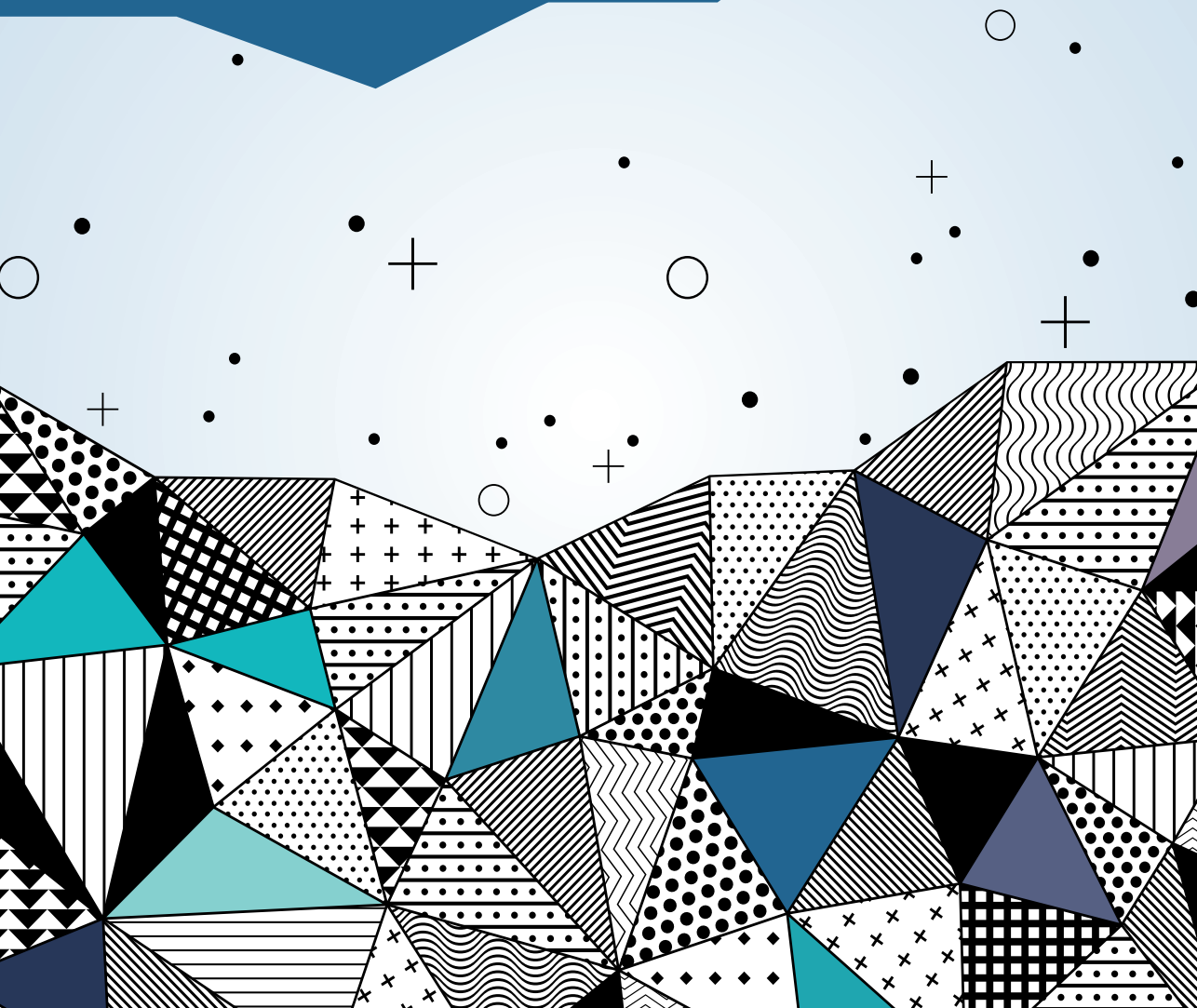
INEQUITIES IN PERINATAL HEALTH

Determinants & strategies for improvement

Anke Gezina Posthumus



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INEQUITIES IN PERINATAL HEALTH

Determinants and strategies for improvement

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Determinanten en strategieën voor verbetering

Proefschrift

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'You must be the change you wish to see in the world'
-Mahatma Gandhi-

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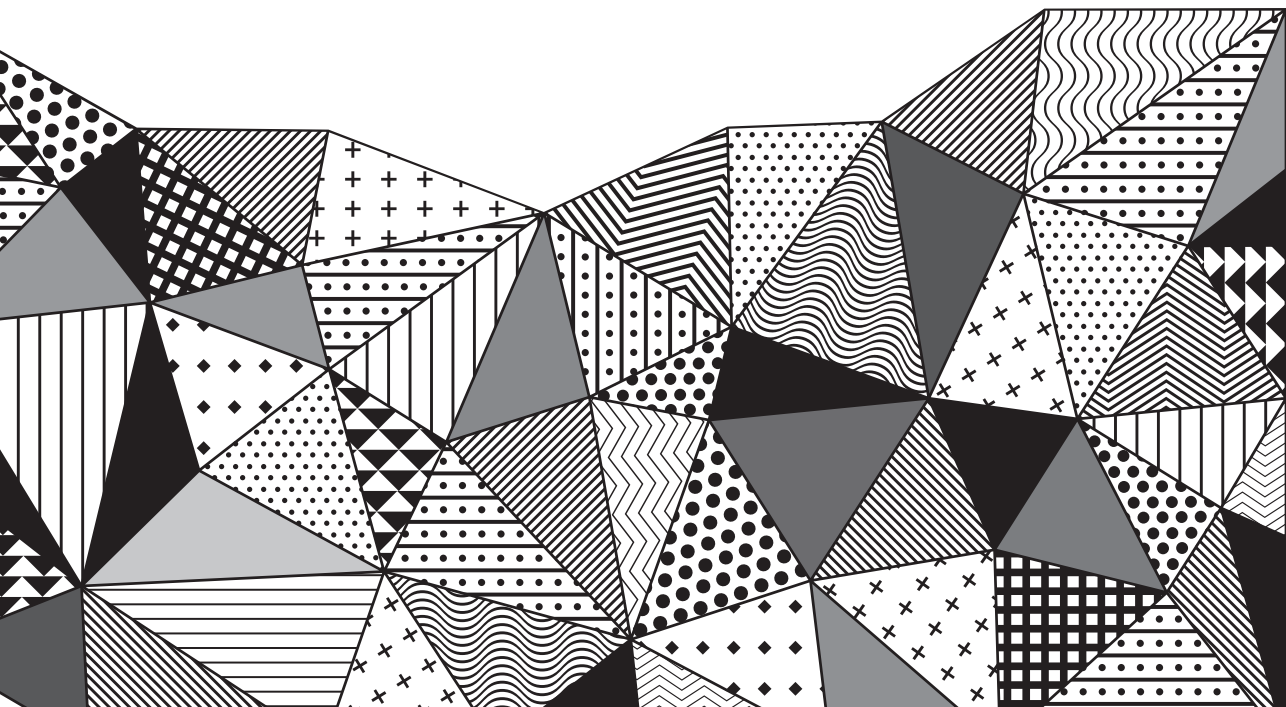

