Research Paper

Improving Maternal and Neonatal Health by a Midwife-led Continuity Model of Care – An Observational Study in One Governmental Hospital in Palestine

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ABSTRACT

Background: From 2013 a midwife-led continuity model of care was implemented in the Nablus region in occupied Palestine, involving a governmental hospital and ten rural villages. This study analysed the relation between the midwife-led model and maternal and neonatal health outcomes.

Method: A register-based, retrospective cohort design was used, involving 2201 singleton births between January 2016 and June 2017 at Nablus governmental hospital. Data from rural women, with singleton pregnancies and mixed risk status, who either lived in villages that offered the midwife-led continuity model and had registered at the governmental clinic, or who lived in villages without the midwife-led model and received regular care, were compared. Primary outcome was unplanned caesarean section. Secondary outcomes were other modes of birth, postpartum anaemia, preterm birth, birth weight, and admission to neonatal intensive care unit.

Findings: Statistically significant less women receiving the midwife-led model had unplanned caesarean sections, 12·8% vs 15·9%, adjusted risk ratio (aRR) 0·80 (95% CI 0·64–0·99) and postpartum anaemia,19·8% vs 28·6%, aRR 0·72 (0·60–0·85). There was also a statistically significant lower rate of preterm births within the exposed group, 13·1% vs 16·8, aRR 0·79 (0·63–0·98), admission to neonatal intensive care unit, 7·0% vs 9·9%, aRR 0·71 (0·52–0·98) and newborn with birth weight 1500 g and less, 0·1% vs 1·1%, aRR 0·13 (0·02–0·97).

Interpretation: Receiving the midwife-led continuity model of care in Palestine was associated with several improved maternal and neonatal health outcomes. The findings support further implementation of the model. Implementation research, including randomised studies, would be useful to further investigate the effect and feasibility of the model in a low resource setting.

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1. Introduction

Interventions to achieve sustainable, accessible, appropriate, and woman-centred care globally are requested [1]. Midwife-led continuity models of care, where a known midwife supports a woman throughout pregnancy, birth and the postnatal period, are recommended in settings with functioning midwife education [2,3]. Sandall et al. [3] concluded in a Cochrane review that midwife-led models of care improved several health outcomes for mothers and babies. For healthy mothers with normal pregnancies such models of care decreased the risk of interventions during birth, such as instrumental birth and regional anaesthesia, and reduced the rate of preterm births <37 weeks [3]. In settings with high caesarean rates, previous studies have shown that midwife-led continuity models of care were associated with decreased caesarean section rates [4,5]. Furthermore, such models of care seem to be a cost-efficient way to improve maternal health services [14]. Midwife-led continuity

Panel: Research in Context

Evidence Before This Study

Midwife-led continuity models of care, where a known midwife supports a woman throughout pregnancy, birth and the postnatal period, are recommended in settings with well-functioning midwife education. Evidence from high income countries found such models to be a cost-efficient way to improve health outcomes, reducing medical interventions and increasing satisfaction with care. Studies of midwife-led models adapted to low- and middle-income countries have been requested.

Added Value of This Study

Between 2013 and 2016 the Palestinian ministry of Health implemented a midwife-led continuity model of care in six hospitals and 37 villages. To our knowledge this is the first study of maternal and neonatal health outcomes after implementing a midwife-led continuity model of care integrated in a low-middle income country's governmental health system. The complex intervention gives new useful insight in how such models can be adapted to and made feasible in settings with limited resources. We investigated the association between receiving midwife-led continuity of care and different outcomes for mothers and babies after birth in a governmental hospital in the West Bank, Palestine. We compared the outcomes of 703 women who received the midwife-led model with 1498 women who received regular care. We found that receiving midwife-led continuity of care was associated with several improved maternal and neonatal health outcomes and reduced medical interventions.

Implications After All the Available Evidence

This study provides new information on how midwife-led continuity models of care can influence maternal and neonatal health outcomes in low-and middle-income countries with well-functioning midwife programmes. The findings support further implementation of the model to new regions. Implementation research including randomised studies would be useful to further investigate the effect and feasibility of the model in low resource settings.

of care is mainly organised as *caseload- or team-midwifery models*. In the *case-load model*, one midwife cares for up to 45 women and facilitates relational continuity, while in the *team-midwifery model* a group of 4–6 midwives provide care for up to 360 women through pregnancy, birth and the postnatal period. Ideally, in both models, women are cared for during birth by a known midwife [2,6]. The case-load model facilitates a relationship between the woman and a midwife, which has been especially valued by women [6]. A trustful relationship can be an important tool to cope with sensitive physical and psychological conditions and social challenges, like intimate partner violence, a threat facing pregnant women globally [10,19].

