Participating MCNs	Standardized difference (unadjusted)
Number of MCNs	**64**	**6**	**NA**	**24**	**6**	**NA**
Average number of pregnancies per MCN	**8763**	**7368**	**NA**	**4712**	**4461**	**NA**
	% / mean (sd)	**% / mean (sd)**		**% / mean (sd)**	**% / mean (sd)**	
Urbanization degree						
1 (highly urban)	29.0	4.1	-0.1	11.7	4.2	-0.1
2	28.5	53.6	0.2	36.2	53.1	0.2
3	16.9	8.8	-0.1	21.3	8.9	-0.1
4	18.1	27.2	0.1	21.5	27.7	0.1
5 (rural)	7.5	6.2	0.0	9.3	6.2	0.0
Distance to hospital (in meters)	4393.6 (3839.6)	4980.4 (4233.7)	195.9	4801.4 (4208.7)	4993.6 (4243.6)	194.1
Child						
Sex						
Girl	48.5	48.3	0.0	48.5	48.9	0.0
Boy	51.5	51.7	0.0	51.5	51.1	0.0
Pregnancy						
Gravidity	2.3 (1.4)	2.2 (1.4)	0.0	2.3 (1.4)	2.2 (1.4)	0.0

MCN = Maternity Care Network; sd = standard deviation; pct = percentile; NA = not applicable.
Participating MCNs were matched to non-participating MCNs through k-means clustering based on urbanization degree of the region and number of pregnancies served annually. Standardized differences are shown to compare the population characteristics of the intervention and control group before and after matching. Based on the standardized differences after matching displayed here, the population characteristics were deemed comparable for the main analysis and additional matching on the pregnancy level was not necessary.

As overmatching can introduce bias (Ryan, 2018; Daw & Hatfield, 2018; Daw & Hatfield, 2018), we decided not to use the second matching. Instead, we adjusted for remaining imbalance by first identifying the top five variables (i.e., urbanization degree of the mother, healthcare spending of the father two years prior to delivery, age of the father, distance to the nearest hospital and age of the mother) causing imbalance through a Random Forest algorithm, and subsequently adjusting for these in the DiD analysis (Figure A3). The Random Forest supervised machine learning algorithm identifies the most important predictors for being in the intervention group, which are by default also the variables on which the populations of the participating MCNs and non-participating MCNs will differ the most, hence cause imbalance in population characteristics.

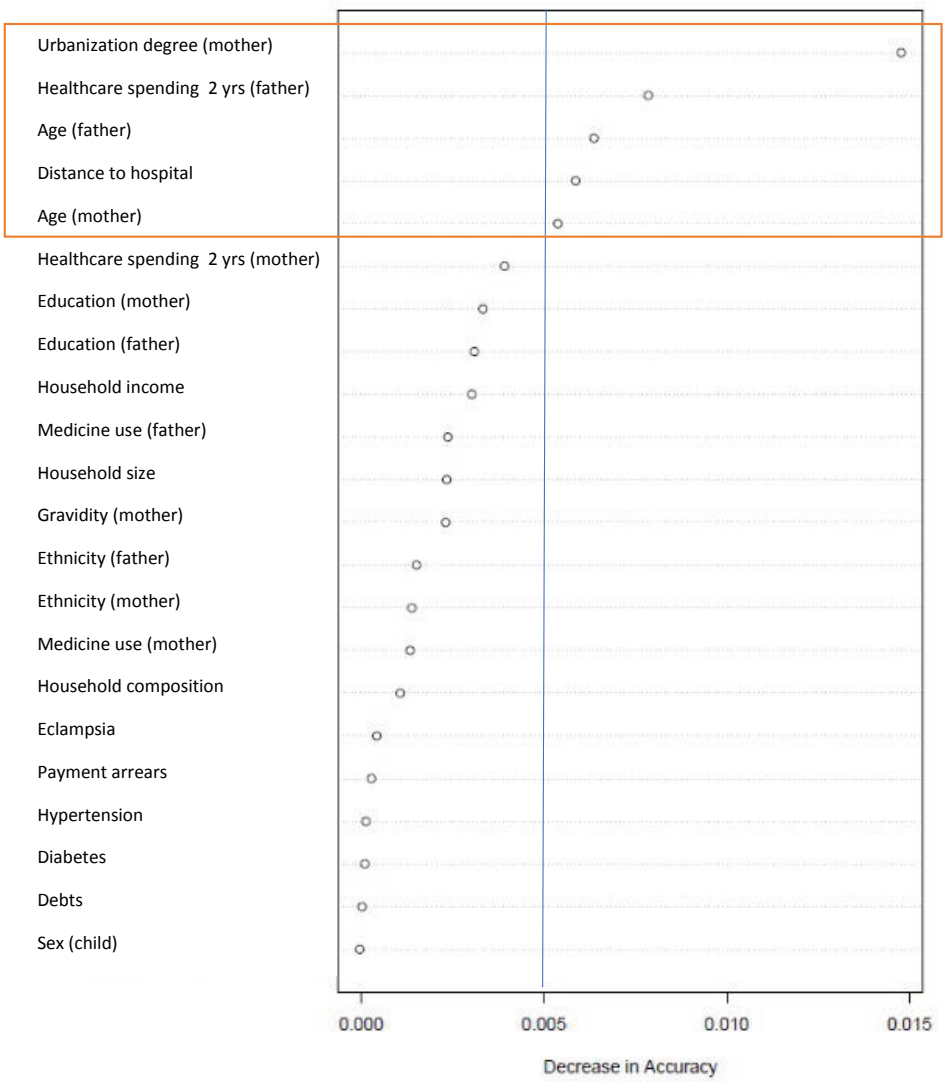


Figure A3. Results of the Random Forest to identify the top five variables causing the remaining imbalance between the intervention and control populations after matching on the organizational level (cut-off point for selection: 0.005).

We merged the dataset from the matching procedure, with the markers indicating to which cluster each MCN belonged, with the complete dataset on the pregnancy level. Through this process, a variable was added to each pregnancy (i.e., each case in the dataset) indicating to which cluster the pregnancy belonged (cluster 1, 2, 3, 4, 5, 6 or none). Pregnancies that did not belong to one of the six clusters were dropped.

An overview of the selection and exclusion process to arrive at the final study sample can be found in Figure A4.

All analyses were conducted using RStudio version 4.0.0, using the following packages: haven, foreign, readstata13, data.table, ggplot2, MatchIt, cem, car, ranger, Hmisc, twang, cobalt, xlsx, dplyr, doBy.

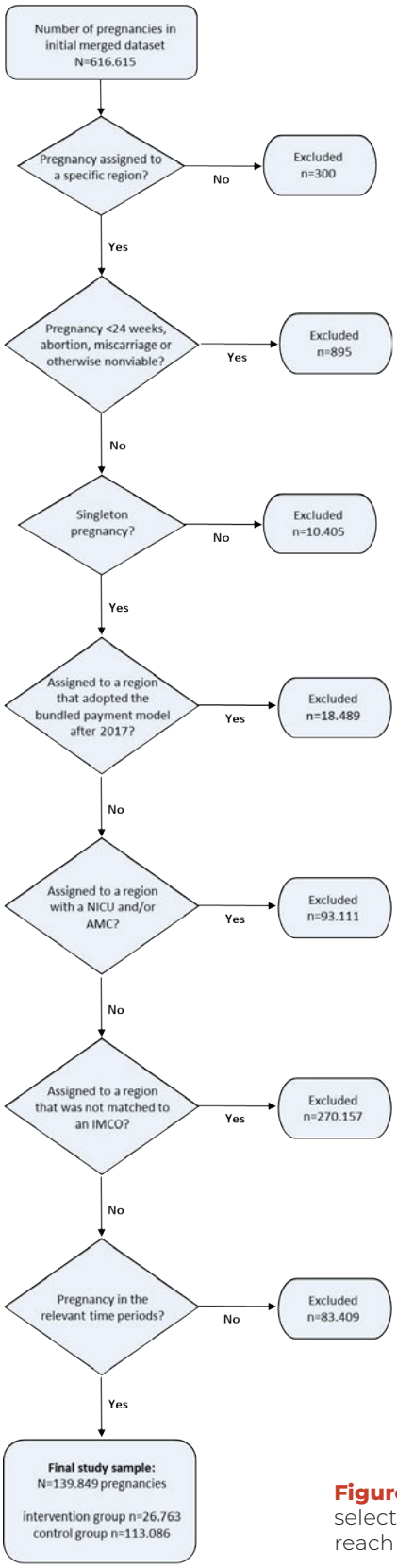


Figure A4. Flowchart of the selection and exclusion process to reach the final study sample.

We also checked the balance in population characteristics of the intervention and control group after matching, in the pre-intervention period and post-intervention period. Results of this are displayed in Table A5.