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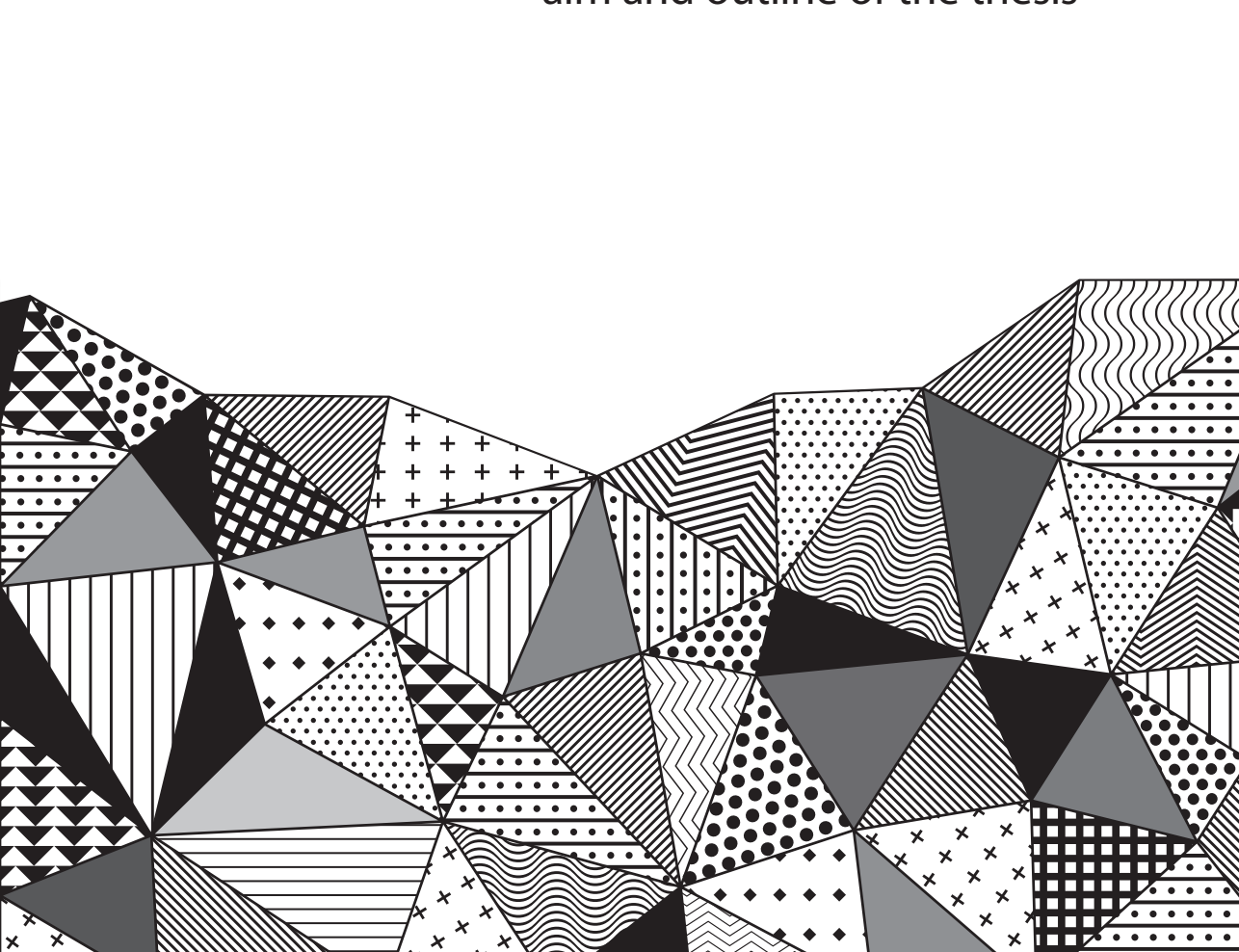
Chapter 1

General introduction,
aim and outline of the thesis



HEALTH INEQUALITY AND INEQUITY

Every society should aim to have low levels of adverse perinatal outcomes, with minimal inequalities due to non-medical factors such as maternal background (e.g. ethnicity or age), area of residence or health care delivery. It is important to differentiate between *inequalities* and *inequities* in health. Inequalities refer to "differences in health status or in the distribution of health determinants between different population groups". [1] These inequalities may for example result from genetic differences or from informed choices people make. Generally such differences in outcomes are deemed ethically acceptable. However, other health inequalities which can be attributed to external factors which the individual has little influence on, such as living conditions or access to care, are potentially "unnecessary and avoidable as well as unjust and unfair". [1] These are considered to be health *inequities* and should be diminished. Not all differences in health with a biological base are thus exempt from being an inequity: if adequate health prevention and health care provision may level the difference, an existing inequality may still be regarded as an inequity. To ensure equity in perinatal health, equal access to care and even more importantly equal performance of care should be available for all women. Additionally, attention should be given to non-health/non-medical measures which are sometimes equally relevant in decreasing inequity.

PROGRESS is an acronym for now widely accepted ethical criteria to judge the presence of inequities in health- and health care (in)equalities. [2] PROGRESS stands for place of residence, ethnicity (before: race), occupation, gender, religion, education, socio-economic position and social capital. In the perinatal context, this thesis explores health inequalities in the Netherlands according to place of residence, ethnicity, education, socio-economic status and social capital.

Western societies are beginning to acknowledge the presence of health inequalities, and its detrimental effects, not only in personal terms (accumulated poor quality of life, which potentially expands to the next generation's health [3]) but also in terms of economic and social development. [4, 5] The Netherlands is a particular case, with surprisingly large health gaps in spite of egalitarian policies, and in view of the observation that health inequalities are reported to increase. [6] In general, scientists and policy makers including the World Health Organization wonder about the persistence or even growth of health gaps; they appear to be hard to overcome, even the avoidable part of them. At the surface one could argue that it takes time to translate scientific knowledge on its determinants into public awareness and grass root policy changes. But this explanation seems insufficient in view of a long tradition in countries with health egalitarian policies (like the United Kingdom, the Netherlands and Nordic countries] which fail to make much progress. [7, 8]

Ironically, interventions to improve outcomes initially tend to benefit the best-off first. Two mechanisms coincide. Firstly, the more deprived and vulnerable people are served less by preventive and curative care if the practical access to these services and their effectiveness in terms of risk reduction rely on their personal resources. Inequalities in the volume of health care services is summarized in the 'inverse care law': those who need most, receive least. [9] Inequalities in performance used to receive less attention; however currently more focus is given to the effects of health illiteracy and communication effects. [10] These come into play when the socio-economic and cultural distance between caregiver and caretaker are large. [11] A second pathway, reinforcing the first, rests on a straightforward epidemiological mechanism. If risk factors are indeed modified, the net effect is less if more risk factors for the same disease are present in one individual. This is often the case. This paradox explains why population measures in populations at moderate risk have a larger absolute effect than the more recognizable risk group approaches which seem more attractive for policymakers and the public (known since the 90's of the last century as the prevention paradox [12]). The same mechanism explains for example the generally smaller effect of drugs in the population of interest compared to the trial population, as patients with comorbidity or high age are excluded. Stated otherwise, in multi-risk patients the maximum space for improvement is smaller, in epidemiological terms the so-called potential impact fraction is smaller.

Inequalities can arise at different levels. We can distinguish the level of the individual, the non-medical environment (including social systems), and the health care level (including preventive services). Determinants of inequality at the individual level concern education (also health literacy), occupation and income (socioeconomic status), ethnicity, cultural assimilation, and health behaviour factors. [13, 14] At the environmental level, factors that are known to play a part include neighbourhood social capital (connectedness and segregation), neighbourhood level deprivation, and physical and chemical exposures (noise, microparticles). [15-18] One may argue that part of the individual determinants, such as educational attainment are at least in part an environmental factor in its way of action and, potentially, in its susceptibility for interventions.

Via various pathways the above mentioned determinants lead to inequalities in perinatal health outcomes. Many of these are part of the PROGRESS set, and may thus be considered inequities. In this thesis we will further address perinatal health inequalities and inequities, starting with a description of its size, and analyses of its sources.

