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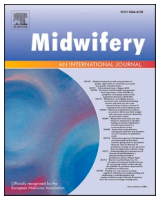

Midwifery continuity of care, breastfeeding and neonatal hyperbilirubinemia: A retrospective cohort study

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ABSTRACT

Aim: To examine the association between Midwifery Continuity of Care (MCoC) and exclusive breastfeeding at hospital discharge and neonatal hyperbilirubinemia.
Methods: A matched cohort design was employed using data from the Swedish Pregnancy Register. The study included 12,096 women who gave birth at a university hospital in Stockholm, Sweden from January 2019 to August 2021. Women and newborns cared for in a MCoC model were compared with a propensity-score matched set receiving standard care. Risk ratios (RR) were determined with 95 % confidence intervals (CI) based on the matched cohort through modified Poisson regressions with robust standard error. A mediation analysis assessed the direct and indirect effects of MCoC on exclusive breastfeeding at hospital discharge and neonatal hyperbilirubinemia and to what extent the association was mediated by preterm birth.
Finding: Findings showed that MCoC was associated with a higher chance of exclusive breastfeeding rate (RR: 1.06, 95 % CI: 1.01–1.12) and lower risk of neonatal hyperbilirubinemia (RR: 0.51, 95 % CI: 0.32–0.82) compared with standard care. Mediation analysis demonstrated that lower preterm birth accounted for approximately 28 % of total effect on the reduced risk of neonatal hyperbilirubinemia.
Discussion/Conclusion: This matched cohort study provided preliminary evidence that MCoC models could be an intervention for improving exclusive breastfeeding rates at hospital discharge and reducing the risk of neonatal hyperbilirubinemia.

Introduction

Neonatal hyperbilirubinemia is a common condition that affects more than 80 % of newborns, manifesting in varying degrees (Kemper et al., 2022). While phototherapy is an effective treatment for excessive hyperbilirubinemia, the most serious and feared complication known as bilirubin encephalopathy or kernicterus remains a leading cause of mortality and disability, not only in low and middle-income countries but also in High-Income Countries (HICs) (Lee et al., 2016). A 2019 study found that one in five infants with extremely high bilirubin levels developed kernicterus, and more than half of these cases occurred due to a lack of screening, delayed diagnosis or treatment, even in HICs like Sweden (Alkén et al., 2019).

Physiological hyperbilirubinemia typically manifests within 2 to 4 days after birth and often resolves naturally without intervention within 1 to 2 weeks (Jardine and Woodgate, 2011). Neonatal hyperbilirubinemia arises from an imbalance in bilirubin production and liver elimination (Kaplan et al., 2002; Stevenson and Wong, 2021). Infants with high bilirubin production (e.g., hemolysis) or limited hepatic bilirubin processing ability may develop non-physiological hyperbilirubinemia, characterized by excessive levels of circulating bilirubin (Stevenson and Wong, 2021).

Neonatal hyperbilirubinemia is a leading cause of newborn hospitalization (Lin et al., 2022). To identify rapidly rising or dangerously

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high levels of bilirubin in the neonate, early detection through transcutaneous or serum bilirubin determinations are needed to initiate treatment in time and prevent severe adverse neonatal outcomes and even death (Aune et al., 2020). Neonatal hyperbilirubinemia can be categorized as nonhemolytic, which is the most frequent, or hemolytic. The top risk factor for nonhemolytic hyperbilirubinemia is preterm birth (Lee et al., 2016) and vacuum extraction in term newborns (Norman et al., 2015). Other risk factors include a history of having a previous infant diagnosed with neonatal hyperbilirubinemia, maternal origin from East or South-East Asia, primiparity, and obesity. Elective cesarean (Norman et al., 2015) and maternal smoking has been shown to lower risk of hyperbilirubinemia (Lee et al., 2016).

The emphasis of the American Academy of Pediatrics' clinical practice guideline addresses strategies for primary prevention of hyperbilirubinemia such as providing feeding support (Kemper et al., 2022). Breastfeeding has been associated with reduced hyperbilirubinemia and lower risk of hyperbilirubinemia requiring treatment (Hudson et al., 2020; Lin et al., 2022). Midwives are well positioned to prevent hyperbilirubinemia via encouraging and educating women about breastfeeding as well as providing support throughout the antenatal and postpartum periods (Shipton et al., 2022). Moreover, midwives play a frontline role in neonatal hyperbilirubinemia screening, especially with the growing trend of screening in home settings (Thomas et al., 2022).