Table A5. Population characteristics of the intervention and control group (after matching) in the pre-intervention period and post-intervention period

	Non-participating MCNs (n=24)		Participating MCNs (n=6)	
Variable	**Pre-intervention**	**Post-intervention**	**Pre-intervention**	**Post-intervention**
Number of pregnancies total	**45746**	**67340**	**11914**	**14849**
Average number of pregnancies per MCN	**1906**	**2806**	**1986**	**2475**
	%	%	%	%
Casemix				
Mother				
Age (mean, sd)	31.0 (4.7)	31.0 (4.7)	30.8 (4.6)	30.8 (4.5)
Educational level				
Low	4.6	4.2	5.4	4.5
Middle	52.4	51.9	54.3	54.0
High	43.0	43.9	40.3	41.4
Etnicity				
Dutch	74.7	73.6	74.4	74.2
Other Western	9.6	9.7	10.7	11.2
Non-Western	15.8	16.8	15.0	14.5
Number of distinct medication types used (mean, sd)	1.9 (2.1)	1.9 (2.1)	1.9 (2.1)	1.9 (2.1)
Health spending two years prior to delivery (mean, sd)	2114.9 (3218.3)	2043.7 (3258.9)	2158.7 (3258.1)	2024.0 (3117.7)
Father				
Age (mean, sd)	34.0 (5.7)	33.9 (5.6)	33.8 (5.7)	33.6 (5.5)
Educational level				
Low	5.2	4.7	5.2	4.7
Middle	56.6	57.8	59.6	61.7
High	38.2	37.5	35.2	33.6
Etnicity				
Dutch	75.2	74.4	75.0	75.6
Other Western	8.4	8.6	9.3	9.5
Non-Western	16.4	17.0	15.7	14.9

	Non-participating MCNs (n=24)		Participating MCNs (n=6)	
Variable	**Pre-intervention**	**Post-intervention**	**Pre-intervention**	**Post-intervention**
Number of pregnancies total	**45746**	**67340**	**11914**	**14849**
Average number of pregnancies per MCN	**1906**	**2806**	**1986**	**2475**
	%	%	%	%
Number of distinct medication types used (mean, sd)	1.1 (1.6)	1.1 (1.7)	1.1 (1.7)	1.1 (1.7)
Health spending two years prior to delivery (mean, sd)	659.6 (2580.7)	668.6 (3493.7)	681.2 (3444.8)	681.8 (3626.3)
Household				
Number of persons in household (mean, sd)	2.8 (1.1)	2.8 (1.1)	2.8 (1.1)	2.8 (1.1)
Standardized household income (pct)				
1-20	15.7	15.6	15.3	13.8
20-40	12.8	12.2	12.2	11.1
40-60	19.2	18.9	18.1	18.9
60-80	26.4	26.8	27.1	27.5
80-100	26.0	26.5	27.4	28.7
Health insurance payment arrears of one or both parents	4.3	3.5	4.1	3.1
Debts of one or both parents	0.5	0.6	0.8	0.5
Urbanization degree				
1 (highly urban)	10.7	12.3	4.0	4.3
2	37.0	35.7	54.4	52.0
3	22.8	20.2	8.9	8.9
4	19.9	22.6	27.3	28.0
5 (rural)	9.5	9.2	5.4	6.8
Distance to hospital (in meters) (mean, sd)	4762.8 (4127.8)	4828.0 (4263.2)	4958.6 (4241.2)	5022.1 (4245.5)
Child				
Sex				
Girl	48.6	48.5	48.6	49.1
Boy	51.4	51.5	51.4	50.9
Pregnancy				
Size (singleton/multiple) (mean, sd)	1.0 (0.0)	1.0 (0.0)	1.0 (0.0)	1.0 (0.0)
Gravidity (mean, sd)	2.3 (1.4)	2.3 (1.4)	2.2 (1.4)	2.2 (1.4)

Appendix 4: Model for the difference-in-differences analysis

We estimated the effect of bundled payments on maternity care utilization, spending and health outcomes with the following equation:

$$1) \qquad Y_{p,j,t} = \beta_0 + \beta_1 \times IMCO_j + \beta_2 \times t + \beta_3 \times IMCO_j \times t + \sum_{p \epsilon P, j \epsilon J} \beta_{p,j} \times X_{p,j,t}$$

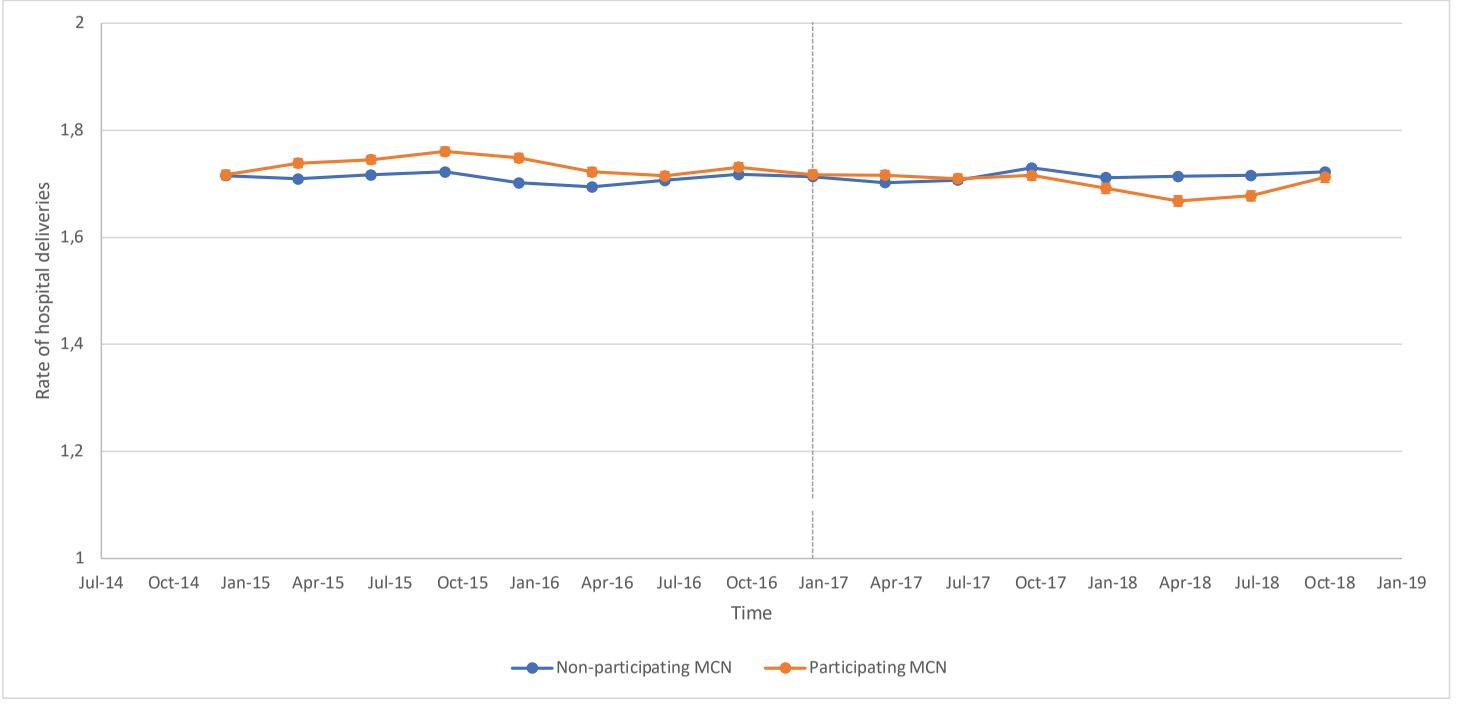
Where $Y_{p,j,t}$ measures healthcare utilization, spending and health outcomes for pregnancy *p* in IMCO/MCN *j* in year *t*. We account for the distribution of the outcomes: we use a generalized linear model with gamma distribution and log-link $\left(Log\left(Y_{p,j,t}\right) = \sum_{p \epsilon P, j \epsilon J} \beta_{p,j} \times X_{p,j,t}\right)$ for spending and a logistic regression and logit link $\left(logit\left(Pr\left(Y_{p,j,t} = 1 \middle| X_{p,j,t}\right)\right) = \sum_{p \epsilon P, j \epsilon J} \beta_{p,j} \times X_{p,j,t}\right)$ for health outcomes and utilization.

β_0 is the constant. β_1 is a coefficient for the treatment effect with $IMCO_j$ indicating whether provider network *j* is in the intervention group with bundled payments (IMCOs). β_2 is a coefficient for the time effect *t,* operationalized as a categorical variable for the year. β_3 is a coefficient for the interaction effect of time and treatment (i.e. the coefficient that captures the difference-in-differences estimate). $\sum_{p \epsilon P, j \epsilon J} \beta_{pj} \times X_{p,j,t}$ represents the sum of the product of each covariate (of year (time) and IMCO/MCN fixed effects, and case-mix variables) and their corresponding covariate.

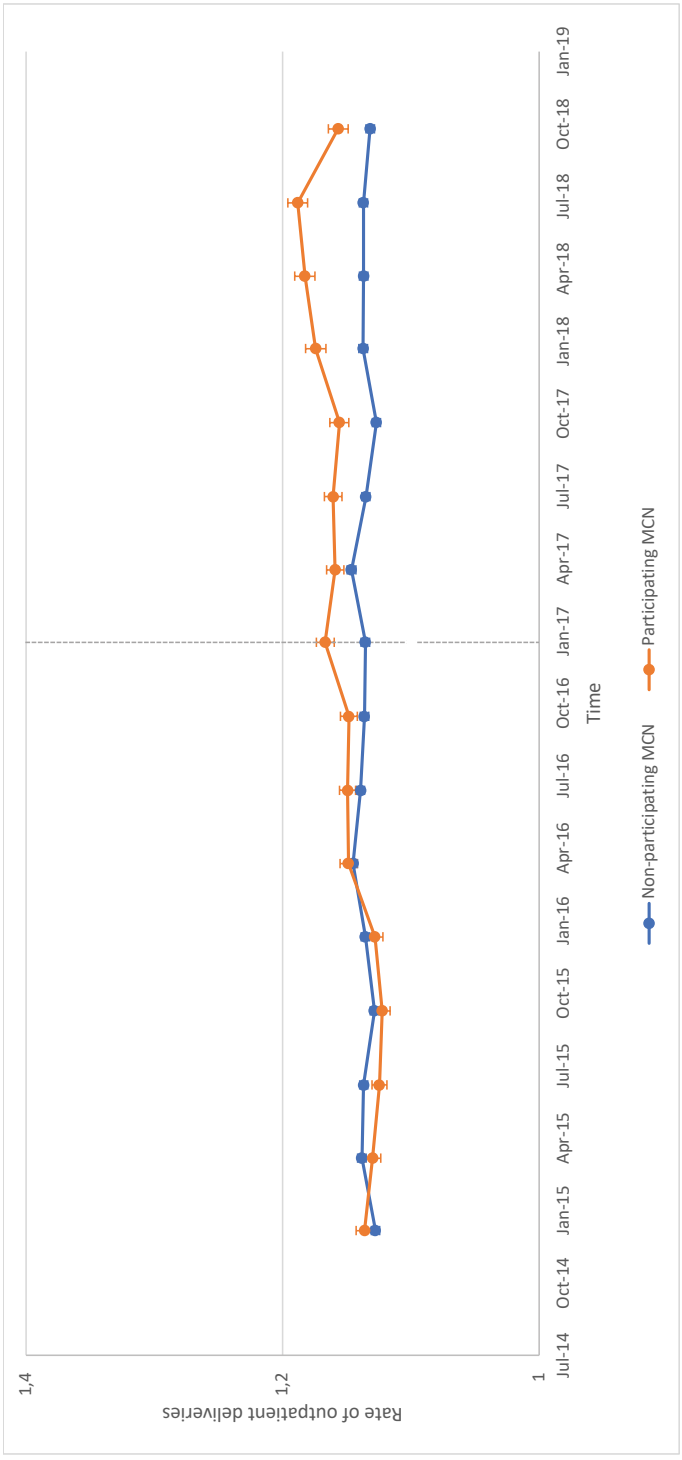
In adjusted analysis, we estimated the DiD model within each cluster of participating MCNs with matched non-participating MCNs, and we pooled each subclass-specific DiD estimate to derive an overall DiD estimate for each outcome (see also Ruijsbroek et al., 2017). We took into account the distribution of the outcomes and we used a generalized linear model with gamma distribution and log-link for spending and a logistic regression for health outcomes and utilization. We obtained 95% confidence intervals around our estimates of the mean differences using the bootstrap resampling method with 10,000 resamples. The estimates were converted to scales that were easier to interpret (i.e., dollars, euros or percentages). All analyses were conducted using RStudio version 4.0.0.