PERINATAL OUTCOMES IN THE NETHERLANDS

The case for perinatal health inequalities in the Netherlands has been made since 2009. Dutch perinatal outcomes in general came under closer scrutiny after the comparative

European Peristat-reports in 2004 and 2008 published disappointing outcomes in terms of fetal and neonatal mortality for the Netherlands. [19] For example, Dutch neonatal mortality rates were the highest of Western Europe and fetal mortality (> 22 weeks of gestation) was only higher in France. At that stage in particular the Rotterdam region, the second largest urban agglomeration of the country, observed strikingly increased levels of perinatal mortality and gaps at the neighbourhood and individual level according to ethnicity and socioeconomic status. Perinatal mortality levels were sixteen-fold in some deprived neighbourhoods compared to more affluent neighbourhoods. [15, 17, 20] The fact that the gaps per se explained part of the low regional average brought both issues, in short 'level' and 'distribution', on the same health policy agenda. A national steering committee on pregnancy and childbirth published a report, using the newly available data [20] which expressed health inequality reduction as a priority with special responsibilities for caregivers. [21]

Unlike any previous policy or professional report, the committee introduced a perspective which paid equal attention to individual and environmental factors on the one hand, and professional, care provision, and organizational factors on the other hand, including the Dutch obstetric system. The challenging view that care factors are relevant to both the level and distribution of outcomes, induced several discussions about the risk management system, continuity of care and care providers in case of referral, 24/7 care provision and inter-professional communication during parturition.

The current system consists of three tiers of care, the first consisting of autonomous working midwives taking care of estimated low risk women during pregnancy (about 84% start care with the midwife), labour (about 51% start delivery under supervision of the midwife), and puerperium. Women in the first tier of care can either deliver at home or in hospital under supervision of their midwife. If medical risks (threaten to) occur during pregnancy, labour or puerperium, women are referred to the second tier of care, consisting of obstetricians and clinical midwives, providing hospital-based care (about 90 hospitals). [22] The third tier of care is reserved for high risk or severely ill women, and threatened pregnancies; this care is provided at so-called perinatological centres which provide neonatal intensive care (NICU care). Their number is limited; all the 8 academic medical centres and 2 specialized centres provide NICU care.

As a general approach to improving the current situation in terms of perinatal care and outcomes, the Steering Committee stressed: 1) the importance of collaboration between professionals within and across the different tiers of care; 2) the need for better early risk detection tools and interventions for risk reduction. [21] In response to the recommendations in the report, numerous initiatives took place while the existing initiative in the region of Rotterdam frequently served as a best practice.

INTERVENTIONS TO IMPROVE PERINATAL HEALTH

In the city of Rotterdam the initiative was coined the 'Ready for a Baby' program. [23] Multiple interventions were developed including organizational, service delivery and non-medical service interventions. Uniquely, right from the start the focus was on simultaneous improvement of level and distribution of outcomes: perinatal mortality should decrease and inequalities between neighbourhoods should be reduced. Interventions and tools were targeted at the entire cycle from preconception care to puerperium, and an elaborate monitoring system was put into place. Reports were published on the urban area level, disclosing both level and inequality information.

To improve the detection of risks for adverse outcomes in pregnancy a new tool was developed, the Rotterdam Reproductive Risk Reduction scorecard (R4U). [24, 25] It incorporates 70 risk factors, both medical and non-medical, which are associated with increased risks of perinatal mortality, preterm birth, being small for gestational age and congenital anomalies. Due to the unequal distribution of the R4U risks in the population, these in turn contribute to unequal outcomes. [14, 20] Thus this tool (if connected to interventions) could add to the improvement of the level of adverse outcomes, and to decreasing inequalities. Because prior studies pointed to inequalities in the time of entry into antenatal care, the program also focused on that issue. Finally, because the R4U risk factors are relevant in all obstetric care tiers, and because uniform risk assessment and risk communication are critical for effectiveness, the R4U also offered an interesting starting point for intensified collaboration between these tiers.

In this thesis we combine data analyses on perinatal outcomes and perinatal health care, and first reports on a so-called 'Shared Care' initiative. The point of departure was to develop a form of 'Shared care' for which there was no true precedent in the Dutch tiered obstetric care system. The R4U would then be imbedded in this Shared Care approach. We will further elaborate on these developments in this thesis, which partly concerns etiological pathways, interventions and lastly decision-making.

AIMS OF THIS THESIS

1. To establish the roles of personal and geographical factors relevant for the presence and perseverance of health inequalities, in the development of adverse perinatal outcomes, in particular the so called Big4 outcomes and perinatal mortality.
2. To investigate whether relevant differences exist in the provision, uptake and quality of perinatal care according to socioeconomic status and ethnicity in the Netherlands.
3. To investigate the feasibility and efficacy of a practice based Shared Care intervention in early pregnancy, aimed at 1) improving the detection and reduction of non-

medical risks (which are known to contribute to perinatal inequalities) ; 2) improving collaboration between perinatal caregivers in risk management.

Research questions

Aim 1

1. Which personal and geographical effects are associated with the occurrence of adverse perinatal outcomes, taking account for various effects of SES and ethnicity?

Aim 2

2. Which personal and geographical factors are associated with timely entry into perinatal care (booking visit) with special attention for SES and ethnicity of the women?
3. For a set of common obstetric interventions: does the probability of their application depend on socioeconomic status and ethnicity after correction for hospital density?
4. What is the association between socioeconomic status, ethnicity and the uptake of prenatal screening, taking into account that insurance conditions are different here?

Aim 3

5. What are the barriers in the coordination of obstetric care in the Netherlands?
6. What should a model for Shared Care in Dutch obstetrics look like?
7. Which contexts and mechanisms are relevant in the implementation of a Shared Care intervention in obstetric practice?

OUTLINE OF THIS THESIS

This thesis consists of three parts. Part I concerns the determinants of perinatal adverse outcomes, with a specific focus on socioeconomic status and ethnic background.

Chapter 2 examines the prevalence and relevance of both medical and non-medical risk factors in the occurrence of adverse perinatal outcomes in the city of Rotterdam, stratified according to socioeconomic status and ethnic background. In **Chapter 3** evidence is compiled on the risk of adverse perinatal outcomes in relation to neighbourhood level deprivation. Next, part II of this thesis examines determinants of inequalities in perinatal health care, with a specific focus on socioeconomic status and ethnic background. **Chapter 4** focusses on the incidence of a number of different obstetric interventions, adjusted for maternal characteristics and hospital density. Group comparisons are made according to geographical location, ethnicity and socioeconomic status. **Chapter 5** investigates the relevance of neighbourhood level characteristics, including neighbourhood social capital and ethnic minority density, for the time of

entry into antenatal care. Potential differences in the influence neighbourhood level determinants have on Western and non-Western women are examined. In **Chapter 6** the focus is specifically on the uptake of prenatal screening in the four largest cities of the Netherlands. Again distinctions are made according to maternal ethnicity and socioeconomic status. **Chapter 7** then takes a closer look at the relevance of a number of different organizational characteristics in the occurrence of intrapartum and neonatal mortality. Additionally the interaction between these organizational characteristics and the severity of peripartum disease is examined. Part lll of this thesis concerns the development of a Shared Care model in Dutch obstetrics, aimed at improving interprofessional collaboration and both medical and non-medical risk detection. **Chapter 8.1** presents a model for Shared Care inspired by literature from other fields of medicine. This model forms the starting point for the Shared Care project in the city of Rotterdam. **Chapter 8.2** examines the causes and consequences of challenges in the collaboration between the different caregivers in the Dutch obstetric care system. **Chapter 8.3** offers a realist evaluation of the actual implementation of the Shared Care project, describing relevant contexts and mechanisms. Lastly, **Chapters 9 and 10** discuss and summarize the findings in the previous chapters. Additionally recommendations are offered for policy, practice and future research.