Previous studies related to midwife-led continuity of care are mainly from high-income countries [3,7]. The needs and challenges in low- and middle-income countries vary, and cultural and contextual sensitivity is essential when introducing improvement strategies to new settings [8,9]. Implementation research is recommended to investigate how midwife-led models can be adapted to low income countries [8,10].

Appropriate and timely medical interventions during pregnancy, birth and the postnatal period save lives and improve health outcomes, while unnecessary interventions can disturb an otherwise healthy natural process and cause serious side effects [11].

1.1. Palestinian Context

Palestine is divided into the regions of West Bank, East Jerusalem and Gaza, occupied by Israel in 1967. Since 1994, The Palestinian Ministry of Health (MoH) has been responsible for the Palestinian health system. Nevertheless, Israeli military checkpoints and armed settlers restrict freedom of movement and reduce access to central health-facilities and medical assistance for people in rural areas [12].

According to World Bank data from 2015, the maternal mortality rate was 45 per 100,000 births in West Bank and Gaza, versus 5 per 100,000 in Israel. The infant mortality rate (<1 year) was 17 per 1000 live birth in the West Bank and Gaza, versus 3 per 1000 in Israel [13]. This study was performed at a West Bank hospital.

In 2016, MoH reported 72,327 births in the West Bank, whereas 53·6% of these were in governmental hospitals, 46·3% in private hospitals, and 0·1% gave birth outside institutions. The fertility rate was 3·7 per woman and the overall caesarean section rate in governmental hospitals was 24·9%. It was reported that 5·6% of the newborn had low birth weight (<2500 g) and that 28·2% of pregnant women had anaemia (Hb < 11 g/dl). Prematurity and low birth weight were reported as reasons for 24·6% of the infant deaths [14].

Governmental services are free of charge and mainly used by poor people, often from rural areas [15]. The rural population accounted for 25·5% of the total population of 2·9 million in the West Bank [14].

Previous local studies have presented a variety of challenges in Palestinian governmental maternal health services. Rahim et al. described in 2009 overcrowded and understaffed facilities and short antenatal visits lacking content [16]. Women reported dissatisfaction both with provider's attitude and interactions [16]. Overcrowded labour rooms prohibited women bringing a birth companion, and over-medicalization and unnecessary interventions were reported in normal births [17].

Since 1990 a growing number of universities and colleges in Palestine offers bachelor's degree in Midwifery. Before the midwife-led continuity model was introduced, Palestinian midwives who worked in the Ministry of Health had restricted scope of practice and little autonomy [16].

To improve services in rural areas, the MoH, in cooperation with the non-governmental humanitarian organisation Norwegian Aid Committee (NORWAC), started a stepwise implementation of a modified midwife-led continuity, *case-load*-model of care, in 2013. By 2016 the model was implemented in six governmental hospitals and 37 villages. The model implies that midwives from the hospitals offer outreaching caseload ante- and postnatal care to pregnant women in rural village's clinics and homes.

In the Nablus region the midwife-led model was implemented in ten of the 40 village clinics by 2014. The low number of available midwives employed in the governmental hospital limited the number of villages. Selection was done by supervisors in the MoH based upon village clinics in most need of improvements. The implementation was associated with increased utilisation of services, number of detected pregnancy complications causing referrals to higher level of care, and a substantial increase in postnatal home visits [18].

The aim of this study was to investigate the association between the Palestinian midwife-led continuity model of care and maternal or neonatal health outcomes, by analysing data of rural women giving birth in a governmental tertiary, referral and teaching hospital in Nablus.

2. Methods

2.1. Design and Participants

A registry-based, retrospective cohort design was conducted.

Women with a singleton pregnancy and mixed risk status, who resided in rural villages more than 3 km away from Nablus city centre, and who gave birth at Rafidia governmental hospital in Nablus, were included in the study. Women who lived in villages with a governmental

clinic that offered the midwife-led continuity model where they had received antenatal care, were allocated to the exposed group, and women in villages without the midwife-led model, and who had received regular care, were allocated to the unexposed group. The two groups were expected to be comparable as they presented a rural population within the same region, with similar health status, using governmental health services.

Ethical approval for the study was granted from the Norwegian Regional Committee for Medical Health Research Ethics South East (REK) with id number: 2015/1235. Oslo University Hospital and the Palestinian Ministry of Health also approved the study. The research presented minimal risk of harm to subjects and involves no procedures for which written consent is normally required.