Figure A5. Pre-trends of the outcome measures in the intervention and control group to visually assess the parallel trend assumption

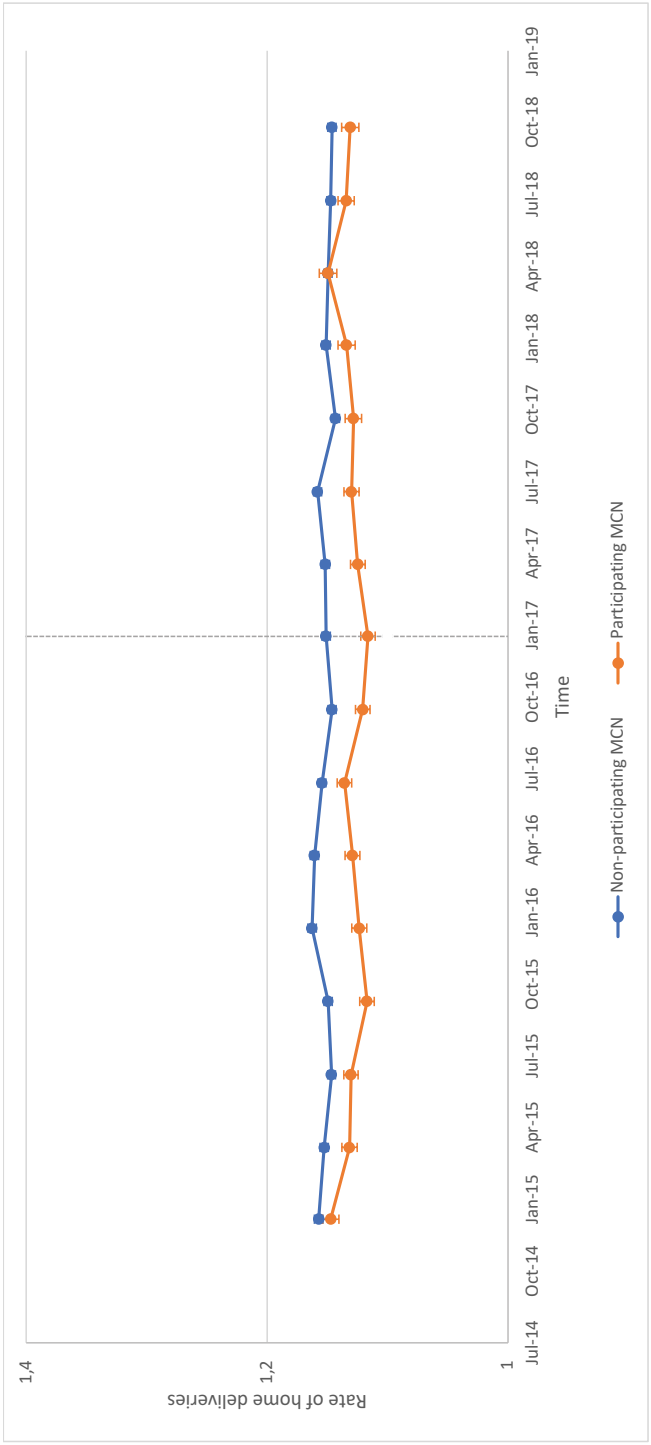
Place of birth: hospital deliveries (obstetrician-led)



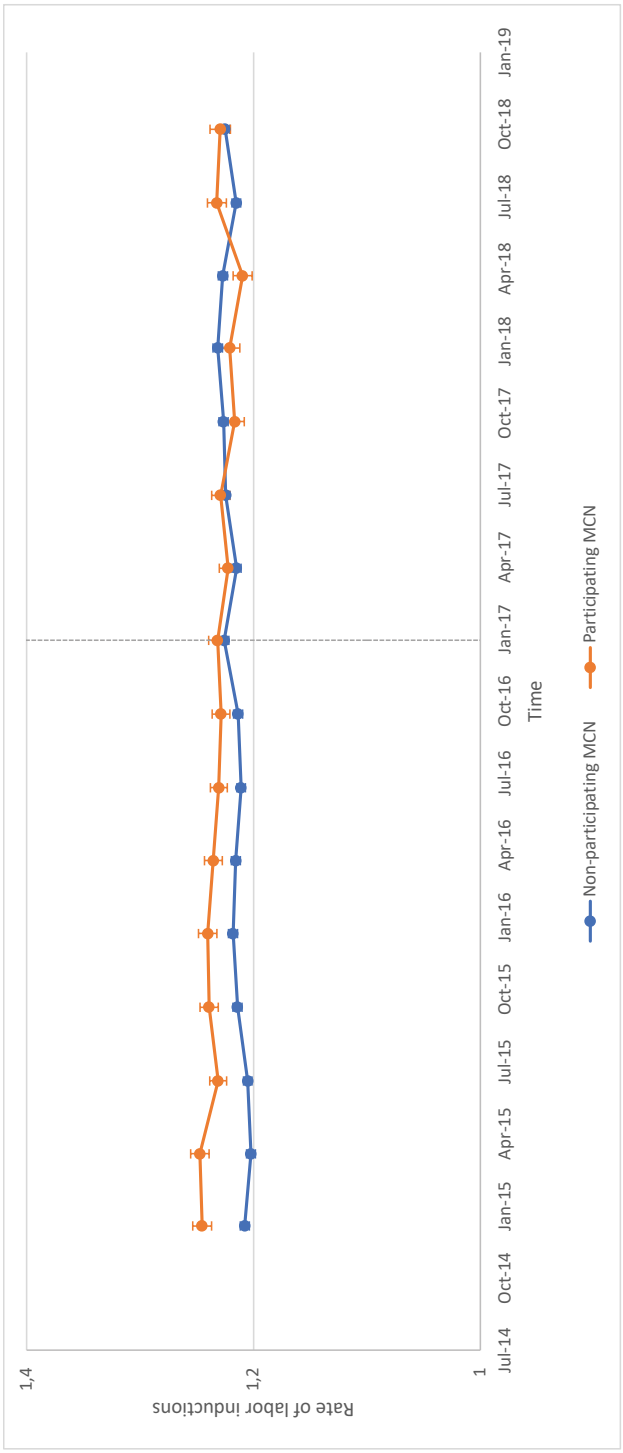
Place of birth: outpatient deliveries in the hospital (midwife-led)