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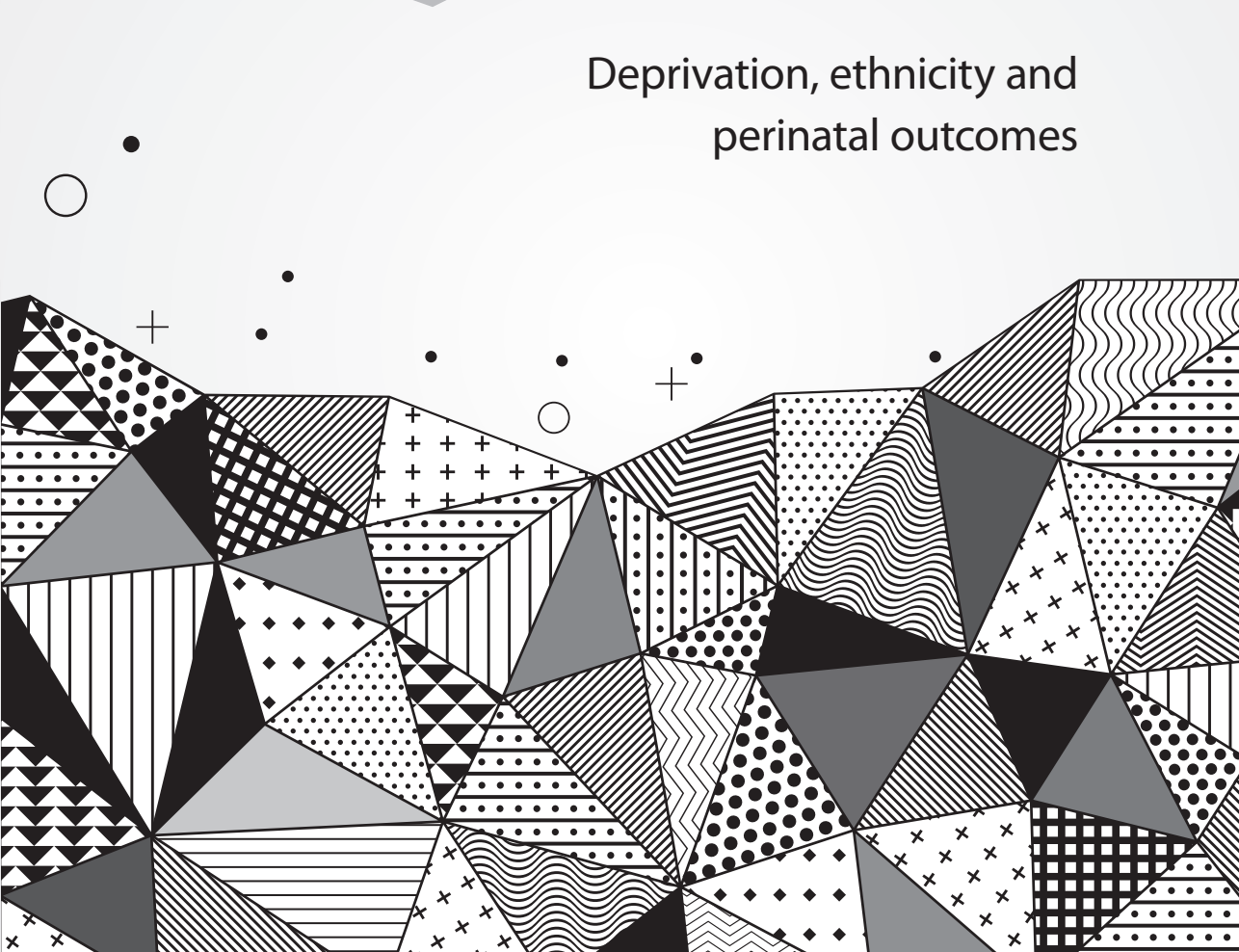
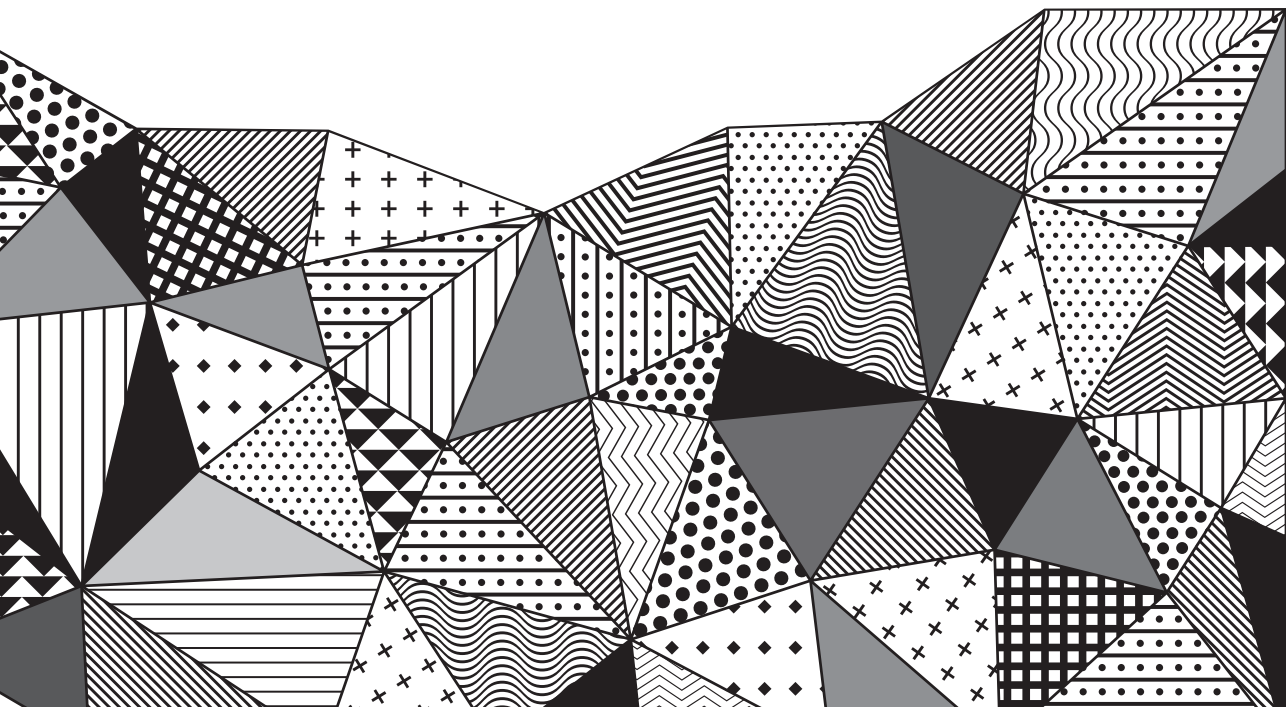
Part I

Deprivation, ethnicity and perinatal outcomes





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Chapter 2

An antenatal prediction model for adverse birth outcomes in an urban population: The contribution of medical and non-medical risks