2.2. The Midwife-led Continuity Model of Care

Midwives educated at bachelor level and who were employed in Nablus governmental hospital, received theoretical and practical updating, including the Ministry of Health standards for primary health care and the principles of continuity of care. They also received driving lessons and were certified as drivers of cars with Ministry of Health logo, marked Midwifery Care, to facilitate transportation between hospital and the rural village clinics, and homes. The hospital had enough midwives to serve ten villages per week, meaning two midwives would leave the hospital each weekday to serve two villages, five days a week. Three extra midwives who were employed at the hospital to maintain the capacity at the labour ward, were also involved in the training. All midwives employed in the MoH are obliged to work full time. A regional midwife supervisor was appointed to assist the head midwife in scheduling at the labour ward and to follow up with the primary health system and supervising the midwives in the program.

The same midwife served the same village, usually once a week. When pregnant women booked for antenatal care they would also receive a consultation with the physician serving the clinic, who would decide in cooperation with the midwife, the further involvement in the care according to the woman's needs. The midwives followed up her case-load of women by individual consultations through pregnancy. They informed about normal pregnancy, labour and birth, and breastfeeding. They assessed health status and risk factors and referred to appropriate specialist care when necessary. The midwife continued to follow up women with detected health risks in collaboration with specialist care. The smallest villages with less than 25 pregnant women per year were visited by one midwife every second week, and the largest one, with more than 100 pregnant women per year was shared by two midwives, each following up a caseload of women. Most villages had one midwife serving them weekly. The midwives spent the remaining working days at the hospital. During vacation or sick leave, the midwives would cover each other's villages. The pregnant women were informed that the midwives providing them antenatal care also worked at Nablus governmental hospital, and that she would visit them at home after birth. They were also informed that their midwife could not ensure they would be on duty or available for them during labour or postnatal care at the hospital, because of the limited number of midwives and the large workload in the labour ward. Women were given the phone number of the midwives to call in case of an emergency. The level of ensured relational continuity was limited to antenatal care and postnatal home visit. Nevertheless, a relational continuity was possible during labour and postnatal hospital stay if their known midwife was on duty. Implementing the model aimed at strengthening the relationship between the woman and her midwife, enhance respectful care, improve midwives' skills, experience and autonomy and improve interdisciplinary cooperation between levels of care.

2.3. Regular Care

Women in the group receiving regular care, lived in rural villages where the midwife-led model was not implemented. They received care either from governmental clinics or private doctors. Approximately 70% of women in rural villages register for governmental antenatal care [18]. Regular governmental antenatal care was provided by midwives, nurses and physicians who only worked with primary health care and who had a variety of other responsibilities, like vaccination, regular health care and minor emergencies.

All governmental facilities, including the one offering the midwife-led model, followed the same MoH standards of care. Female physicians rotated to all governmental clinics, including those with the midwife-led model, offering ultrasound examinations. All women who were included in this study gave birth at the same governmental hospital in Nablus.

2.4. Hospital Setting and Birth Registry

Rafidia governmental hospital in Nablus has a labour and a postnatal ward, and a neonatal intensive care unit. In 2016, the hospital registered 5408 births and a total caesarean section rate of 35·1% [14]. The hospital had both a handwritten and an electronic birth registry, where maternal and neonatal characteristic, health status and interventions were registered continuously by doctors and midwives. Mode of birth was described by doctors who defined planned and unplanned caesarean section, and vacuum extraction. Routine ultrasound during pregnancy defined the gestational age. A routine blood test before leaving hospital defined the haemoglobin level postpartum.

2.5. Outcome Variables

Outcomes were limited to the available and reliable information at the hospital's birth registry. Unplanned caesarean section rate was the primary outcome. Secondary maternal outcomes were planned caesarean section, spontaneous vaginal birth, vacuum extraction, induction of labour, postpartum anaemia (Hb < 11 g/dl and Hb < 9·5 g/dl) and postpartum blood transfusion. Neonatal outcomes were rate of preterm newborn (≤37 gestational weeks), and very preterm newborn (≤32 gestational weeks), low and very low birth weight (≤2500 g and ≤1500 g), admission to neonatal intensive care unit (NICU), Apgar score after 5 min, and perinatal deaths, including stillbirths and deaths during postpartum hospital stay.

2.6. Sample Size and Statistical Analyses

Power calculations were based on the total caesarean section rate of 35·6% at the hospital in 2015. Whereas the published reports from the MoH did not differentiate between planned and unplanned caesareans, we assumed that the unplanned caesarean section rate was around 20%. The proportion of the rural women who received the midwife-led continuity model were much smaller than the proportion who received regular care. To ensure that data were collected within a time frame as equal as possible, a group size of 2:1 was necessary. A sample size of 2200 births, with a ratio of the exposed group size to the unexposed group of 1:2, was adequate to detect a difference of 5% in caesarean section rate between the groups receiving midwife-led and regular care, with a power of 80% and a significance level of 5%.