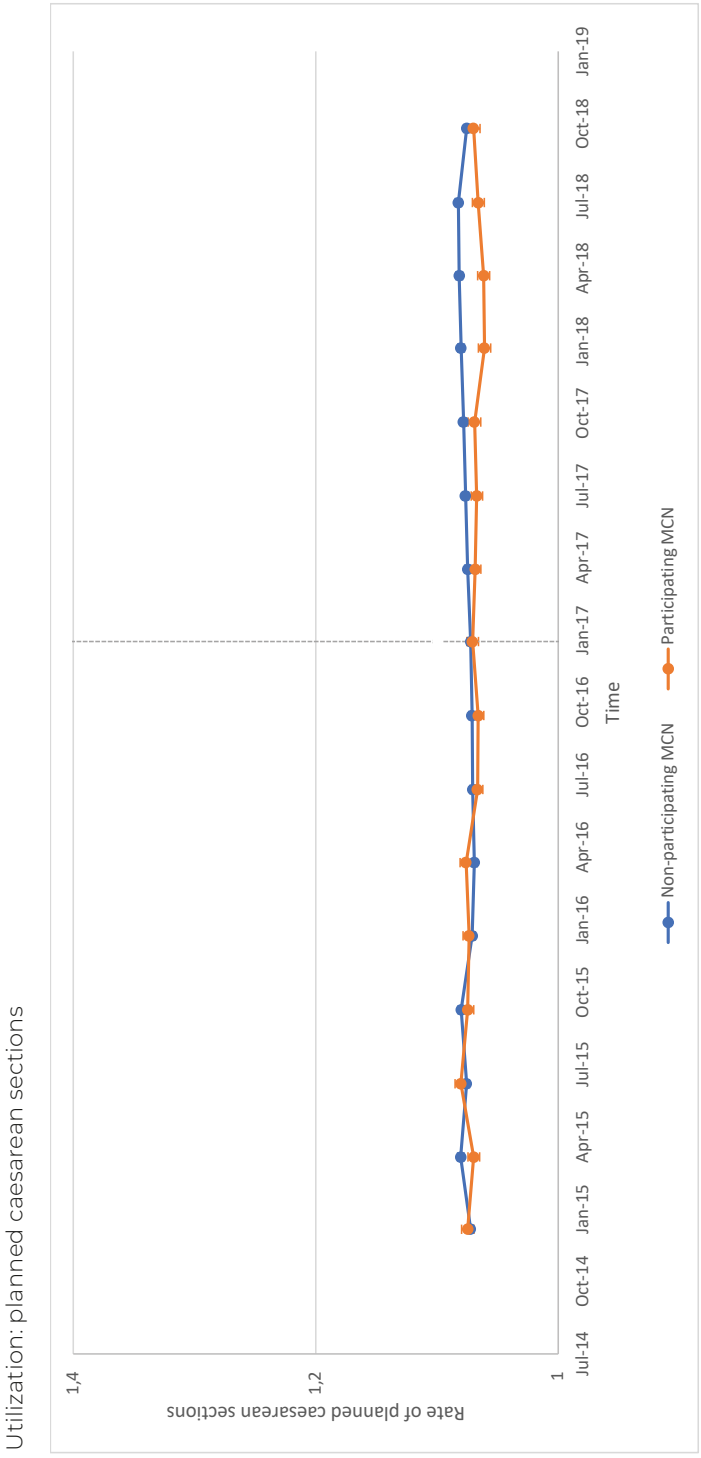


Place of birth: home deliveries

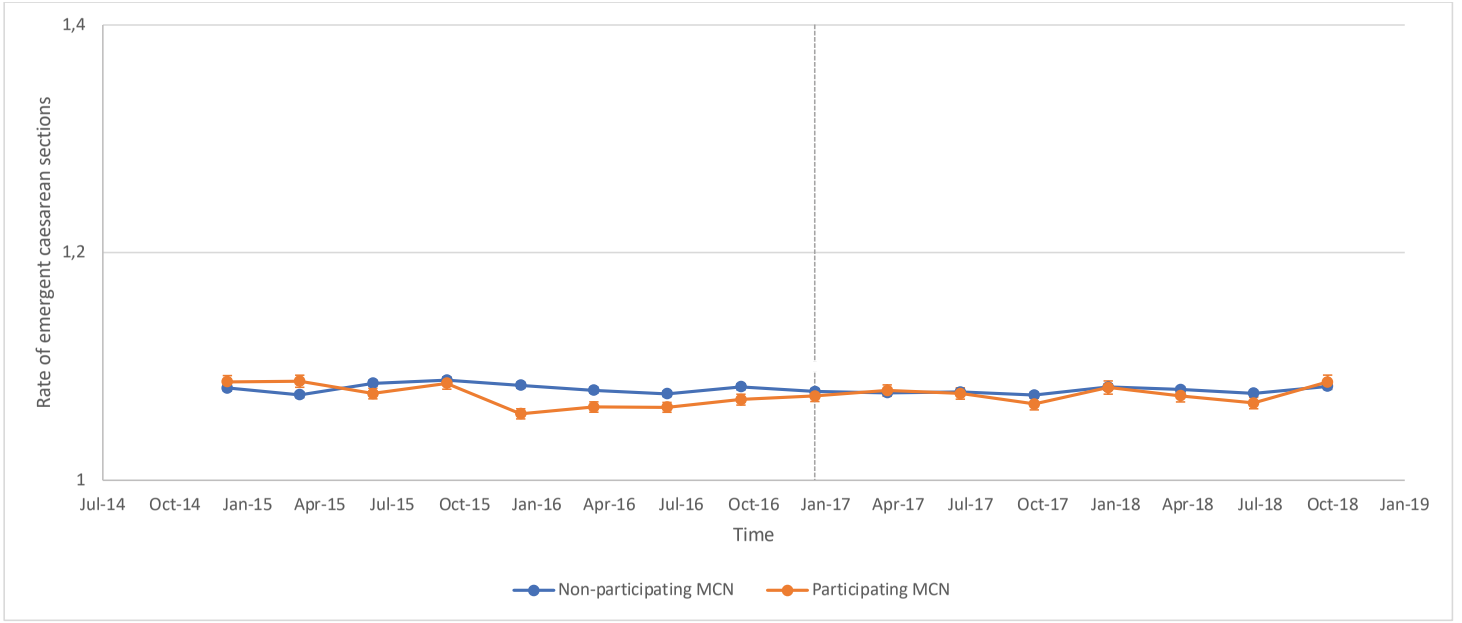


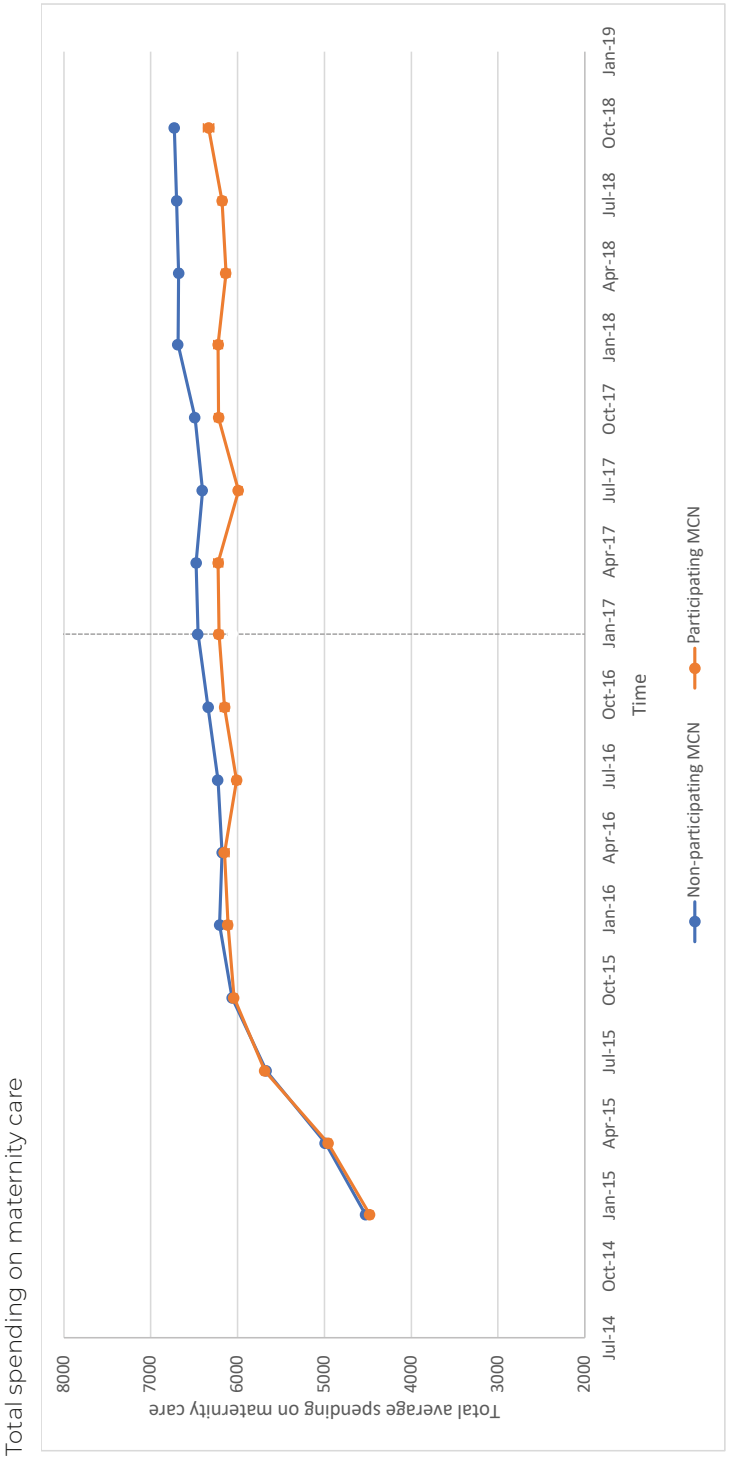
Utilization: labor inductions



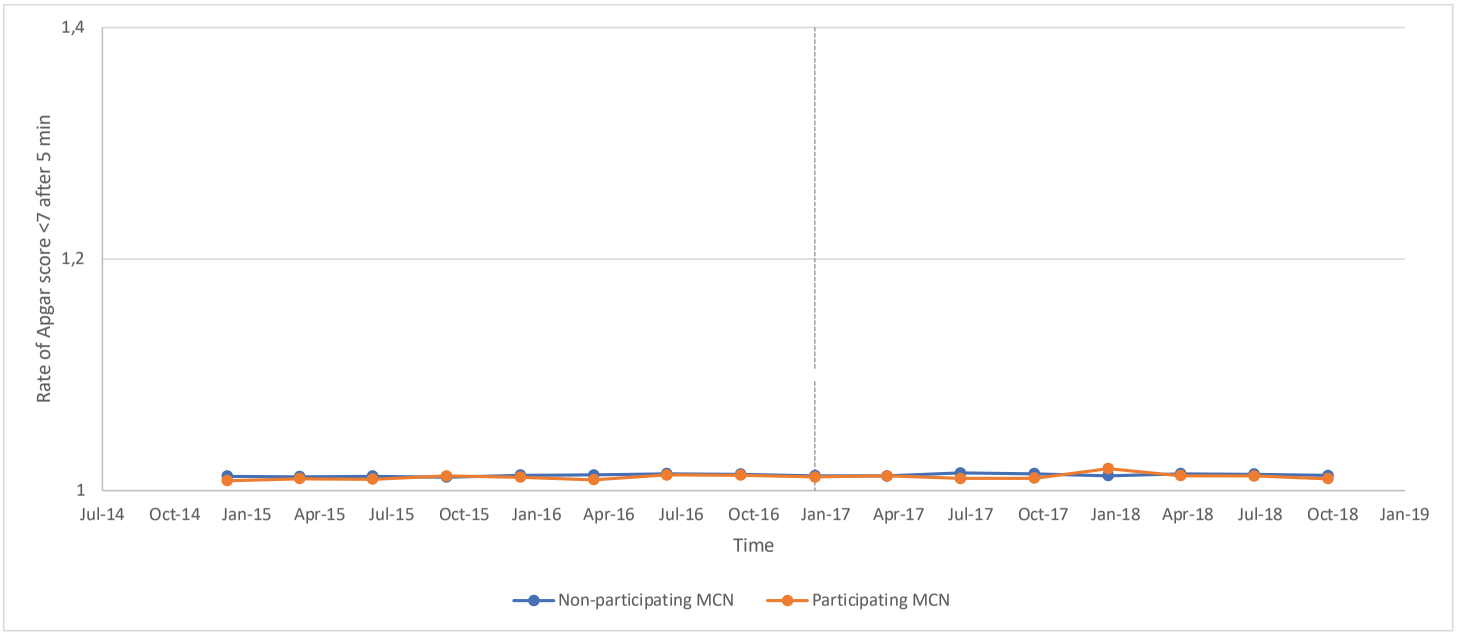

Utilization: planned caesarean sections
Rate of planned caesarean sections
1,4
1,2
1
Jul-14
Oct-14
Jan-15
Apr-15
Jul-15
Oct-15
Jan-16
Apr-16
Jul-16
Oct-16
Jan-17
Apr-17
Jul-17
Oct-17
Jan-18
Apr-18
Jul-18
Oct-18
Jan-19
Time
Non-participating MCN
Participating MCN