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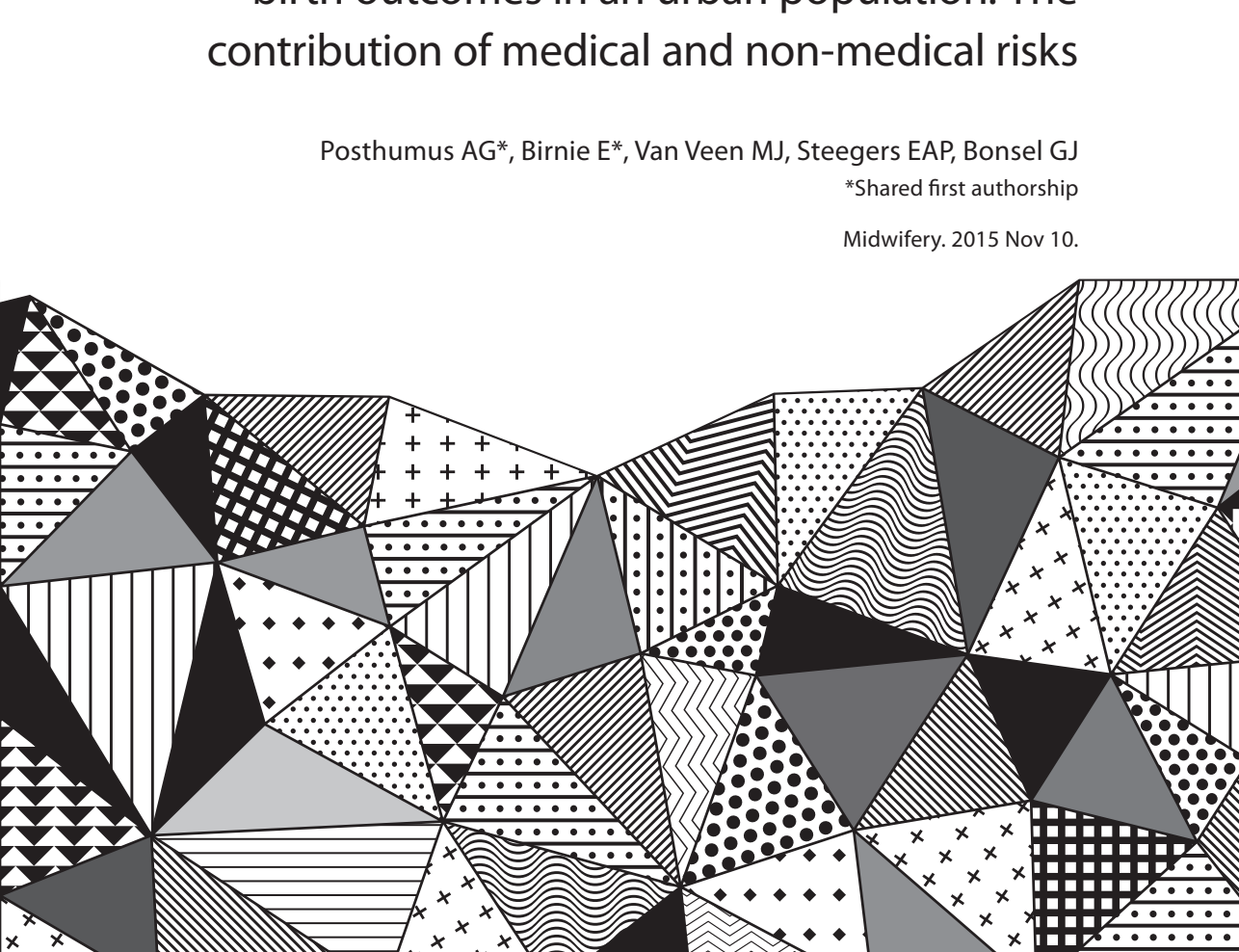
*Shared first authorship

Midwifery. 2015 Nov 10.



ABSTRACT

Objectives: In the Netherlands the perinatal mortality rate is high compared to other European countries. Around eighty percent of perinatal mortality cases is preceded by being small for gestational age (SGA), preterm birth and / or having a low Apgar-score at 5 minutes after birth. Current risk detection in pregnancy focusses primarily on medical risks. However, non-medical risk factors may be relevant too. Both non-medical and medical risk factors are incorporated in the Rotterdam Reproductive Risk Reduction (R4U) scorecard. We investigated the associations between R4U risk factors and preterm birth, SGA and a low Apgar score.

Design: A prospective cohort study under routine practice conditions.

Setting: Six midwifery practices and two hospitals in Rotterdam, the Netherlands.

Participants: 836 pregnant women.

Interventions: The R4U scorecard was filled out at the booking visit.

Measurements: After birth, the follow-up data on pregnancy outcomes were collected. Multivariate logistic regression was used to fit models for the prediction of any adverse outcome (preterm birth, SGA and / or a low Apgar score), stratified for ethnicity and socioeconomic status (SES).

Findings: Factors predicting any adverse outcome for Western women were smoking during the first trimester and over-the-counter medication. For non-Western women risk factors were teenage pregnancy, advanced maternal age and an obstetric history of SGA. Risk factors for high SES women were low family income, no daily intake of vegetables and a history of preterm birth. For low SES women risk factors appeared to be low family income, non-Western ethnicity, smoking during the first trimester and a history of SGA.

Key conclusions: The presence of both medical and non-medical risk factors early in pregnancy predict the occurrence of adverse outcomes at birth. Furthermore the risk profiles for adverse outcomes differed according to SES and ethnicity.

Implications for practice: To optimize effective risk selection, both medical and non-medical risk factors should be taken into account in midwifery and obstetric care at the booking visit.

INTRODUCTION

The perinatal mortality rate in the Netherlands is high compared to other European countries (9 per 1000 births). [1] A Dutch study demonstrated that 85% of perinatal mortality cases are preceded by one or more of the following adverse outcomes: preterm birth, small for gestational age (SGA), low Apgar score and congenital anomalies. Together these outcomes have been labelled the 'Big4'. [2] The perinatal mortality rate is 6% in neonates with one Big4 outcome and increases to 79% if two or more Big4 outcomes are present. [3]

In the Netherlands the assignment of a presumed low or high risk status to each pregnant woman is a key feature of the current care system. Low risk women receive care from autonomously working community midwives ('first level' of care). High risk women receive care from obstetricians in hospitals ('second or third level' of care). Because a woman's risk status can change during pregnancy, labour or the postpartum period, she may be transferred at any stage from one level of care to the other. The current method of risk assignment is based on the 'List of Obstetric Indications' (LOI), which specifies criteria defining a high risk status. [4] A high risk status is based on the presence of a distinct (single) medical or obstetric risk factor for adverse outcomes.

Particularly in deprived urban areas the medically focused risk assignment of the LOI may fall short, since public health research has long established the influence of deprivation on health outcomes. [5] Moreover multiple cohort studies have revealed strong associations between non-medical risk factors and adverse birth outcome. The increased prevalence of such risk factors is held responsible for part of the elevated adverse birth outcomes in urban areas. [6-9] Non-Western ethnic descent, low income and a lack of social support are among the non-medical risk factors which are often reported in this context.

Previous research has demonstrated that the accumulation of multiple small to intermediate risk factors, both medical and non-medical, are the cause of inequalities in perinatal mortality. [9] This sliding scale of risk accumulation is not reflected in the current LOI which is based on a low/high risk dichotomy. To account for the principle of risk accumulation and the equally important role of non-medical risks, a new antenatal risk scorecard was developed, the Rotterdam Reproductive Risk Reduction scorecard (R4U). [10,11] The R4U was created as part of the comprehensive municipal 'Ready for a Baby' programme in the city of Rotterdam. In this programme health researchers and policy makers collaborated to develop and implement multiple strategies to improve perinatal outcomes. [12]

To reflect the equal importance of medical and non-medical risks in pregnancy and child birth, the R4U scorecard consists of both types of risk factors. These risks were selected for their contribution to adverse perinatal outcomes, and have been derived

from publications on large perinatal cohort studies. The selected 69 risk factors in the R4U are categorized into six risk domains: 1) social, 2) ethnic descent and language barriers, 3) life style, 4) health care behaviours, 5) general medical, and 6) obstetric. In prior studies Van Veen *et al.* and Vos *et al.* showed the R4U to be a feasible and reliable tool for professional based risk detection in daily midwifery and obstetric practice. [10,11] However, the predictive properties of the R4U have not yet been investigated under practice circumstances.