Descriptive statistics were used to calculate means, standard deviations, medians, interquartile ranges, ranges, frequencies, and percentages. The chi-squared tests were used for categorial variables and Mann–Whitney U tests were used for continuous variables to explore any differences between the groups. Multivariate analyses with generalised linear models (GLMs) for binary outcomes with the log link were conducted to estimate adjusted risk ratios (aRR) and 95% confidence intervals. Age, parity and previous caesarean section that are known to affect the birth outcomes, were included in the GLMs for adjusting. Since there was a difference of 4 months in length of data collection period between the two groups, year of current birth was also included in the GLMs for adjusting. Additionally, we used the GLMs to examine whether the impact of previous caesarean on the maternal outcomes differed between

the two groups by testing the interaction between group and previous caesarean.

Stata version 15 was used to calculate the sample size for the present study. Data were analysed using SPSS version 25 and p values of <0·05 were considered statistically significant.

2.7. Data Collection

Women and newborn's place of living, personal and medical information were recorded routinely by midwives and doctors both in a handwritten and in an electronic registry at the hospital. A designated midwife extracted the data, and entered it to a code locked excel form, developed for the purpose by the first author. Data were extracted from the hospital's birth registry until the required number of births in each group was obtained, starting from January 1st 2016 until February 1st 2017, 13 months, for the unexposed group and until May 31st 2017, 17 months, for the exposed group (Fig. 1). The data were cross-checked with both registries to assure validity and that all eligible births were consecutively included. Identities were cross-checked with registries at the governmental clinics offering the midwife-led model to confirm that women allocated to the exposed group actually had received antenatal care at the clinic. All identifications were removed before the data were transferred to Oslo University Hospital's repository for sensitive data, in compliance with Norwegian regulations for individual privacy.

3. Results

All together 2201 women were included in the study, 703 receiving midwife-led care and 1498 receiving regular care. Table 1 presents the available personal characteristics for the study participants.

Table 1
Participants demographic and obstetric characteristics.

	Midwife-led care (n = 703)	Regular care (n = 1498)	p value[*]
Age (years)	26(7/16–45)	26(8/15–44)	0·572
Data missing	0	0	
Parity	2 (3/1–11)	3 (3/1–13)	0·115
Data missing	0	0	
Nulliparous women	206 (29·3%)	396 (26·4%)	0·160
Data missing	0	0	
Previous caesarean	106 (15·1%)	232 (15·5%)	0·804
Data missing	0	0	
Birth year 2016	516 (73·4%)	1326 (88·6%)	0·0001
Data missing	0	0	
Birth year 2017	187 (26·6%)	172 (11·5%)	0·0001
Data missing	0	0	

Data are in n (%) or median (IQR/min-max). PP = postpartum.
 [*] Pearson's chi-squared test and Mann–Whitney U test.