Midwifery Continuity of Care (MCoC) is defined as a care model in which perinatal care is delivered by the same midwife or small group of midwives throughout the childbearing cycle who provide continuous relational maternity care from early pregnancy, during birth, and postpartum (Sandall et al., 2024). MCoC routinely includes care at home after hospital discharge, including breastfeeding support or formula feeding support and neonatal care advice. There are significant results that support the positive effect of MCoC on mother and newborn outcomes. Findings from a Cochrane review indicate that women who received MCoC were less likely to require medical interventions such as instrument birth and cesarean section and more likely to be satisfied with care, information, support, and advice (Sandall et al., 2024). In the review, 8 trials investigated the association between MCoC and the initiation of breastfeeding, showing little or no difference between MCoC versus standard care (average RR 1.06, 95 % CI 1.00 to 1.12) (Sandall et al., 2024). The effect of MCoC on the risk of neonatal hyperbilirubinemia has, to our knowledge, not been evaluated previously. The purpose of this study was to examine the association between exclusive breastfeeding at hospital discharge and the risk of neonatal hyperbilirubinemia among maternal/child dyads who received MCoC versus standard care. We also examined to what extent the association between care model and neonatal hyperbilirubinemia and exclusive breastfeeding at hospital discharge was mediated through preterm birth.

Participants, ethics and methods

Study design and population

Data on all births at a hospital providing both MCoC and standard care from January 1, 2019 to August 31, 2021 were extracted from the Swedish Pregnancy Register, including information on maternal medical history, antenatal and obstetrical care from pregnancy until postpartum, exclusive breastfeeding at hospital discharge and a diagnosis of treated neonatal hyperbilirubinemia. A matched cohort study was designed to assess the association between MCoC versus standard care and exclusive breastfeeding at hospital discharge and neonatal hyperbilirubinemia. During this time no other MCoC models in the study region were available. Based on propensity scores (Austin, 2011), maternal/child dyads receiving the MCoC model were matched (1:3) to maternal/child dyads receiving standard care (Fig. 1).

Data source and study setting

The Swedish Pregnancy Register (www.graviditetsregistret.se)

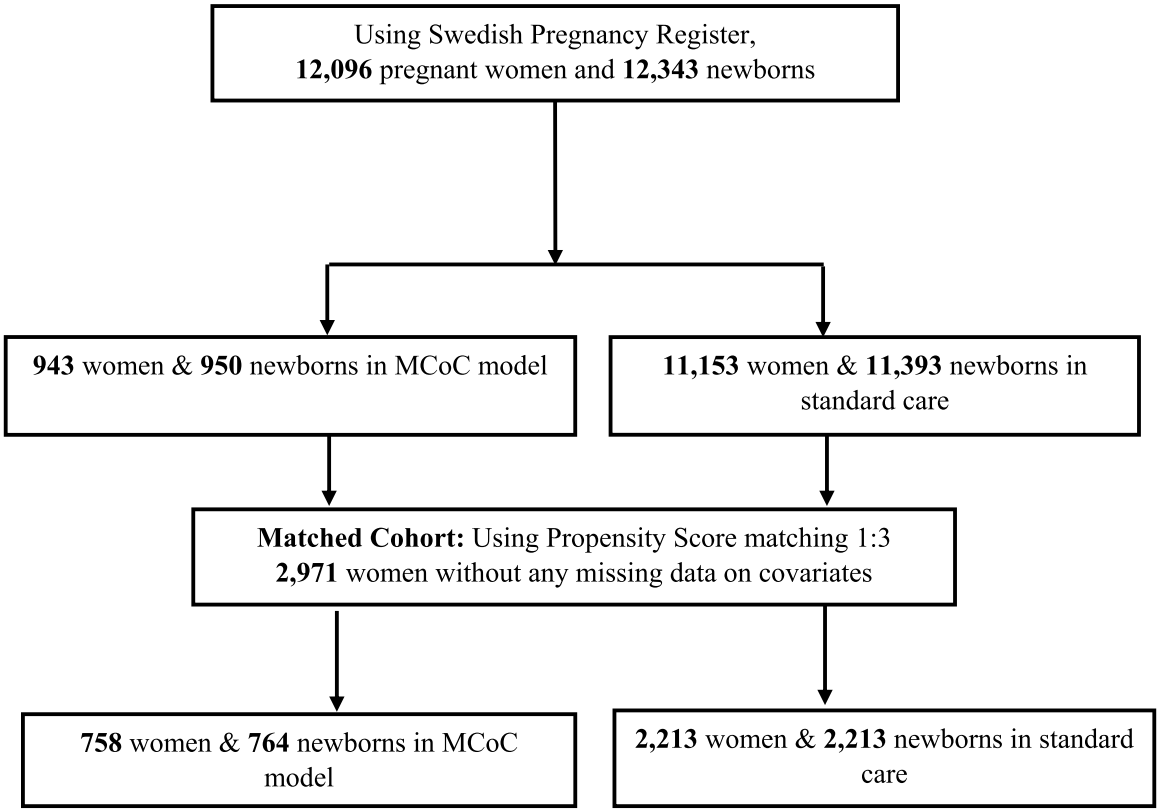

Fig. 1. Flowchart of sampling.

gathers data from pregnancy and childbirth electronic medical records, beginning with the initial antenatal appointment and terminating with the follow-up postpartum visit, routinely between 8 and 16 weeks after birth (Stephansson et al., 2018). The registry contains information about demographics, maternal and reproductive health, prenatal diagnosis, labor and birth processes and postpartum outcomes for both mother and infant (Stephansson et al., 2018). All subjects received intrapartum care at a public hospital in Stockholm, Sweden. In this setting, all care provided during pregnancy and childbirth is tax-funded and free of charge for all citizens regardless models of care. Midwives in both models provided care based on the same clinical guidelines. In both models, midwives worked collaboratively with obstetricians or other healthcare providers in accordance with the same standard referral procedure.