Utilization: emergency caesarean sections

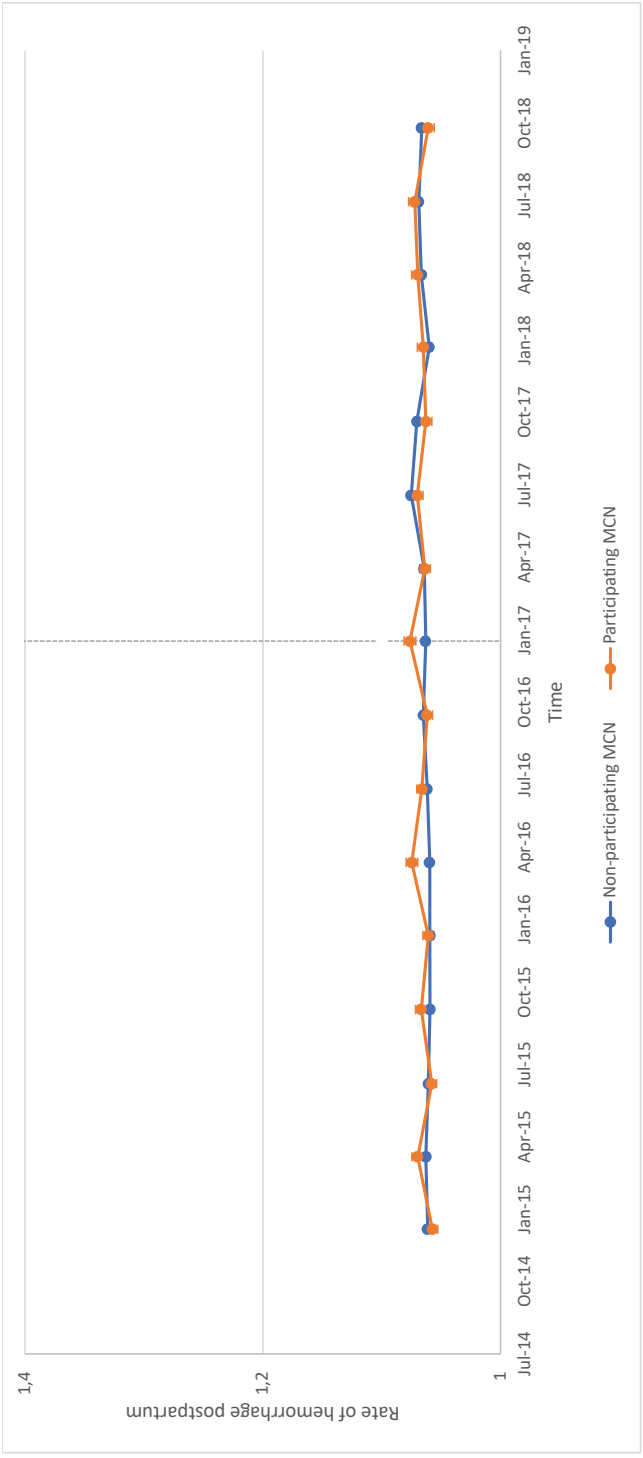



Total spending on maternity care
Total average spending on maternity care
8000
7000
6000
5000
4000
3000
2000
Jul-14
Oct-14
Jan-15
Apr-15
Jul-15
Oct-15
Jan-16
Apr-16
Jul-16
Oct-16
Jan-17
Apr-17
Jul-17
Oct-17
Jan-18
Apr-18
Jul-18
Oct-18
Jan-19
Time
Non-participating MCN
Participating MCN