3.1. Maternal Outcomes

Statistically significant less women receiving the midwife-led continuity model underwent unplanned caesarean section (CS), 12·8% vs 15·9%, an adjusted risk ratio (aRR) of 0·80 (95% CI 0·64–0·99). There were no statistically significant differences between the two groups regarding any other modes of birth: planned CS 11·9% vs 10·7, aRR 1·14 (0·97–1·34), total CS (planned and unplanned) 24·8% vs 26·6%, aRR 0·95 (0·82–1·11), spontaneous vaginal birth 71·4% vs 70·9%, aRR 1·02 (0·96–1·08) or vacuum extraction 3·7% vs 2·5%, 1·19 (0·72–1·97). Statistically less women exposed for the midwife-led model of care had induced labour, 8·7% vs 12% aRR 0·66 (0·49–0·88).
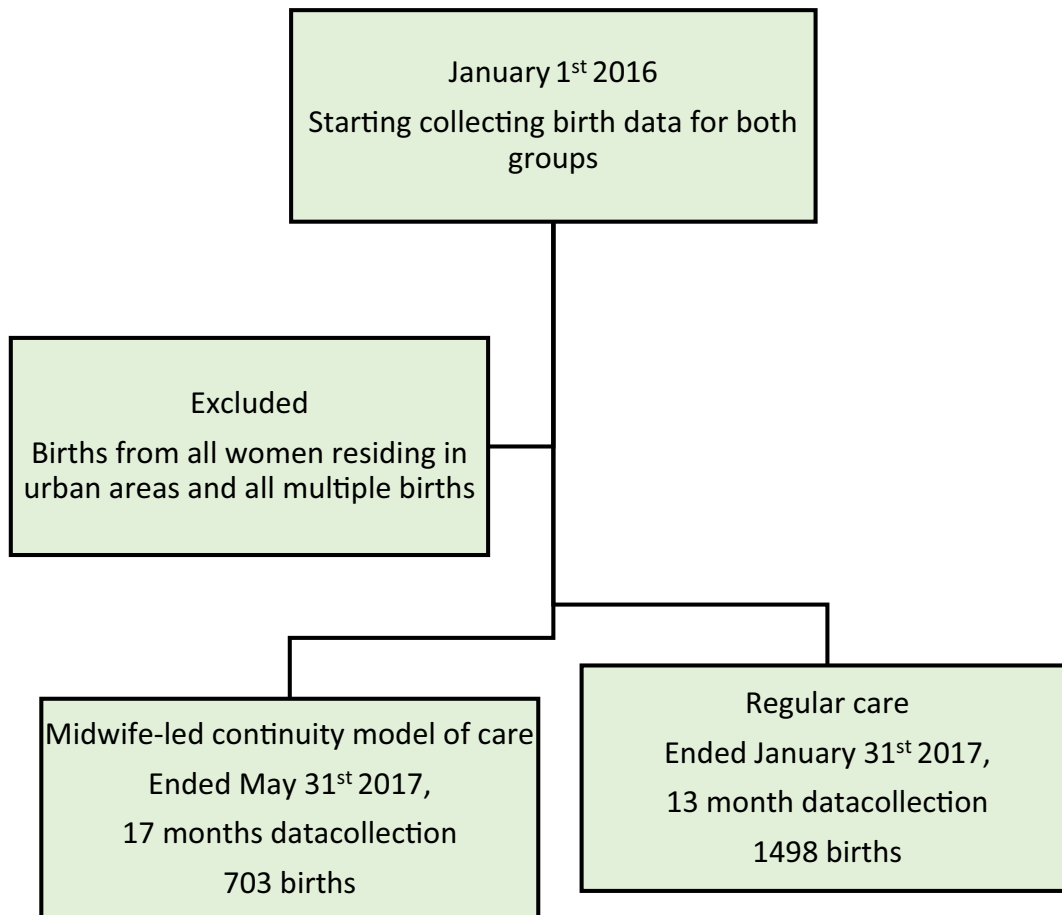

Fig. 1. Flowchart of the data-selection process.

Table 2

Maternal outcomes.

Outcomes	Outcome category	Midwife-led care (n = 703)	Regular care (n = 1498)	Unadjusted risk ratio[a] RR (95% CI)	*p* value	Adjusted risk ratio[b] aRR (95% CI)	Adj *p* value
Unplanned CS	No	613 (87·2%)	1269 (84·1%)	1 (ref)		1 (ref)	
	Yes	90 (12·8%)	238 (15·9%)	0·81 (0·64–1·01)	0·060	0·80 (0·64–0·99)	0·043
Data missing		0	0				
Planned CS	No	619 (88·1%)	1337 (89·3%)	1 (ref)		1 (ref)	
	Yes	84 (11·9%)	161 (10·7%)	1·11 (0·87–1·43)	0·403	1·14 (0·97–1·34)	0·105
Data missing		0	0				
Total CS (planned and unplanned)[c]	No	529 (75·2%)	1099 (73·4%)	1 (ref)		1 (ref)	
	Yes	174 (24·8%)	399 (26·6%)	0·93 (0·80–1·08)	0·350	0·95 (0·82–1·11)	0·520
Data missing		0	0				
Spontaneous vaginal birth[c]	No	201 (28·6)	436 (29·1%)	1 (ref)		1 (ref)	
	Yes	502 (71·4%)	1062 (70·9%)	1·01 (0·95–1·07)	0·804	1·02 (0·96–1·08)	0·566
Data missing		0	0				
Vacuum extraction	No	677 (96·3%)	1461 (97·5%)	1 (ref)		1 (ref)	
	Yes	26 (3·7%)	37 (2·5%)	1·50 (0·91–2·45)	0·109	1·19 (0·72–1·97)	0·490
Data missing		0	0				
Induction of labour[d]	No	565 (91·3%)	1176 (88·0%)	1 (ref)		1 (ref)	
	Yes	54 (8·7%)	161 (12·0%)	0·72 (0·54–0·97)	0·031	0·66 (0·49–0·88)	0·004
Maternal anaemia postpartum Hb < 11 g/dl	>11 g/dl	564 (80·2%)	1069 (71·4%)	1 (ref)		1 (ref)	
	<11 g/dl	139 (19·8%)	429 (28·6%)	0·69 (0·58–0·81)	0·0001	0·72 (0·60–0·85)	0·0001
Data missing		0	0				
Maternal anaemia postpartum Hb < 9·5 g/dl	>9·5 g/dl	675 (96·0%)	1399 (93·4%)	1 (ref)		1 (ref)	
	<9·5 g/dl	28 (4·0%)	99 (6·6%)	0·60 (0·40–0·91)	0·015	0·62 (0·41–0·95)	0·026
Data missing		0	0				
Maternal blood transfusion postpartum	No	700 (99·6%)	1455 (97·1)	1 (ref)		1 (ref)	
	Yes	3 (0·4%)	43 (2·9%)	0·15 (0·05–0·48)	0·001	0·14 (0·04–0·47)	0·001
Data missing		0	0				