MCoC model

An MCoC model was initiated as a project at the hospital in 2018targeting women with fear of birth. Women were predominantly self-referred to the model and available regardless of medical risk. In September 2018, the MCoC model was implemented with two case-load teams, each comprising three midwives. The model gradually grew, and by September 2020 four teams with four midwives in each team were in operation. Each midwife provides care for about forty pregnant women annually. In this MCoC model, midwives are continuously available to their patients for consultations and care, regardless of care setting (e.g., in the community, at home, and in the hospital). MCoC midwives provide postpartum care at home for up to seven days after birth and a final check-up at six and eight weeks postpartum. During the postpartum period at home midwives screen for hyperbilirubinemia through transcutaneous bilirubinometer as well as blood sampling when indicated including ongoing support and education to the parents. This helps to ensure that parents understand the importance of monitoring their baby's bilirubin levels and effective feeding, as well as seeking medical attention promptly if necessary. When the woman is discharged from the hospital, community-based pediatric care is notified and the family is advised to arrange for outpatient newborn assessment in addition to MCoC care at home.

Standard care

In standard care, midwives work either in community-based primary antenatal care clinics or in hospitals, providing labor and postnatal care. Pregnant women usually meet one or two midwives during their prenatal check-ups (Hildingsson et al., 2021). Primary antenatal care is accessible for women during business hour, Monday through Friday. Standard care does not include antenatal or postpartum care at home. In the standard care model, women routinely interface with multiple unfamiliar midwives during labor, birth and postpartum. After hospital discharge, women in the standard care model can seek advice from hospital midwives for up to seven days after birth. After this time period, the primary antenatal clinic midwife assumes maternal care responsibilities, including routine examination between six and eight weeks postpartum. When the woman is discharged from the hospital, community-based pediatric care is notified and the family is advised to arrange for outpatient newborn assessment.

Main variables

Exposure and control

The Swedish Pregnancy Register contains information about care providers during pregnancy and childbirth through a personal identification code assigned to each midwife. The exposure group was defined as women receiving MCoC care. The control group was defined as women whose health records did not have a notation of receiving MCoC care. All in the exposure and control groups received intrapartum care at the same hospital and in the same time frame.

Outcomes

In this study, exclusive breastfeeding at discharge from the hospital was defined as: Yes: if breastfeeding = exclusively; No: if breastfeeding = No or Partially; Missing: if breastfeeding = Not indicated or not available. Neonatal hyperbilirubinemia was defined by an ICD-10 code including P59 and sub-classes (non-hemolytic hyperbilirubinemia in need of treatment).

Confounders and mediator

All potential observed confounders were selected based on previous research and availability. The covariates included maternal characteristics such as mother's age, height, parity, Body Mass Index (BMI), twin pregnancy, pre-pregnancy co-morbidities, previous or ongoing psychiatric care, smoking, mother's education, mother's birth region, gestational age, and pregnancy or giving birth during the Covid-19 pandemic (from March 2020).

Preterm birth (<37+0 gestational weeks) was considered a mediator in this study, with previous research supporting the association between MCoC and lower risk for preterm birth (Ahlberg et al., 2022); and b) the association between preterm birth and hyperbilirubinemia (Jardine and Woodgate, 2015). Since preterm birth is the main risk factor for hyperbilirubinemia this factor was included in the mediation analysis. In this study we also consider mode of birth as a mediator and not a confounder. Vacuum extraction increases risk for neonatal hyperbilirubinemia (Norman et al., 2015) and elective caesarean birth decreases risk for neonatal hyperbilirubinemia (Norman et al., 2015). This study is part of a broader cohort study on MCoC in Stockholm Sweden, which indicated there was no significant difference between women in MCoC and those in standard care regarding instrumental delivery and a significant decrease in elective caesarean (Ahlberg et al., 2022). Importantly, mediators are not included in the propensity model (Heinze, 2011).

Statistical analysis

All participants' demographics, maternal and reproductive health, and prenatal diagnosis data related to or affected by the exposure and outcome (Austin, 2011) were collected and described (Tables 1). Covariates with different distributions between MCoC model and standard care groups were noted at this step in analyses and association between potential confounders were assessed using Pearson's chi-square for categorical variables and T-test for continuous variables. Based on identified differences (confounding) among women cared for in the MCoC model versus standard care every woman in the MCoC model received a matched set from the standard care group using propensity score matching (PSM). PSM is an analytic approach to reduce bias of measured confounding effects from covariates (Austin, 2011; Benedetto et al., 2018). In observational studies, controlling for confounding factors is crucial (Kirkwood and Sterne, 2010), and PSM is considered a robust method (Austin, 2011; Benedetto et al., 2018).