In this study we therefore investigated the associations between the risk factors of the R4U scorecard at the booking visit and the subsequent perinatal outcomes in a cohort of urban, deprived pregnant women in the city of Rotterdam.

METHODS

Study design and setting

To investigate the associations between the risk factors of the R4U scorecard and perinatal outcomes, we conducted a prospective cohort study under routine practice conditions between November 2010 and February 2013 in the city of Rotterdam, the Netherlands. The study took place in six community midwifery practices and two hospitals, in urban relatively deprived areas. Details on the study setting have been published previously. [10] All pregnant women who came to these facilities for their booking visit were invited for study participation. The booking visit is the first antenatal appointment a pregnant woman has with her care provider and it usually takes place before 11 weeks of gestation. For inclusion, women had to have sufficient command of the Dutch or English language. Women with multiple pregnancies were excluded. Approval of the study protocol was obtained from the Medical Ethics Committee of the Erasmus Medical Centre, Rotterdam (MEC-2010-332). Study consent entailed access to and collection of the R4U data at the booking visit and follow-up data on perinatal outcomes at the time of delivery and the first postnatal week.

Data collection

At the booking visit the R4U scorecard was filled out by the caregiver (primary care midwife, obstetrics/gynaecology resident or nurse) in addition to the usual medical history taking and examination. In practice, approximately one-third of the R4U risk factors overlapped with current history taking, while the remaining risk factors were new. Caregivers received a short training and instruction sheet on the use of the R4U. After the R4U scorecard was filled out, care was provided as usual.

Once a woman had given birth, the researchers collected the follow-up data on birth outcomes by reviewing the patients' obstetric chart. Specific attention was paid to the presence of so called Big3 outcomes (see below).

Outcome measures

The primary outcome in this study was the presence of a Big3 outcome, comprising: SGA (birth weight below the 10th percentile stratified for gender, gestational age and parity), preterm birth (<37 weeks of gestation) and low APGAR-score at five minutes after birth (score <7). Congenital anomalies were excluded. Four pregnancies with congenital anomalies in our study were terminated after prenatal screening/diagnostics. Additionally 50 pregnancies resulted in a spontaneous miscarriage, and we have no information on the presence or absence of congenital anomalies in these cases.

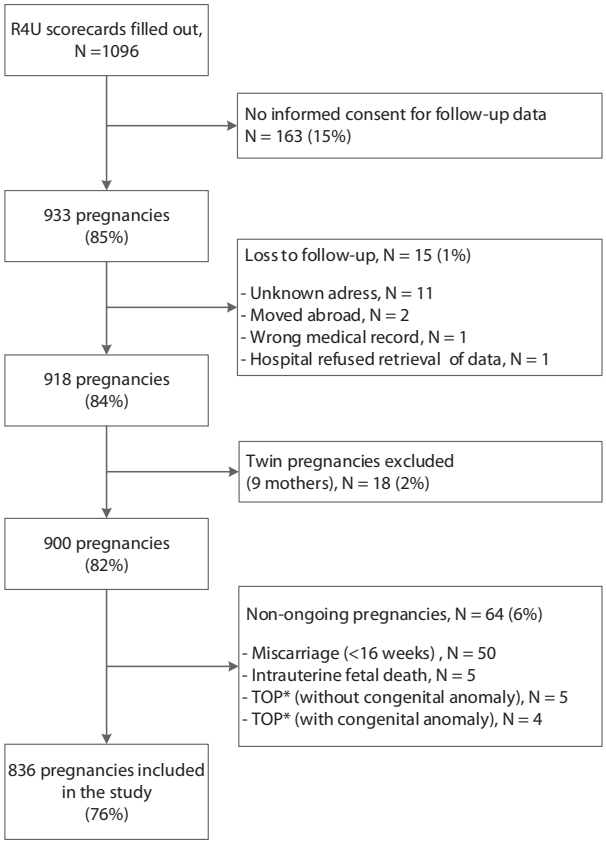


Figure 1. Study profile.

Exclusions and handling of missing data

Included were 836 pregnancies (see figure 1). Multiple pregnancies were excluded from the study because this determinant is itself already associated with a high risk status, independent from other considerations.

We were able to retrieve follow-up data on pregnancy outcomes of 98.6% of pregnancies included in the study. Not all 69 items of the R4U scorecard were filled out completely for all patients. Data on Chlamydia was missing in more than 92.0% of cases and this item was therefore excluded. Of the other risk factors, missing rates varied between 0.1 and 20.6%. We tested whether values were missing completely at random (MCAR) using Little's MCAR test. No statistically significant deviation from randomness was found ($\chi 2 = 0.255$, $df = 2$, $p = 0.880$).

First, some missing values were replaced, based on information available on other variables of the same record (e.g. if data on 'postpartum haemorrhage during prior deliveries' was missing, this missing value was replaced by 'no' in nulliparous women). Values that could not be replaced were imputed. [13] Each missing value was imputed five times, using the available data from the other variables within the same R4U domain (social, communication and ethnic descent, life style, health care behaviours, general medical, obstetric). After this procedure the risk factors 'refuses blood transfusion', 'shoulder dystocia during delivery prior to the index pregnancy' and 'congenital anomaly in prior birth' were removed because multiple imputation produced unrealistic results (e.g. in the original data the prevalence was 0.5%, in the imputed datasets it was around 6%, where the former is close to the true prevalence). Apparently the low prevalence of the risk factors and the lack of correlation with the other determinants caused overestimation of the prevalence. The multiple imputation procedure resulted in 5 complete datasets, in addition to the smaller 'complete' dataset without missing data.

Analyses were then carried out for each of the datasets separately. If an association was observed to be significant in at least four out of five complete datasets, it was considered a significant result. The median value of the coefficient was then reported with its confidence interval. [9]

Statistical analysis

We started with descriptive analyses of the demographic characteristics and the prevalence of the R4U risk factors in the study population. The primary explanatory analyses were based on the total study population without stratification. For ethnicity Non-Western was defined as: Afro-Surinamese, Indian-Surinamese, Javanese-Surinamese, Antillean, Cape Verdean, Turkish, Moroccan, and Other non-Western. The remaining women were categorized as Western. Socio-economic status was based on available SES-scores which were assigned by the Netherlands Institute of Social Research to all postal code areas. [14] This SES score is based on the mean income per household, % households

with a low income, % unemployed inhabitants and % households with an on average low education. The unit of measurement are 4-digit zip codes, which contain around 4000 inhabitants; [15] the number of births per zip code is about 1% of the number of inhabitants. In this study we dichotomized the continuous SES-score into low SES (< 20th percentile) and high SES (≥20th percentile).