Data are in n (%) and risk ratio RR (95% CI) and adjusted risk ratio aRR (95% CI). CS = caesarean section. The table includes singleton births by women from rural areas.

[a] Univariate analyses using Pearson's chi-squared tests.

[b] Multivariate analyses using generalised linear models for binary outcomes with the log link to adjust for mothers' age, parity, previous CS and year of current birth.

[c] Proportion of previous CS could not be adjusted for due to the number who had vaginal birth combined with previous CS was less than 1%.

[d] Planned CS was excluded from reference group.

The occurrence of postpartum anaemia, (Hb < 11 g/dl), was statistically significant lower in the exposed group, 19·8% vs 28·6%, aRR 0·72 (0·60–0·85). Accordingly, the difference in number of women receiving blood transfusion was 0·4% vs 2·9%, aRR 0·14 (0·40–0·47) (Table 2). Adjusting for age and parity changed the results significantly, while adjusting for previous caesarean section and year of current birth gave no significant change. We did not find any statistically significant interactions between maternal outcomes and previous caesarean section in the subgroup analysis.

3.2. Neonatal Outcomes

A statistically significant difference was observed in favour of those who received the midwife-led continuity model of care regarding rate of preterm newborn, 37 weeks and less, 13·1% vs 16·8, aRR of 0·76 (0·58–0·99). The rate of newborn with low birth weight, 2500 g and less, was 7·0% for the exposed group and 8·9% for the unexposed group. The difference was not statistically significant. The rate of newborn with very low birth weight, 1500 g and less, was 0·1% of babies born from mothers receiving midwife-led care compared to 1·1% receiving regular care, aRR of 0·13 (0·02–0·96) and was statistically significant, as was the admission rate to NICU, with 6·6% in the midwife-led care vs 9·9% regular care, aRR 0·66 (0·46–0·93). There was no statistically significant difference in Apgar score and number of neonatal deaths (Table 3). Adjusting for age and parity changed results significantly, while adjusting for previous caesarean section and year of current birth gave no significant change.

4. Discussion

Several improved outcomes both for mothers and babies were observed when women received the midwife-led continuity model of care during pregnancy. The findings are in line with the existing evidence on Midwife-led continuity models of care. A Cochrane review by Sandall et al. from 2016 found that midwife-led continuity of care reduces preterm births, and randomised studies in setting with high caesarean section rates found that Midwife-led models reduced the rates significantly [3–5]. The Palestinian midwife-led model of care can be evaluated based on the Framework for quality maternal and newborn care, presented by Renfrew et al. in the Lancet series on Midwifery in 2014 [19]. As such the implementation aimed at improving the midwives scope of practice, strengthen the organisation of care, enhance woman-centred values and a philosophy of relational care, improving referral lines and interdisciplinary cooperation. But the midwives' role during labour, where medical doctors were in charge, was less autonomous than their role as antenatal care providers. Thus, it is surprising that the model also seemed to have impact on the rate of medical interventions during labour, such as unplanned caesarean section and induction of labour. We assumed that indications for planned caesarean section would affect all women equally, thus we chose unplanned caesarean section as main outcome to investigate if the model would have an effect. The possible impact of the midwives' role through the pregnancy could be related to information, education, trust and empowerment. If women felt more confident and relaxed before and during labour, it could have an indirect impact on medical interventions like induction of labour and unplanned caesarean section rates. The relation to a midwife that works in the labour ward could indirectly make the women feel more familiar with her midwives' colleagues when she came to the hospital to give birth. The governmental hospital in Nablus had, according to Zimmo et al. [20], one of the highest rates of unplanned caesarean sections in Palestine and consequently a potential for reductions [20]. The total caesarean rate of 35·1% at the hospital was high, even for a tertiary referral hospital. An optimal general caesarean section rate is disputed, but rates above of 15%–20% are not associated with lifesaving benefits [21,22]. The statistically significant reduction of unplanned caesarean sections with 3·1% in the

Table 3

Neonatal outcomes.