Propensity score and matching

The generated propensity score was an estimate of the probability of women receiving MCoC, given observed characteristics. In this study, propensity scores were estimated by logistic regression on selected covariates to not only improve the exposure effect's accuracy but also to minimize confounding bias (Brookhart et al., 2006). There were missing data on covariates, and numbers of missing observations are presented in Table 1. Missing at random may not be valid for maternal BMI, education level, and maternal birth countries or regions (Bhaskaran and Smeeth, 2014). In this study, as described in Fig. 1, we only analyzed data among women without missing data on covariates.

Propensity score without replacement was used in this study. Nearest neighbor matching on the logit of propensity score within caliper width of 0.2 of SD of the logit of the propensity score was used for matching

Table 1
Descriptive statistics of covariates before matching.

Characteristics	Standard care *N* (%)	MCoC care *N* (%)	*p*-value*
Pregnant women	11,153	943	
Maternal Age, year, mean(±SD)	31.8 (5.1)	33.5 (3.8)	<0.001
Maternal Age, years			
15–24	1003 (9.0)	10 (1.1)	<0.001
25–29	3127 (28.0)	160 (17.0)	
30–34	4043 (36.3)	451 (47.8)	
>=35	2980 (26.7)	322 (34.1)	
Height, cm, mean (±SD)	164.6 (6.7)	167.8 (6.6)	<0.001
Height, cm			
<= 159	2362 (21.6)	83 (9.0)	<0.000
160–164	3066 (28.0)	210 (22.7)	
165–169	2839 (25.9)	254 (27.4)	
>= 170	2678 (24.5)	380 (41.0)	
Missing	208	16	
BMI, kg/m^2, mean (±SD)	25.6 (5.0)	24.0 (4.1)	<0.001
BMI, kg/m^2			
Underweight (< 18.5)	229 (2.1)	17 (1.9)	<0.001
Normal weight (18.5–24.9)	5461 (50.9)	597 (66.3)	
Overweight (25.0–29.9)	3175 (29.6)	209 (23.2)	
Obese (≥ 30.0)	1863 (17.4)	78 (8.7)	
Missing	425	42	
Multiple pregnancy			
Yes	237 (2.1)	7 (0.7)	0.004
No	10,916 (97.9)	936 (99.3)	
Psychiatric care			
Yes	1835 (16.9)	318 (34.7)	<0.001
No	9007 (83.1)	598 (65.3)	
Missing	311	27	
Previous CS			
Yes	1502 (13.5)	50 (5.3)	<0.001
No	9651 (86.5)	893 (94.7)	
Smoking status			
Smoker	435 (4.0)	7 (0.8)	<0.001
Non-smoker	10,445 (96.0)	850 (99.2)	
Missing	273	86	
Level of education, years			
<= 9 years	977 (10.1)	5 (0.6)	<0.001
10–12 years	3567 (36.8)	116 (13.0)	
> 12 years	5137 (53.1)	769 (86.4)	
Missing	1472	53	
Mother's birth Region			
Nordic	5308 (51.7)	801 (86.1)	<0.001
Europe (non-Nordic)	1129 (11.0)	52 (5.6)	
Middle East/Africa	2280 (22.2)	26 (2.8)	
Others	1554 (15.1)	51 (5.5)	
Missing	882	13	
Pre-Pregnancy comorbidity**			<0.001
Yes	3805 (34.9)	433 (46.9)	
No	7090 (65.1)	490 (53.1)	
Missing	258	20	
Parity			
Primiparity	4584 (41.1)	522 (55.4)	<0.001
Multiparity	6568 (58.9)	421 (44.6)	
Missing	1	0	
Give birth during Covid19			
Yes	6356 (57.0)	654 (69.4)	<0.001
No	4797 (43.0)	289 (30.6)	

Abbreviations: MCoC: Midwifery Continuity of Care, BMI: Body Mass Index.
* *p*-value derived from Pearson's chi-squared for categorical variables and from Two sample t-test for continues variables.
**Pre-pregnancy comorbidity includes cardiovascular disease, liver disease, diabetes, gynecological disease, lung disease, endocrine disease, kidney disease, inflammatory bowel disease, chronic hypertension, and neurological disorder.

(Austin, 2011). To reduce impact of missing matched pairs and obtain more precise estimates, a matching ratio of 1:1 to 2:1 to 3:1 was performed until covariate balance was achieved (Austin, 2011; Linden, 2013). In this study matching ratio of 3:1 was finally applied for matching. The balance of covariates was examined across exposed and unexposed groups. The Absolute Standardized Difference was measured for continuous, binary, and categorical variables and was considered to be in good balance if it was lower than 10 % (Table 3).

Main analysis for comparison of outcomes

The measures of association (i.e. relative risks) for neonatal hyperbilirubinemia and exclusive breastfeeding at hospital discharge by exposure versus control groups were generated using modified Poisson regressions with robust standard error (Chen et al., 2018; Zou, 2004).

Sensitivity analysis

We conducted an extreme case analysis to address the potential impact of missing breastfeeding data (Unnebrink and Windeler, 1999). Around 7 % of exclusive breastfeeding at hospital discharge data were missing, and it was determined that the missing mechanism may not be at random (Table 2). To ascertain if exclusive breastfeeding at hospital discharge results after excluding observations with missing outcomes were robust, sensitivity analyses was performed by imputing the missing data with either 0 or 1. Both analyses assuming all missing by 0 or 1 among those with missing information on breastfeeding at discharge confirmed that the missing data had a minor influence on the results obtained from the complete case analyses.