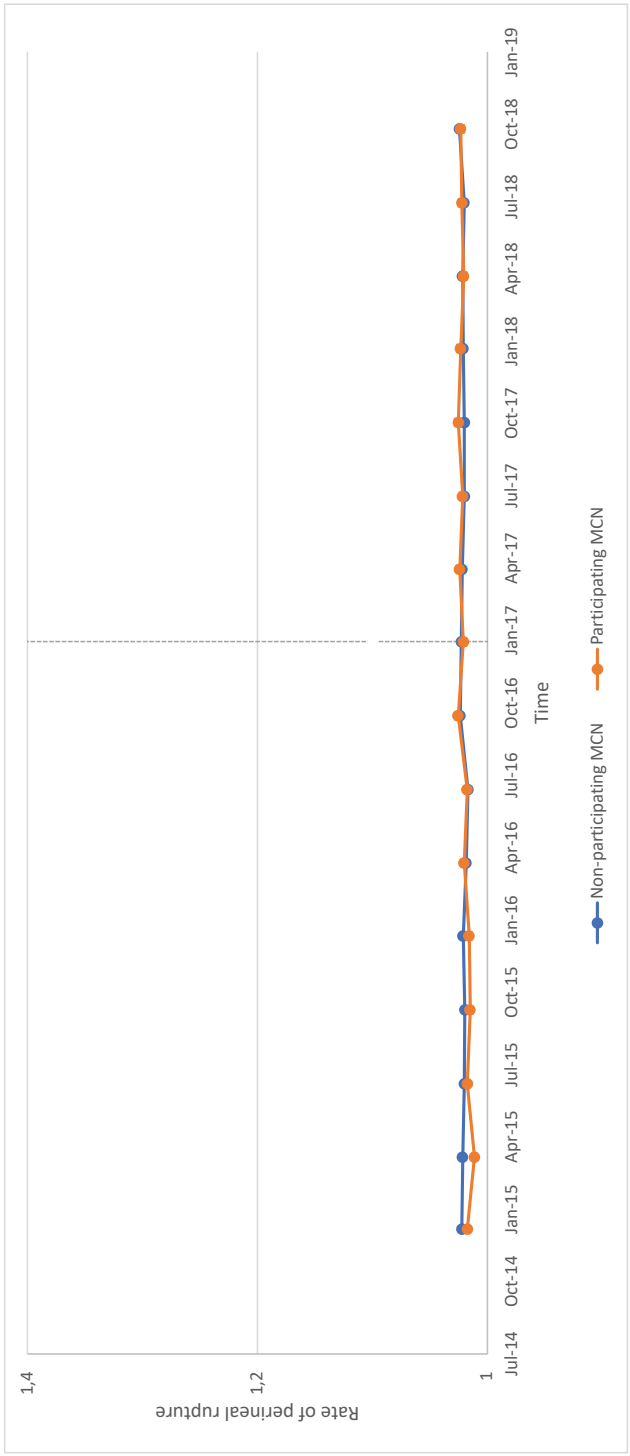
Health outcomes: Apgar score



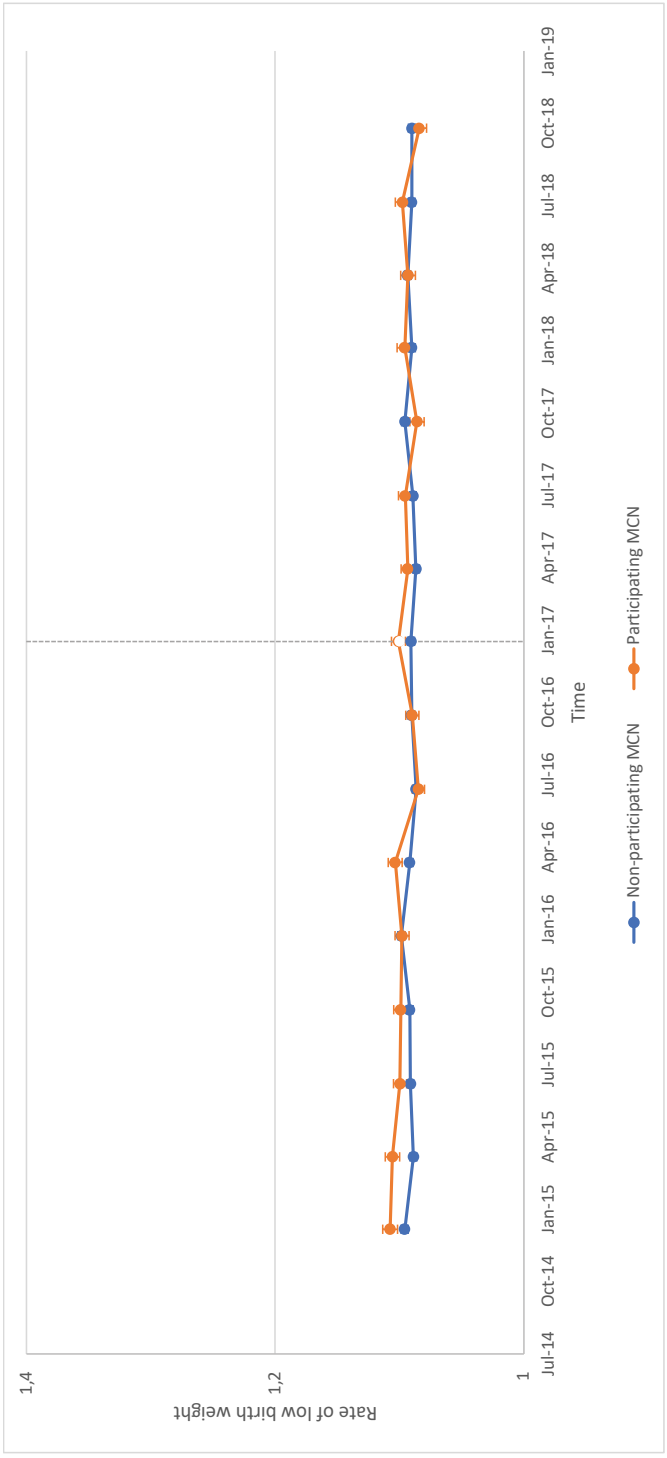
Health outcomes: hemorrhage postpartum



Health outcomes: perineal rupture



Health outcomes: low birth weight



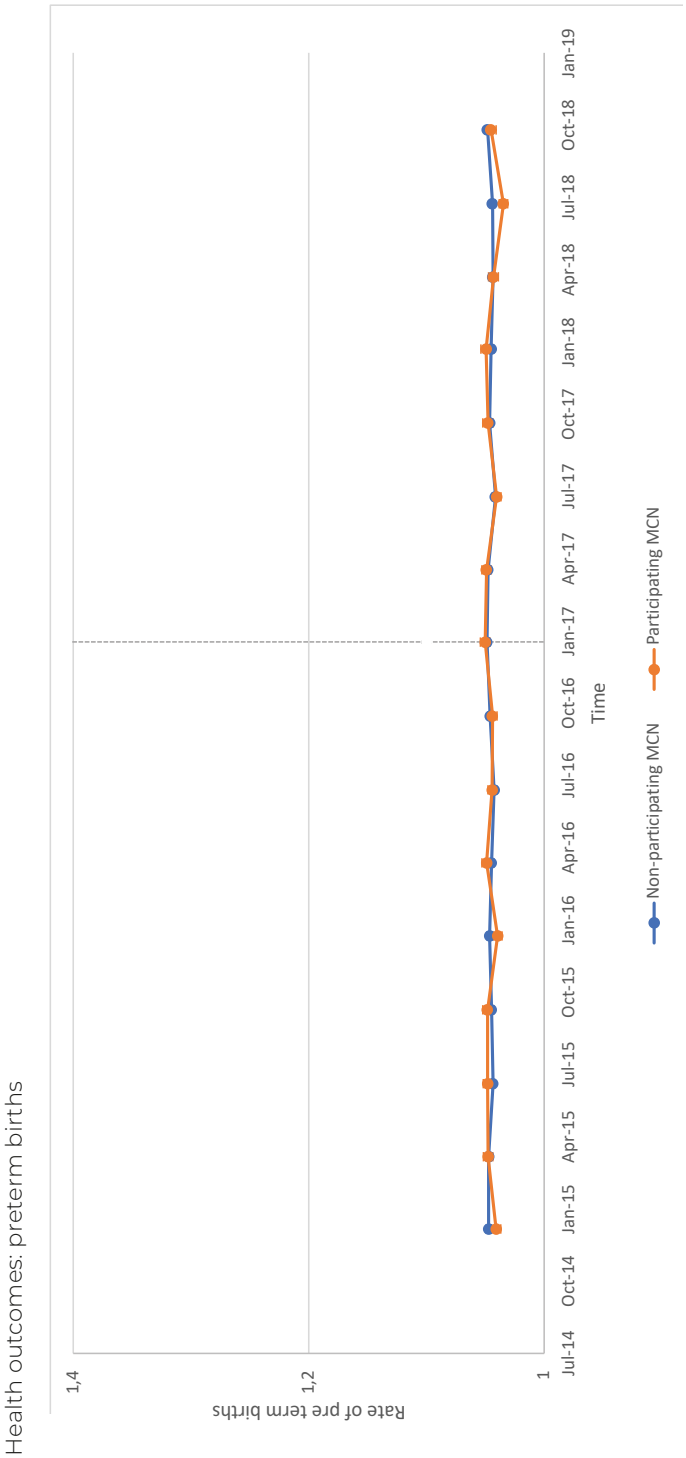
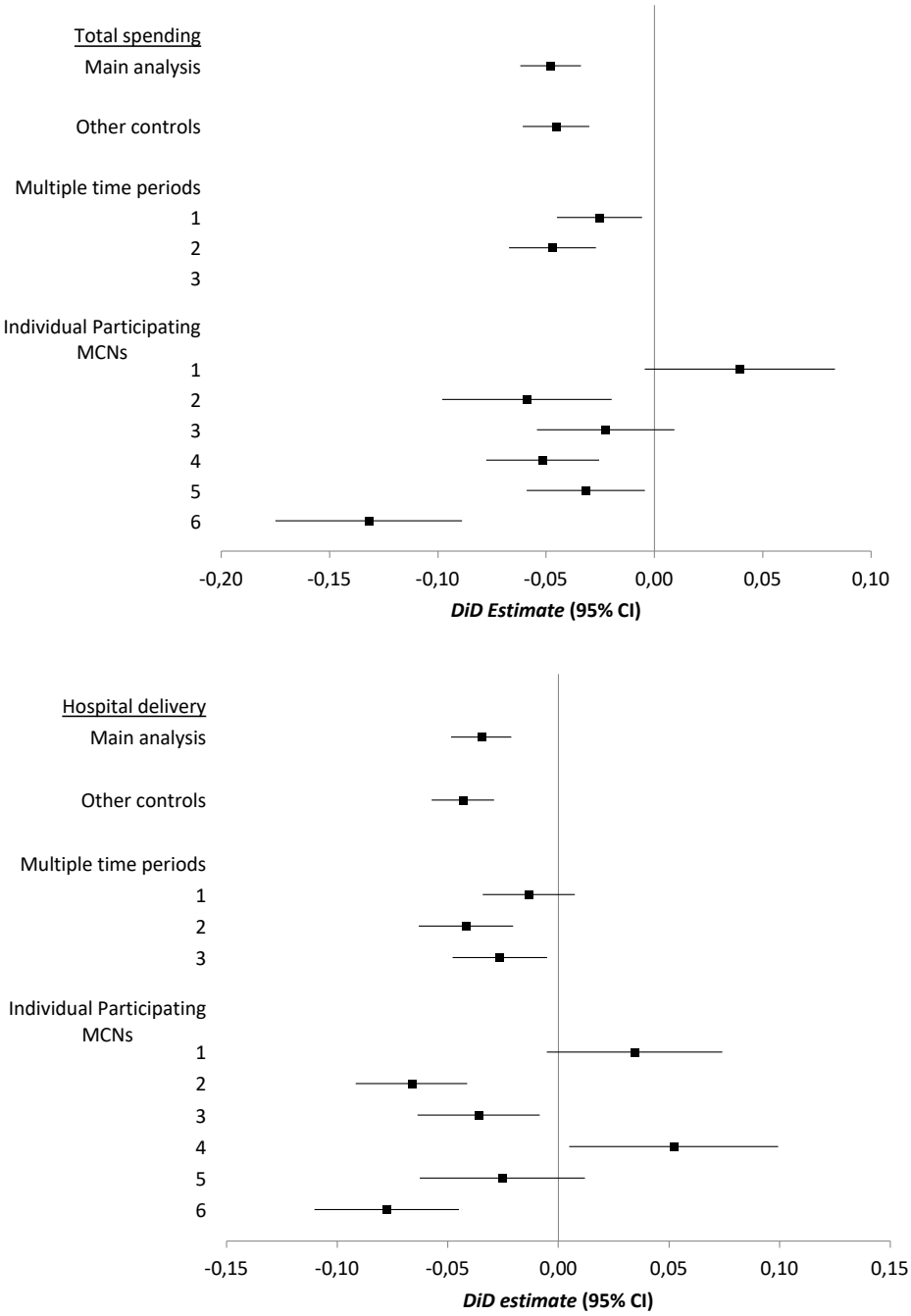
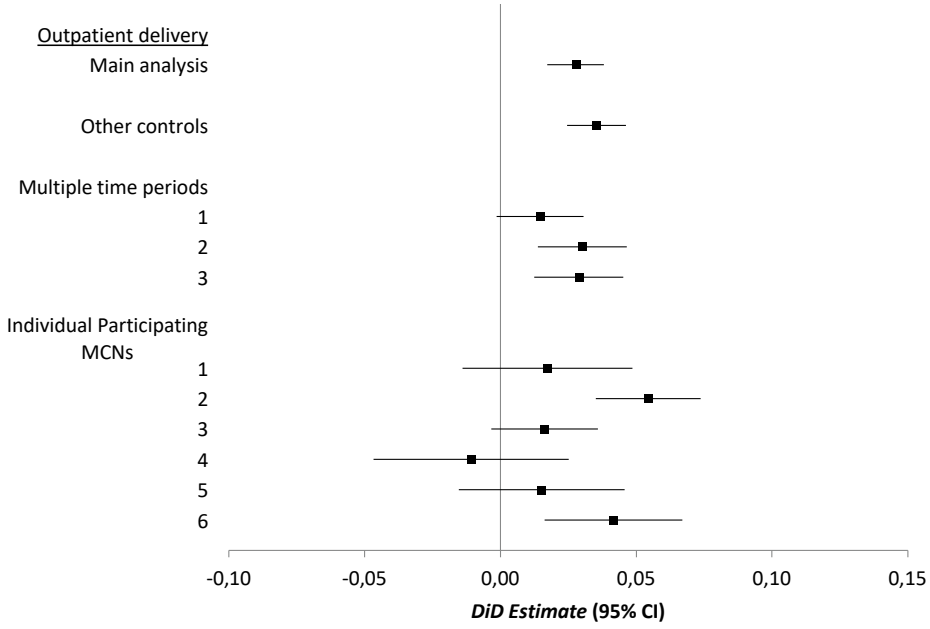
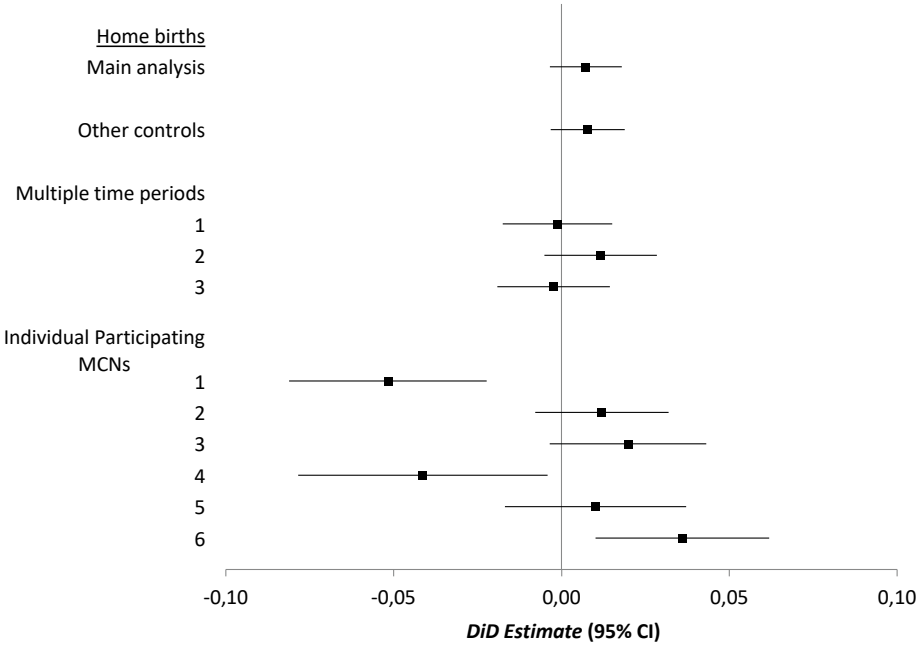
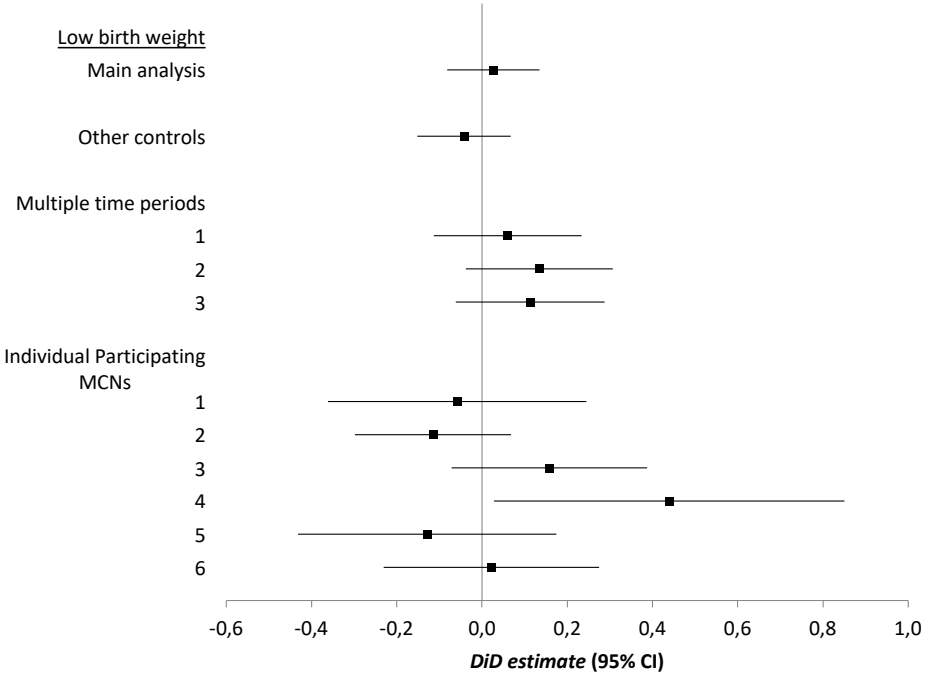