Outcomes	Outcome category	Midwife-led care (n = 703)	Regular care (n = 1498)	Unadjusted risk ratio RR[c] (95% CI)	p value	Adjusted risk ratio aRR[d] (95% CI)	Adj p value
Preterm birth ≤ 37 weeks	>37 w	613 (86·9%)	1247 (83·2%)	1 (ref)		1 (ref)	
	≤37 w	92 (13·1%)	251 (16·8%)	0·78 (0·63–0·98)	0·029	0·79 (0·63–0·98)	0·035
Data missing		0	0				
Very preterm birth ≤ 32 weeks	>32 w	700 (99·6%)	1475 (98·5%)	1 (ref)		1 (ref)	
	≤32 w	3 (0·4%)	23 (1·5%)	0·28 (0·08–0·92)	0·036	0·27 (0·08–0·91)	0·035
Data missing		0	0				
Birthweight ≤ 2500 g	>2500 g	652 (92·7%)	1364 (91·1%)	1 (ref)		1 (ref)	
	≤2500 g	51 (7·3%)	134 (8·9%)	0·81 (0·60–1·11)	0·185	0·79 (0·58–1·09)	0·146
Data missing		0	0				
Birthweight ≤ 1500 g	>1500 g	702 (99·9%)	1482 (98·9%)	1 (ref)		1 (ref)	
	≤1500 g	1 (0·1%)	16 (1·1%)	0·13 (0·02–1·00)	0·050	0·13 (0·02–0·97)	0·046
Data missing		0	0				
Apgar score at 5 min	>7	683 (97·2%)	1433 (95·7%)	1 (ref)		1 (ref)	
	≤7	20 (2·8%)	65 (4·3%)	0·66 (0·40–1·07)	0·093	0·70 (0·43–1·15)	0·156
Data missing		0	0				
Neonatal death[a]	No	697 (99·1%)	1484 (99·1%)	1 (ref)		1 (ref)	
	Yes	6 (0·9%)	14 (0·9%)	0·91 (0·35–2·37)	0·852	0·90 (0·34–2·37)	0·832
Data missing		0	0				
Newborn admitted to NICU[b]	No	654 (93%)	1349 (90·1%)	1 (ref)		1 (ref)	
	Yes	49 (7%)	149 (9·9%)	0·70 (0·51–0·96)	0·025	0·71 (0·52–0·98)	0·036
Data missing		0	0				

Data are in n (%), risk ratio RR (95% CI) and adjusted risk ratio aRR (95% CI).
[a] Neonatal deaths include stillbirths and deaths during hospital stay.
[b] NICU = neonatal intensive care unit. The table includes singleton births by women from rural areas.
[c] Univariate analyses using Pearson's chi-squared tests.
[d] Multivariate analyses using generalised linear models for binary outcomes with the log link. Adjusted for mothers' age, parity, previous CS and year of current birth.

group receiving the Midwife-led continuity model of care depended on increases in vaginal births and in planned caesarean sections. The reduction in the total caesarean section rate of 2·2%, was not statistically significant, but could be clinically interesting when discussing further action to reduce the caesarean section rate. Caesarean section increases maternal risk for infections, haemorrhage, placental pathology in later pregnancies, as well as neonatal respiratory distress and gastrointestinal allergy [21,23,24]. Thus a reduction in the caesarean section rate has short and long-term positive effects for both mothers and their babies. Unlike the evidence from the Cochrane review on midwife-led models of care, this study found that the model was associated with reduction of induced labour, which could also be related to the experience of psychological support during pregnancy. Consequently, women who received information and education from a midwife they trusted could be more prepared for the labour process, encounter less stress and hence present less demands of induction of labour. An overuse of inductions and augmentations increases the risk of uterus rupture and perineal- and anal-sphincter trauma [11].

Regional anaesthesia is a relevant outcome for midwife-led models in high-income settings. We chose maternal anaemia as an outcome as it is more relevant in low- and middle-income countries [2,7,25]. The high incidence and risks related to maternal anaemia require priority attention globally, especially in low and middle-income countries [26,27]. Postpartum anaemia and blood transfusion are important indicators of morbidity and give more accurate information than estimations of blood loss. This important information was available as all women had their haemoglobin measured before leaving hospital.