Mediation analysis

A mediation analysis assessed the direct and indirect effects of MCoC on exclusive breastfeeding at hospital discharge and neonatal hyperbilirubinemia and to what extent the association was mediated by preterm birth (Ananth and Brandt, 2022).

We calculated the direct and indirect effects of MCoC on exclusive breastfeeding at hospital discharge and neonatal hyperbilirubinemia, mediated by preterm birth (< 37 weeks' gestation; binary mediator) (Ananth and Brandt, 2022). We calculated the following mediation components: *Natural Direct Effect (NDE)* through the direct pathway or arrow starting from the exposure to outcomes; *Natural Indirect Effect (NIE)* through the indirect pathway mediated through preterm birth; *Total Effect (TE)* of the exposure on outcomes calculated based on NDE and NIE; and *Proportion Mediated (PM)* to measure how much of the effect of MCoC on each outcome (breastfeeding and neonatal hyperbilirubinemia) that was mediated thru preterm birth (VanderWeele and Vansteelandt, 2010). For a rare outcome such as neonatal hyperbilirubinemia, the proportion-mediated (%) can be used to measure how much of the effect of MCoC on each outcome is mediated through preterm birth (VanderWeele and Vansteelandt, 2010).

The data were analysed with R version 4.1.2 (R Core Team, 2021; R

Table 2
Descriptive statistics of outcomes before matching.

Outcomes	Standard care *N* (%)	MCoC *N* (%)	Total	*p*-value *
Newborns	11,393	950	12,343	
Exclusive breastfeeding at hospital discharge				
Yes	6721 (64.7)**	665 **(78.1)****	7386 (65.74)	**<0.001**
No	3662 (35.3)	187 (21.9)	3849 (34.26)	
Missing	1010	98	1108	
Neonatal hyperbilirubinemia				
Yes	586 **(5.1)**	25 (2.6)	611 (4.9)	**<0.001**
No	10,807 (94.9)	925 (97.4)	11,732 (95)	

Abbreviation: MCoC: Midwifery Continuity of Care.
* *p*-value derived from Pearson's chi-squared.
** Without drop the missing data, frequency is 70 % in MCoC and 59 in standard group.

Foundation for Statistical Computing, Vienna, Austria), with the MatchIt package for PSM, and STATA version 16 with the PSMATCH2, stddiff and Paramed modules for statistical tests, covariate balance check, and statistical analyses, respectively.

Ethical considerations

The Study protocol was approved by the Ethics Review Authority (Reference No. 2021-02722) on May 20, 2021. The committee's decision stated that informed consent was not required from the participants.

The research was conducted according to relevant guidelines and regulations, de-identifying data before analysis, and followed ethical standards and STROBE guidelines for observational cohort studies. The database stored in the Unit of Clinical Epidemiology at Karolinska Institutet, cannot be publicly shared.

Results

The characteristics of the study population before matching

A total number of 12,096 pregnant women were included (before matching) in this study. The distribution of all characteristics between the two groups was significantly different (Table 1). Women cared for in the MCoC model were older, more educated, had lower BMI, smoked less, and were more often born in Nordic countries compared with women in the standard care group. Further, women cared for in the MCoC model more often had a history of psychiatric disease and maternal morbidity including cardiovascular disease, liver disease, diabetes, gynecological disease, lung disease, endocrine disease, kidney disease, inflammatory bowel disease, chronic hypertension, and neurological disorder compared with women in the standard care group.

Outcomes before matching

A total number of 12,343 newborns were included in the study. The incidence of newborns with neonatal hyperbilirubinemia was significantly lower in the MCoC group versus the standard care group. There was a higher proportion of exclusive breastfeeding before hospital discharge in the MCoC group compared with the standard group, after excluding those with missing information on exclusive breastfeeding at discharge (Table 2).

Characteristics of matched cohort (after matching)

After propensity score matching, a total number of 2971 pregnant women were included in the matched cohort. In the matched cohort, all covariates were balanced between the two comparison groups evaluated by the criterion of an absolute standardized difference less than < 0.1 (Table 3).

Main analysis for comparison of outcomes

Based on the matched cohort, the absolute risk of neonatal hyperbilirubinemia in the MCoC group was significantly lower than in the standard care group. After excluding those with missing outcomes, the probability of exclusive breastfeeding at hospital discharge was significantly higher in the MCoC group compared with the standard care group. Neonates of mothers cared for in the MCoC model had a 49 % decreased risk of neonatal hyperbilirubinemia compared with those in the standard care group (RR: 0.51, 95 % CI: 0.32–0.82, $p = 0.006$). After excluding those with missing outcomes, neonates of mothers cared for in the MCoC model had 6 % higher probability of exclusive breastfeeding at hospital discharge compared with newborns in the standard care group (RR: 1.06, 95 % CI: 1.01–1.12, $p = 0.010$) (Table 4).