Health outcomes: preterm births
Rate of pre term births
1,4
1,2
1
Jul-14
Oct-14
Jan-15
Apr-15
Jul-15
Oct-15
Jan-16
Apr-16
Jul-16
Oct-16
Jan-17
Apr-17
Jul-17
Oct-17
Jan-18
Apr-18
Jul-18
Oct-18
Jan-19
Time
Non-participating MCN
Participating MCN

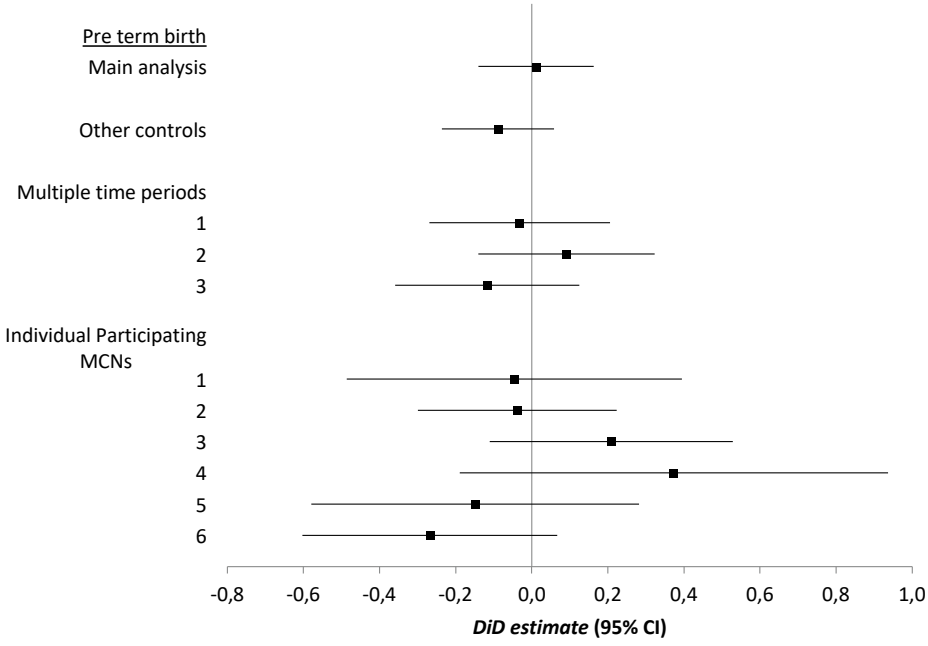
Figure A6. Forest plots of changes in outcomes associated with the bundled payment model for maternity care.

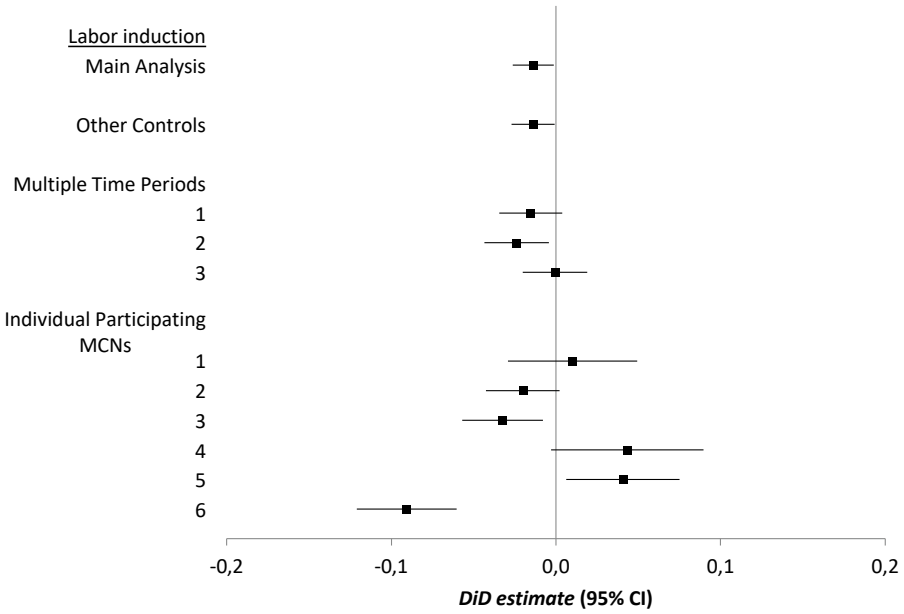


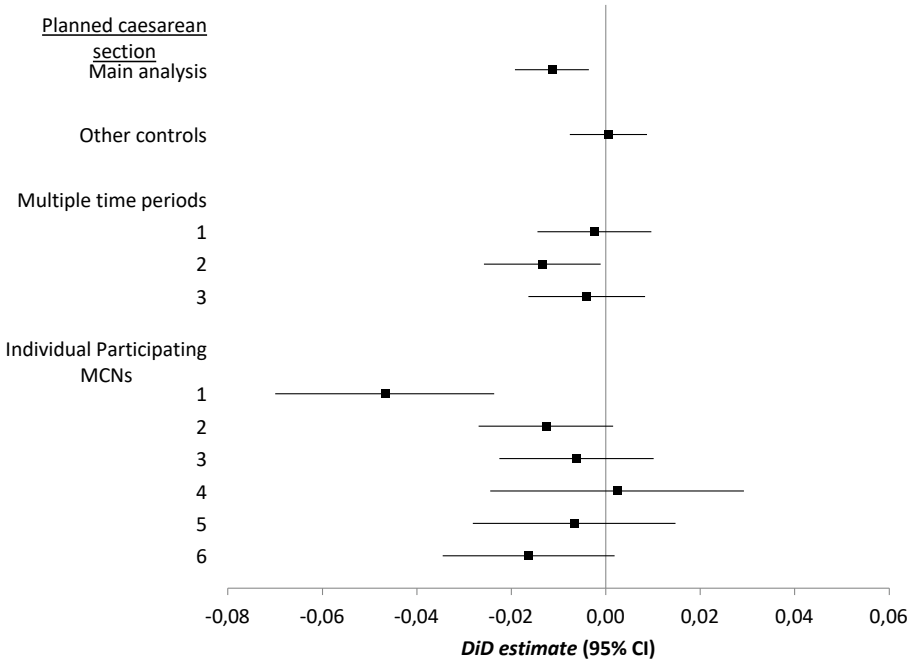

Outpatient delivery
Main analysis
Other controls
Multiple time periods
1
2
3
Individual Participating MCNs
1
2
3
4
5
6
-0,10
-0,05
0,00
0,05
0,10
0,15
DiD Estimate (95% CI)