Univariate logistic analyses first established the crude odds ratios (OR, 95% CI) between the R4U risk factors and any Big3 outcome for the total study sample (model 1). R4U risk factors with a univariate significance level of $p<0.10$ were then included in a multivariable logistic regression model (forced entry method) (model 2). To account for potential instability of results due to collinearity, both a stepwise forward and stepwise backward method were performed next (forward: inclusion $p<0.05$, exclusion $p>0.10$; backward: inclusion $p>0.10$, exclusion $p<0.05$). To establish the independent influence of the social risks and the obstetric risks, we fitted a separate model for each of these groups of determinants (forced entry method) (model 3 and 4). Finally, only determinants which were significant ($p<0.05$) in four complete datasets and for all three methods of analysis (forced entry, stepwise forward and backward) were included in the model (model 5, forward stepwise entry). This approach was repeated after stratifying the participants for low/high SES and for Western/non-Western ethnicity, as previous research reported confounding effects of, and interaction between ethnicity and SES. [16] The stratified results presented only report the results from the multivariate analyses. The stratified univariate analyses have been included as Appendix 1 and 2.

The goodness of fit of the models at the individual level was determined with Nagelkerke's R^2, and by calculating the expected and observed event rates in subgroups to determine model calibration in accordance with Hosmer-Lemeshow's method. All analyses were performed using IBM SPSS Statistics version 20.0 (IBM Corp., Armonk, NY, USA).

FINDINGS

Demographic characteristics and risk prevalence

Table 1 shows the demographic characteristics and the risk of adverse perinatal outcomes of the study population. A total of 2110 women received their booking visit during the study period, 51.9% was included in the study. In the included sample 19% of the women experienced a Big3 outcome. Children were SGA in 12% of the study participants. The prevalence of any Big3 outcome was significantly higher in both Non-Western women (25%) and women from low SES areas (21%).

Table 2 shows the prevalence of the R4U risk factors for the total study population, and for the Western/non-Western ethnic and low/high SES subgroups. Twenty-three

Table 1. Characteristics of included women and adverse perinatal outcomes stratified by ethnicity and socio-economic status.

	Total N (%)	Western N (%)	Non-Western N (%)	High SES (≥ 20th percentile) N (%)	Low SES (< 20th percentile) N (%)
Total number of cases	836 (100)	545 (65)	291 (35)	293 (35)°	538 (64)°
Individual determinants					
Maternal age at booking visit (mean)	29.9	30.1	29.6	30.9	29.5
<20 years	14 (2)	10 (2)	4 (1)	4 (1)	10 (2)
20-29 years	352 (42)	216 (40)	136 (47)	93 (32)	256 (48)
30-35 years	304 (36)	210 (39)	94 (32)	133 (45)	169 (31)
36-40 years	137 (16)	94 (17)	43 (15)	55 (19)	82 (15)
>40 years	29 (4)	15 (3)	14 (5)	8 (3)	21 (4)
Parity					
Primiparous (no prior birth)	373 (45)	271 (50)	102 (35)	142 (49)	228 (42)
Multiparous (1-2 prior birth)	402 (48)	247 (45)	155 (53)	142 (49)	258 (48)
Multiparous (≥3 prior births)	61 (7)	27 (5)	34 (12)	9 (3)	52 (10)
Ethnicity					
Western ethnicity	545 (65)	545 (100)	0 (0)	243 (83)	300 (56)
Non-Western ethnicity	291 (35)	0 (0)	291 (100)	50 (17)	238 (44)
Adverse perinatal outcomes					
Low Apgar score	33 (4)	18 (3)	15 (5)	10 (3)	23 (4)
SGA	97 (12)	50 (9)	47 (16)	23 (8)	74 (14)
Premature birth	46 (6)	22 (4)	24 (8)	12 (4)	34 (6)
Congenital / chromosomal anomaly	18 (2)	14 (3)	4 (1)	5 (2)	13 (2)
Any Big3°°	158 (19)	85 (16)	73 (25)	43 (15)	115 (21)

° 1% missing information on SES, °° At least one of low Apgar, SGA and premature birth.
Percentages may not add up to 100% due to rounding.

percent (23%) of the total population was unemployed. Also, 45% of the participating women did not take folic acid before they knew they were pregnant. After stratification for ethnicity, risk factors in the social domain were much more prevalent amongst Non-Western women than amongst Western women. In contrast, smoking and alcohol use occurred more often in Western women. Within the obstetric domain there were no differences between the two ethnic groups, except that the caesarean section rate was higher among non-Western women. Stratification for SES gave rise to a similar pattern as described for ethnicity: Low SES women had more risk factors in the social domain. The risk of assisted reproduction and time to conception of over one year, were both

increased in the high SES group. Women from the low SES group were more likely to have a history of gestational diabetes. Adverse birth outcomes in prior pregnancies (SGA, preterm birth and congenital anomalies) occurred equally often in all ethnic and SES groups.

Table 2. Prevalences of risk factors on the Rotterdam Reproductive Risk Reduction scorecard, by ethnicity and socio-economic status.

	Total N (%)	Western N (%)	Non-Western N (%)	Sig.	High SES N (%)	Low SES N (%)	Sig.
Total number of cases	836 (100)	545 (65)	291 (35)		293 (35)	538 (64)	
Single mother	63 (8)	23.2 (4)	39.8 (14)	**	11 (4)	52 (10)	**
Relationship problems	35.4 (4)	18.2 (3)	17.2 (6)		3 (1)	32.4 (6)	**
Experience of inadequate social support				**			**
No support	13 (2)	8 (2)	5 (2)		5 (2)	8 (2)	
1-2 persons	44 (5)	13 (2)	31 (11)		36 (12)	8 (2)	
Domestic violence	14 (2)	5 (1)	9 (3)	*	4 (1)	10 (2)	
Previous referral to children's social services	27.4 (3)	19.2 (4)	8.2 (3)		4.2 (1)	23.2 (4)	*
Unemployed (> 3 months)	190 (23)	85.2 (16)	104.8 (36)	**	30 (10)	160 (30)	**
Working in standing position	190 (23)	133.6 (25)	56.4 (19)		71 (24)	119 (22)	
Working > 32 hours and stressful	136 (16)	99 (18)	37 (13)	*	61 (21)	75 (14)	*
Net family income < 1000 euro per month	72.8 (9)	31.4 (6)	41.4 (14)	**	10.8 (4)	62 (12)	**
Irredeemable financial debts	63 (8)	30.2 (6)	32.8 (11)	**	11 (4)	52 (10)	**
Partner unemployed	74.2 (9)	36.8 (7)	37.4 (13)	**	10.6 (4)	63.6 (12)	**
Low education level (or illiterate)	33 (4)	14 (3)	19 (7)	**	4 (1)	29 (5)	**
Housing problems	37 (4)	17 (3)	20 (7)	*	6 (2)	31 (6)	*
Deprived neighbourhood	213 (26)	96.2 (18)	116.8 (40)	**	0 (0)	213 (40)	**
Language barrier	43,8 (5)	11 (2)	32.8 (11)	**	3.4 (1)	40.4 (8)	**
Communication through a translator	14.6 (2)	4 (1)	10.6 (4)	**	2.4 (1)	12.2 (2)	
Mentally disabled	4 (1)	3 (1)	1 (0.3)		0.4 (0)	3.6 (1)	
Non-western ethnicity					52.2 (18)	238.8 (44)	**
Preconceptional smoking past 6 months	195.8 (23)	144.6 (27)	51.2 (18)	**	66.4 (22)	129.4 (24)	
Smoking during pregnancy -1st trimester	123.4 (15)	89.6 (16)	33.8 (12)	*	34.2 (12)	89.2 (17)	*
Smoking during pregnancy -2nd trimester	33.6 (4)	21.8 (4)	11.8 (4)		9.2 (3)	24.4 (5)	
Preconceptional alcohol use past 6 months	178 (21)	141.4 (26)	36.6 (13)	**	64.4 (22)	113.6 (21)	

Table 2. Prevalences of risk factors on the Rotterdam Reproductive Risk Reduction scorecard, by ethnicity and socio-economic status (continued).