Table 3
Descriptive statistics and balancing of covariates after matching.

Characteristics	Standard care *N* (%)	MCoC *N* (%)	Absolute Standardized difference (<0.1)
Pregnant women	2213	758	
Maternal Age, y, mean (SD)	33.33 (4.1)	33.5 (3.8)	0.032
Maternal Age, years*			
15–24	21 (0.9 %)	10 (1.3 %)	0.049
25–29	378 (17.1 %)	129 (17.0 %)	
30–34	1097 (49.6 %)	363 (47.9 %)	
>=35	717 (32.4 %)	256 (33.8 %)	
Height, cm, mean (SD)	167.7 (6.2)	167.8 (6.6)	0.028
Height, cm*			
<= 159	176 (8.0 %)	66 (8.7 %)	0.036
160–164	525 (23.7 %)	171 (22.6 %)	
165–169	615 (27.8 %)	210 (27.7 %)	
>= 170	897 (40.5 %)	311 (41.0 %)	
BMI, kg/m^2, mean (SD)	24.2 (4.0)	24(4.1)	0.046
BMI, kg/m^2*			
Underweight (< 18.5)	39 (1.8 %)	16 (2.1 %)	0.055
Normal weight (18.5–24.9)	1455 (65.7 %)	501 (66.1 %)	
Overweight (25.0–29.9)	551 (24.9 %)	176 (23.2 %)	
Obese (≥ 30.0)	168 (7.6 %)	65 (8.6 %)	
Multiple pregnancy			
Yes	8 (0.4)	6 (0.8)	0.057
No	2205 (99.6)	725 (99.2)	
Psychiatric care			
Yes	652 (29.5)	249 (32.8)	0.073
No	1561 (70.5)	509 (67.2)	
Previous CS			
Yes	112 (5.1)	33 (4.4)	0.033
No	2101 (94.9)	725 (95.6)	
Smoking status			
Smoker	16 (0.7)	6 (0.8)	0.008
Non-smoker	2197 (99.3)	752 (99.2)	
Level of education, years			0.034
<= 9 years	17 (0.8)	4 (0.5)	
10–12 years	289 (13.1)	95 (12.5)	
> 12 years	1907 (86.2)	659 (86.9)	
Mother's birth Region			
Nordic	1935 (87.4)	653 (86.1)	0.043
Europe (non-Nordic)	127 (5.7)	46 (6.1)	
Middle East/Africa	58 (2.6)	21 (2.8)	
Others	93 (4.2)	38 (5.0)	
Pre-Pregnancy comorbidity**			
Yes	971 (43.9)	348 (45.9)	0.041
No	1242 (56.1)	410 (54.1)	
Parity			
Primiparity	1168 (52.8)	420 (55.4)	0.053
Multiparity	1045 (47.2)	338 (44.6)	
Give birth during Covid19			

(*continued on next page*)

Table 3 (*continued*)

Characteristics	Standard care *N* (%)	MCoC *N* (%)	Absolute Standardized difference (<0.1)
Yes	1560 (70.5)	545 (71.9)	0.031
No	653 (29.5)	213 (28.1)	

MCoC: Midwifery Continuity of Care, BMI: Body Mass Index.
* Age, height, and BMI in categorical forms used to estimate propensity score.
** Pre-pregnancy comorbidity includes cardiovascular disease, liver disease, diabetes, gynecological disease, lung disease, endocrine disease, kidney disease, inflammatory bowel disease, chronic hypertension, and neurological disorder.

Table 4
Association between MCoC and neonatal outcomes after matching.

Outcomes	Standard care *N* (%)	MCoC *N* (%)	*p*-value	Risk Ratio (95 % CI)*
Newborn	2213	764		
Exclusive breastfeeding at hospital discharge				
Yes	1530 (73.4)**	535 (**78.1**)**	**0.010**	**1.06 (1.01–1.12)**
No	554 (26.6)	150 (21.9)		
Missing	129	79		
Neonatal hyperbilirubinemia				
Yes	108 (**4.9**)	19 (2.5)	**0.006**	**0.51 (0.32–0.82)**
No	2105(95.1)	745 (97.5)		

Abbreviations: MCoC: Midwifery Continuity of Care; CI: Confidence Interval.
* Risk Ratio and 95 % CI derived from modified Poisson regressions with robust standard error.
** Without drop the missing data, frequency is 70 % in MCoC and 69.1 % in standard group.

Mediation analysis

In this cohort, women in the MCoC model had 49 % lower risk of preterm birth (≤37+0 weeks) RR 0.51 (0.32–0.82) compared with standard care (Ahlberg et al., 2022). The mediation analyses showed that the odds ratios (ORs) for the natural direct effect (NDE) and natural indirect effect (NIE) mediated by MCoC on neonatal hyperbilirubinemia were significant (Table 5), that the proportion mediated of the total effect (TE) (OR: 0.42, 95 % CI: 0.22–0.73, p = 0.004) of MCoC on neonatal hyperbilirubinemia was mediated through preterm birth was 28 %. Therefore other undiscovered pathways (other than the preterm birth) accounted for 72 % of the TE. After removing those with missing data, the association between MCoC and exclusive breastfeeding at hospital discharge may not have been mediated by preterm birth. The TE, and NDE on exclusive breastfeeding were significant, but NIE was not statistically significant.