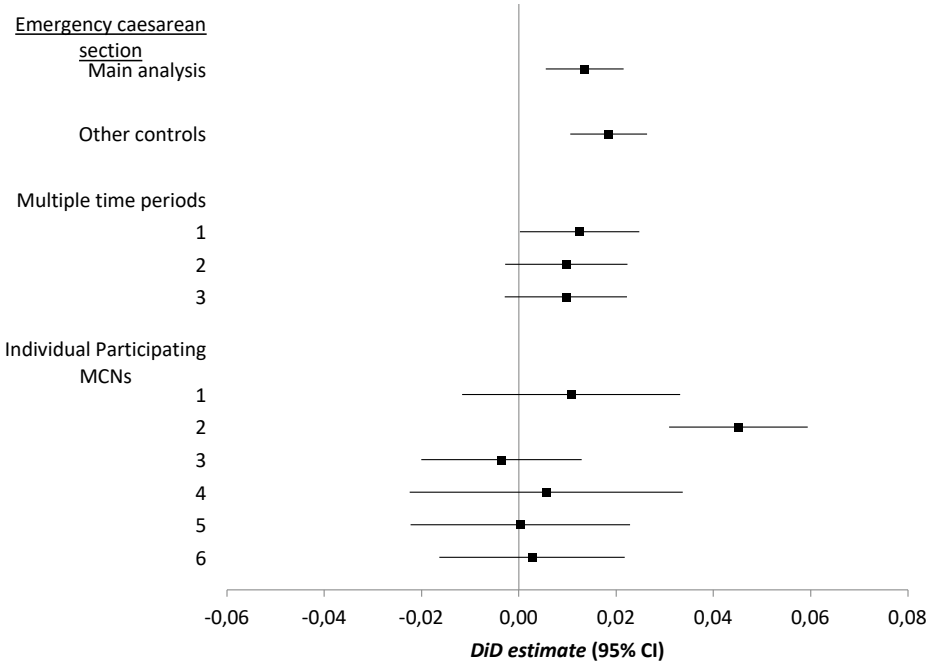

Home births
Main analysis
Other controls
Multiple time periods
1
2
3
Individual Participating MCNs
1
2
3
4
5
6
-0,10
-0,05
0,00
0,05
0,10
DiD Estimate (95% CI)

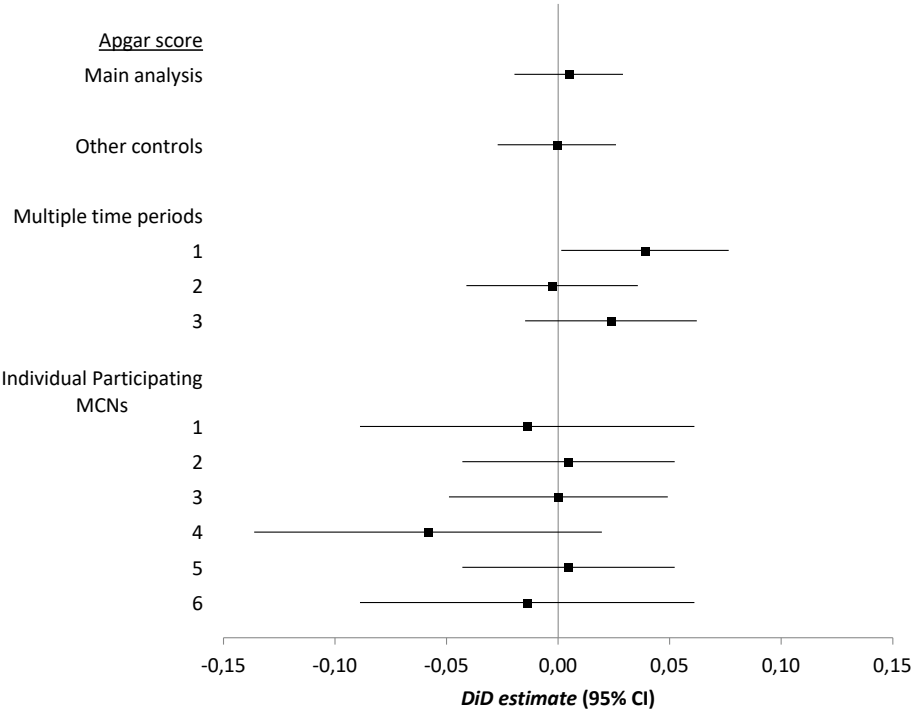

Low birth weight
Main analysis
Other controls
Multiple time periods
1
2
3
Individual Participating MCNs
1
2
3
4
5
6
-0,6
-0,4
-0,2
0,0
0,2
0,4
0,6
0,8
1,0
DiD estimate (95% CI)

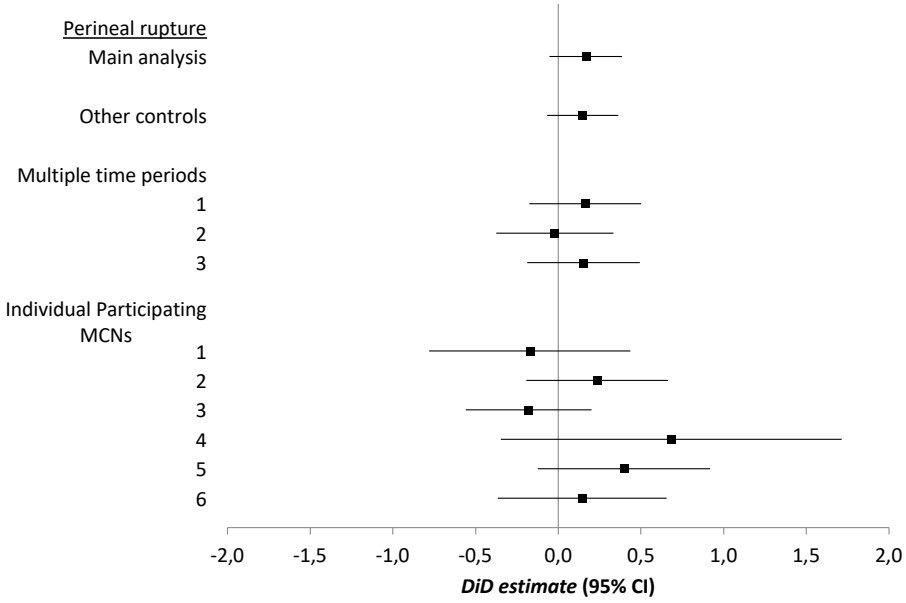

Pre term birth
Main analysis
Other controls
Multiple time periods
1
2
3
Individual Participating MCNs
1
2
3
4
5
6
-0,8
-0,6
-0,4
-0,2
0,0
0,2
0,4
0,6
0,8
1,0
DiD estimate (95% CI)

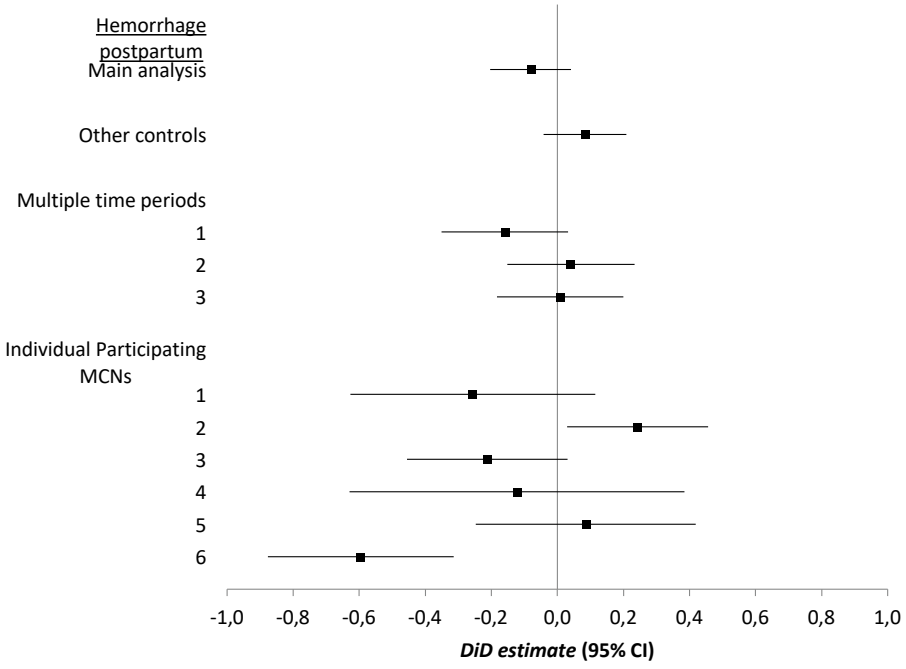

Labor induction
Main Analysis
Other Controls
Multiple Time Periods
1
2
3
Individual Participating MCNs
1
2
3
4
5
6
-0,2
-0,1
0,0
0,1
0,2
DiD estimate (95% CI)


Planned caesarean section
Main analysis
Other controls
Multiple time periods
1
2
3
Individual Participating MCNs
1
2
3
4
5
6
-0,08
-0,06
-0,04
-0,02
0,00
0,02
0,04
0,06
DiD estimate (95% CI)


Emergency caesarean section
Main analysis
Other controls
Multiple time periods
1
2
3
Individual Participating MCNs
1
2
3
4
5
6
-0,06
-0,04
-0,02
0,00
0,02
0,04
0,06
0,08
DiD estimate (95% CI)


Apgar score
Main analysis
Other controls
Multiple time periods
1
2
3
Individual Participating MCNs
1
2
3
4
5
6
-0,15
-0,10
-0,05
0,00
0,05
0,10
0,15
DiD estimate (95% CI)


Perineal rupture
Main analysis
Other controls
Multiple time periods
1
2
3
Individual Participating MCNs
1
2
3
4
5
6
-2,0
-1,5
-1,0
-0,5
0,0
0,5
1,0
1,5
2,0
DiD estimate (95% CI)


Hemorrhage postpartum
Main analysis
Other controls
Multiple time periods
1
2
3
Individual Participating MCNs
1
2
3
4
5
6
-1,0
-0,8
-0,6
-0,4
-0,2
0,0
0,2
0,4
0,6
0,8
1,0
DiD estimate (95% CI)

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