Less postpartum anaemia and blood transfusions in the exposed group are positive outcomes that seem strongly related to the midwife-led continuity model of care. This result is promising and a reasonable consequence of being followed up closer through pregnancy with haemoglobin measurements, iron supplements and nutritional advice. Postpartum anaemia is caused mainly by anaemia in pregnancy and/or intrapartum haemorrhage [28]. Due to a high incidence of anaemia in pregnant women, the MoH guidelines advice to treat all pregnant women with 60 mg iron daily and 400 μg folic acid as daily supplementation for six months during pregnancy. Anaemia should be treated with 120 mg iron, in line with WHO recommendations [2]. Nevertheless, good standards are not enough if women do not use or trust the services provided. Women who received the midwife-led model of care, seem to have stronger adherence to the service provided, which increases the midwife's chance to follow up [18]. Another reason for postpartum anaemia is related to haemorrhage caused by caesarean section, and the reduced unplanned caesarean section rate could explain some of the difference between the groups. Postpartum anaemia causes both physical and psychological morbidity, such as fatigue and infections, and is associated with postpartum depression [28].

The reduction in preterm births and low birth weight in the group receiving midwife-led care is important, as these are the main reasons for infant mortality and morbidity. The findings from this study suggest that there is an association between the midwife-led continuity model of care and less preterm births and children with very low birth weight (≤1500 g). Reduced preterm births and low birth weight consequently reduce the need of treatment in the neonatal intensive care unit. A Cochrane review found that receiving iron supplement during pregnancy reduces the risk of preterm births and low birth weight [29]. This implies that the outcomes are linked to each other and the causal path is not straight forward in maternal care. Further studies should consequently be done to investigate complex interventions that can improve care and important health outcomes. The neonatal death rate, stillbirths and neonatal deaths during hospitalisation were 0·9% and similar in both groups, indicating that a larger sample size would be necessary to detect any impact on mortality or a more efficient intervention is needed to reduce neonatal mortality. It would be interesting to investigate what long term impact the model could have on maternal and/or neonatal morbidity.

The costs related to education and training, investments and running costs were initially supported by Norwegian humanitarian aid, and subsequently taken over by the Palestinian Ministry of Health. The costs should be justified in relation to the benefit of improved care and health outcomes. A review concluded that midwife-led models of care would be a cost-efficient way to improve maternal services in low- and middle-income countries [30]. The implementation process included co-operation between Palestinian and Norwegian midwife kadres in the

initial planning, further a broad collaboration between all levels in the Palestinian Ministry of health was required to anchor the model within the MoH system and make the model sustainable. The implementation process including cost analysis should be studied and described in detail.

The strength of this study is the pragmatic approach to improve maternal services and the available information of the midwife-led continuity model. The large sample size and complete data on important clinical outcomes furthermore strengthen the study. This study confirms that the Midwife-led continuity model can be implemented in new settings. However, further research with high quality methods is required to describe the implementation in detail to make the model applicable to other settings.

Limitations of the study are related to the risk of bias in observational design and lack of data on potential confounders such as socioeconomic factors, indications for caesarean sections and more detailed health information on pregnancy complications. Information on whether the women in the exposed group also received care elsewhere, or if the proportion of women that could have belonged to either group chose to give birth in another hospital could be valuable. It would also be useful to know the number of urban women and women with multiple pregnancies that were excluded. The study also lacks information on the grade of continuity, how many times women met the same midwife, and if they met their midwife during labour or postnatal ward. A potential bias could also be related to the different group size, and the difference in time of data collection, as a longer period was needed to reach the required sample size for the group receiving the midwife-led care. Information from the hospital implies that there were no other interventions affecting the outcomes at the hospital during those extra months in 2017, and this makes it unlikely that the difference in time had an influence on the results.

5. Conclusion

Receiving care from the midwife-led continuity model in Palestine was associated with reduced unplanned caesarean sections and other medical interventions during labour as well as reduced maternal and neonatal morbidity. These factors may contribute to improved quality of life and to reduced hospital- and social costs. The results support expansion of the model. Further implementation research and randomised studies can produce useful knowledge on the effect and feasibility of such models in low resource settings. The experience from the Midwife-led continuity model of care in Palestine could be useful for others who strives to improve mothers and babies' health globally.

Contributors

BM was involved with the implementation, study design, preparation of data collection, data analysis, data interpretation and writing. MaL was involved with study design, data interpretation and writing. LMD was involved with study design, data analysis and writing. MiL was involved with study design, data interpretation and writing. KA were involved with the implementation and data collection. EF was involved in study design, data collection, data analysis, data interpretation and writing. BM drafted the article and tables. All authors have reviewed and approved the final manuscript. The corresponding author had full access to all the data in the study and had final responsibility for the decision to submit for publication.

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Declaration of Interest

EF is the director of Norwegian Aid Committee (NORWAC). BM was partly employed by NORWAC until February 2017 as project manager for implementing the model. All other authors have nothing to disclose.

Data Sharing Statement

Data can be obtained upon request to the Palestinian Ministry of Health.

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