Table 5
Association between MCoC and breastfeeding rate and risk of neonatal hyperbilirubinemia: mediation effects by preterm birth.

Mediator	Neonatal outcome	OR (95 % Conf. Interval)**		
		TE	NDE	NIE
Preterm birth	**Breastfeeding**	1.27 (1.02-1.59)*	1.26 (1.01-1.56)*	1.01 (1- 1.02)*
Preterm birth	**Neonatal hyperbilirubinemia**	0.42 (0.22-0.73)*	0.58 (0.32-0.91)*	0.72 (0.56–0.90)*

NDE: natural direct effect, NIE: natural indirect effect, TE: total effect.
* Bias-corrected confidence interval.
** 95 % CIs were estimated based on the bias-corrected bootstrap resampling method.

Discussion

Main findings

MCoC was significantly associated with a decreased risk of hyperbilirubinemia in need of treatment and an increase in exclusive breastfeeding at hospital discharge compared with standard care. Moreover, 28 % of the total effect of MCoC on neonatal hyperbilirubinemia was mediated through preterm birth.

Interpretation of the findings

Neonatal hyperbilirubinemia

In this cohort study, the total rate of significant neonatal hyperbilirubinemia between 2019 and 2021 before matching was 5 %. This is higher than the reported prevalence of nonhemolytic hyperbilirubinemia of 3.6 % between 1987 and 2020 in Sweden (Lee et al., 2016). The variance in prevalence could be attributed to the fact that the study by Lee et al. only included singleton newborns, whereas this study involved both singleton and multiple pregnancies (Lee et al., 2016). Additionally, the hospital where the study was conducted is a regional referral hospital, providing care for high-risk births with a higher rate of preterm births increasing the risk of hyperbilirubinemia. The limits for treatment have also been changed over the years.

To the best of our knowledge, no previous studies have investigated the effect of MCoC on neonatal hyperbilirubinemia. Previous studies have mainly examined the association between MCoC and risk of admission to the neonatal unit but without neonatal diagnoses. In the Cochrane review there were no statistically significant differences between groups regarding admission to the neonatal unit (Sandall et al., 2024). It is worth noting that hyperbilirubinemia is the most common reason for admission to the neonatal unit (Lin et al., 2022).

MCoC, postpartum home visits, and breastfeeding as potential mechanisms of action

The MCoC model in this cohort was associated with a decreased risk of preterm birth (Ahlberg et al.,2022). Research has shown that the prevalence of newborn hyperbilirubinemia may be decreased by interventions that decrease preterm birth (Lee et al., 2016). Our findings from the mediation analysis demonstrated that 28 % of the total effect of MCoC on neonatal hyperbilirubinemia was mediated through preterm birth. Hence, there are other explanations why MCoC care was associated with a lower risk of hyperbilirubinemia.

We speculate that the postpartum home visits enable personal advice on effective feeding of the newborn and might contribute to the decreased risk of significant neonatal hyperbilirubinemia. It might also be less stressful for mothers/parents to be at home than in the hospital, which may benefit breastfeeding.

One study in the United States discovered that implementing Baby friendly hospital, which supports exclusive breastfeeding, had a significant correlation with lower rates of neonatal hyperbilirubinemia and the need for phototherapy treatment in newborns. The same study showed no significant increase in the number of hospital readmissions within 30 days for treatment of hyperbilirubinemia (Hudson et al., 2020). The breastfeeding factor is supported by another study conducted in Canada that compared different models of postpartum continuity of care to determine the most effective approach in reducing infant readmission rates for hyperbilirubinemia. Breastfeeding guidance was a crucial component of after-hospital care, consistent across all types of ongoing care. Breastfeeding guidance was seen as particularly important for mothers of newborns with mild hyperbilirubinemia as insufficient feeding with breast milk can lead to dehydration, increasing the risk of hyperbilirubinemia (Goulet et al., 2007). They concluded that integrating community-based services, in which women and infants were followed at home, with hospital-provided home phototherapy would be more advantageous for both infants and mothers (Goulet et al., 2007).

Another study showed similar results, that implementing postnatal home visits after discharge is a cost-efficient and preventive strategy for decreasing hospital admissions due to hyperbilirubinemia and dehydration (Paul et al., 2004).

Further, early detection of hyperbilirubinemia is critical in ensuring timely and effective treatment (Slusher et al., 2011) and this may have contributed to the reduction of neonatal hyperbilirubinemia in the MCoC model by providing home-based care after discharge.

Exclusive breastfeeding at hospital discharge

The findings of significantly higher rates of exclusive breastfeeding at hospital discharge among women cared for in a MCoC model, compared with standard care, are consistent with findings from another Swedish study by Hildingsson et al. evaluating MCoC compared with standard care in another Region in Sweden (Hildingsson et al., 2020).

MCoC, relational continuity and postpartum home visits as potential mechanisms of action

There are multiple theories regarding the mechanism through which MCoC models may influence breastfeeding rates. A meta-analysis of 13 qualitative studies showed that "the midwife-woman relationship, personalized care, trust development, and empowerment" are crucial components of the MCoC model from the womeńs point of view (Perriman et al., 2018). This relationship creates a sense of security and support throughout the prenatal, birth, and postpartum period (Fahlbeck et al., 2022). These components may contribute to the observed increase in breastfeeding rates at hospital discharge in our study.

The midwives involved in the MCoC model provided continuous care and support around the clock, ensuring that mothers received continuity of care and education from the prenatal to postpartum stages, including support in their homes. A systematic review has shown that interventions starting from antenatal care and continuing to the postpartum period are more effective in promoting breastfeeding and enhancing maternal health, compared with those that commence postnatally (D'Haenens et al., 2020). Breastfeeding mothers were more satisfied when they got accessible, available when needed, and consistent professional support in a non-judgmental and reassuring manner (Cramer et al., 2021). Midwives who provide MCoC prioritize building a trusting relationship with their clients, which leads to a greater commitment to delivering high-quality care (McInnes et al., 2020). The trust relationship between a midwife and a pregnant woman can have a significant impact on the woman's confidence and overall well-being as she transitions into motherhood (McInnes and Donnellan-Fernandez, 2023). Interviews with Australian breastfeeding association peer counsellors, who had current or past experience of breastfeeding, revealed that MCoC provides support for women who are breastfeeding. Furthermore, the interviews emphasized the significance of personalized and face-to-face support for women who encounter challenges with breastfeeding (Burns et al., 2020).

Another observational study conducted in Palestine showed that a MCoC model was associated with increased duration of exclusively breastfeeding compared with the standard model. The study demonstrated the effectiveness of MCoC on breastfeeding rates in a low-middle income country (Mortensen et al., 2019). Although the reported studies vary in terms of their settings, they all indicate a positive association between the MCoC model and an increased prevalence of exclusive breastfeeding.

Strengths and limitations

This study utilized prospectively collected data from the Swedish Pregnancy Register, which is a notable strength. The register captures a wide range of factors that can influence maternal and infant health, enabling control for various covariates. Furthermore, the study included all women participating in the MCoC model without the risk of losing follow-up, enhancing the study's validity.

Another strength was the inclusion of the matched comparison group among women who received standard care and gave birth at the same hospital. This reduced confounding factors arising from differences in clinical protocols, staffing levels, and expertise among healthcare facilities in Stockholm.

Although we strive to balance the distributions of covariates between the MCoC and standard care groups, using PSM and the standardized difference criterion with a 10 % limit, the results of this study should be interpreted cautiously due to the limitations of observational research.

The limitations of the study are connected to the possibility of bias in observational studies. Observational studies are prone to bias, particularly regarding potential residual confounding from unobserved (unknown or unmeasured) confounders that are not considered in the propensity score calculation. The analysis of neonatal hyperbilirubinemia was constrained by limited access to certain components of participants' medical history, primarily whether the woman had a history of neonatal hyperbilirubinemia, which is a major risk factor (Lee et al., 2016).

The study also lacked data on successful breastfeeding history and the intention to breastfeed, which are important factors. Intentions and beliefs regarding breastfeeding can impact both the initiation and duration of breastfeeding (Kronborg and Foverskov, 2020).

Moreover, data on the duration of exclusive breastfeeding was not available which is important from a public health point of view. However, the indicator "Exclusive breastfeeding for the first two days after birth" (North et al., 2022) predicts the continuation of exclusive breastfeeding for up to six weeks (Jakaitė et al., 2021).

Another limitation is the self-selection of MCoC by mothers, which may introduce unmeasured confounding and selection bias, despite efforts to match the two groups.

Lastly, missing data on breastfeeding and the current imputation method hindered clear evidence of the association between the MCoC model of care and exclusive breastfeeding at discharge. Further research is necessary to gain a better understanding of the relationship between the MCoC model and breastfeeding outcomes.

Conclusions

This matched cohort study provided evidence that MCoC models could be an intervention to reduce the risk of treatment dependent hyperbilirubinemia and for improving exclusive breastfeeding rates at hospital discharge.

However, due to inherited limitations in cohort studies, these results should be interpreted with caution, and the findings should be tested in randomized controlled trials. Additionally, conducting qualitative studies to explore the experiences and satisfaction of MCoC models in relation to breastfeeding is of utmost importance.

Disclosures abbreviations

MCoC: Midwifery continuity of care, TE: Total effect, NIE: Natural Indirect Effect, DE: Direct Effect.

CRediT authorship contribution statement

Mahshid Abdi Shahshahani: Conceptualization, Methodology, Formal analysis, Writing – original draft. **Xingrong Liu:** Writing – review & editing, Methodology, Formal analysis. **Mikael Norman:** Writing – review & editing. **Ellen L. Tilden:** Writing – review & editing. **Mia Ahlberg:** Conceptualization, Data curation, Investigation, Methodology, Project administration, Supervision, Writing – review & editing.

Declaration of competing interest

The authors declare there is no conflict of interests.

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