	Total N (%)	Western N (%)	Non-Western N (%)	Sig.	High SES N (%)	Low SES N (%)	Sig.
Alcohol use during pregnancy -1st trimester	17.8 (2)	11.2 (2)	6.6 (2)		3.2 (1)	14.6 (3)	
Alcohol use during pregnancy -2nd trimester	7.8 (1)	6.8 (1)	1 (0.3)		3.4 (1)	4.4 (1)	
Drug abuse past 6 months	21.6 (3)	16.2 (3)	5.4 (2)		7.2 (2)	14.4 (3)	
Drug abuse during pregnancy -1st trimester	10.4 (1)	9.2 (2)	1.2 (0.4)		3.6 (1)	6.8 (1)	
Drug abuse during pregnancy -2nd trimester	6.2 (1)	4.2 (1)	2 (1)		2.6 (1)	3.6 (1)	
Vegetarian, vegan or macrobiotic diet	24.4 (3)	19 (4)	5.4 (2)		11 (4)	13.4 (3)	
No daily intake of vegetables	114.8 (14)	53.6 (10)	61.2 (21)	**	26.6 (9)	88.2 (16)	**
No daily intake of fruit	114.6 (14)	56.4 (10)	58.2 (20)	*	24.4 (8)	90.2 (17)	**
Body Mass Index				*			
<20	79.8 (10)	57.6 (11)	22.2 (8)		31 (10)	48.8 (9)	
20-30	606.2 (73)	400.6 (73)	205.6 (71)		223.6 (75)	382.6 (71)	
30-40	125.4 (15)	78 (14)	47.4 (16)		37.2 (13)	88.2 (16)	
>40	24.6 (3)	9 (2)	15.6 (5)		6.2 (2)	18.4 (3)	
Uninsured	12 (1)	5 (1)	7 (2)		3 (1)	9 (2)	
Unwanted pregnancy	42 (5)	16.2 (3)	25.8 (9)	**	8 (3)	34 (6)	*
Assisted reproduction	59 (7)	45 (8)	14 (5)		37 (12)	22 (4)	**
Teenage pregnancy (≤18 years)	21 (3)	15 (3)	6 (2)		6 (2)	15 (3)	
Advanced maternal age (>40 years)	30 (4)	15 (3)	15 (5)		8 (3)	22 (4)	
Late start antenatal care				*			*
14-24 weeks	43 (5)	15 (3)	16 (6)		8 (3)	23 (4)	
>24 weeks	19 (2)	9 (2)	10 (3)		1 (0)	17 (3)	
Chronic maternal illness	96.6 (12)	66.8 (12)	29.8 (10)		34 (11)	62.6 (12)	
Annual consultation physician	181.2 (22)	114.6 (21)	66.6 (23)		70.8 (24)	110.4 (21)	
Prior surgery	413.2 (49)	291.2 (53)	122 (42)	**	163.4 (55)	249.8 (46)	*
Prescribed medication	169.6 (20)	104.2 (19)	65.4 (23)		61 (21)	108.6 (20)	
Over-the-counter drugs	158.6 (19)	105.2 (19)	53.4 (18)		60.2 (20)	98.4 (18)	
No preconceptional folic acid use	377.2 (45)	218 (40)	159.2 (55)	**	110.4 (37)	266.8 (50)	**
Sexually transmitted disease last year	17 (2)	7 (1)	10 (3)	*	3 (1)	14 (3)	
Promiscuity	5.4 (1)	3 (1)	2.4 (1)		0 (0)	5.4 (1)	
At risk for toxoplasmosis	45 (5)	24.4 (5)	20.6 (7)		13.8 (5)	31.2 (6)	
At risk for rubella	88.4 (11)	77 (14)	11.4 (4)	**	39 (13)	49.4 (9)	
Refuses blood transfusion (Jehovah's witness)	8.8 (1)	5 (1)	3.8 (1)		1.4 (1)	7.4 (1)	

Table 2. Prevalences of risk factors on the Rotterdam Reproductive Risk Reduction scorecard, by ethnicity and socio-economic status (continued).

	Total N (%)	Western N (%)	Non-Western N (%)	Sig.	High SES N (%)	Low SES N (%)	Sig.
History of psychiatric admission or positive family history (1st degree relative)	42.4 (5)	29.2 (5)	13.2 (5)		12.2 (4)	30.2 (6)	
(History of) psychiatric medication	49.6 (6)	33 (6)	16.6 (6)		19 (6)	30.6 (6)	
Current psychiatric problems	29 (4)	17 (3)	12 (4)		8 (3)	21 (4)	
Time to conception (>1 year)	114.8 (14)	73.8 (14)	41 (14)		57.4 (19)	57.4 (11)	**
Nulliparous	372 (45)	271 (50)	101 (35)	**	145 (49)	227(42)	
Recurrent miscarriage (2 or more)	73.8 (9)	44.8 (8)	29 (10)		23.8 (8)	50 (9)	
History of preterm birth	40 (5)	21 (4)	19 (7)		12 (4)	28 (5)	
History of small for gestational age < 10th percentile	29.4 (4)	16 (3)	13.4 (5)		12 (4)	17.4 (3)	
History of major congenital anomalies	9 (1)	5 (1)	4 (1)		2 (1)	7 (1)	
History of perinatal mortality	15 (2)	6 (1)	9 (3)		3 (1)	12 (2)	
History of shoulder dystocia	4 (1)	3 (1)	1 (0.3)		0 (0)	4 (1)	
History of instrumental delivery	61 (7)	44 (8)	17 (6)		26 (9)	35 (7)	
History of primary caesarean section	36 (4)	17 (3)	19 (7)	**	11 (4)	25 (5)	
History of secondary caesarean section	60 (7)	28 (5)	32 (11)	**	21 (7)	39 (7)	
History of gestational diabetes	24.2 (3)	11.2 (2)	13 (5)		3 (1)	21.2 (4)	*
History of manual placental removal or postpartum hemorrhage	35 (4)	22 (4)	13 (5)		22 (7)	13 (2)	**
History of placental abruption	2.2 (0,3)	0.2 (0)	2 (1)		0.2 (0)	2 (0)	
History of (pre)eclampsia or HELLP	22.2 (3)	13.2 (2)	9 (3)		9.2 (3)	13 (2)	
Haemoglobinopathy	4.6 (1)	0.6 (0)	4 (1)		1.6 (1)	3 (1)	
Congenital anomaly in 1st degree relative	76.4 (9)	53.6 (10)	22.8 (8)		26.6 (9)	49.8 (9)	

*Level of significance:+p<0.10, *p<0.05, **p<0.01, ***p<0.001.*

Logistic regression

Table 3 shows the results from the univariate and multivariate logistic regression analyses (forced entry and forward) for the association with any Big3 outcome for the total sample. In the univariate analyses (model 1) a low net family income, teenage pregnancy and prematurity or SGA or perinatal mortality in prior births showed the largest effects. In the forced entry model (model 2) most notably non-Western ethnicity and a prior child with SGA featured a stronger association. Model 3 represents the results for the multivariate analysis when the obstetric history domain is not included in the forced

Table 3. Associations between Rotterdam Reproductive Risk Reduction (R4U) risk factors and the incidence of any Big3-outcome°°, results from 5 imputed datasets for the total study sample (n=836).

	Model 1		Model 2 (R^2= 13%)		Model 3 (R^2= 7%)		Model 4 (R^2=8%)		Model 5 (R^2= 10%)	
	OR	95% CI	OR	95% CI	OR	95% CI	OR	95% CI	OR	95% CI
Single mother	1.51	0.83-2.75	0.98	0.45-2.10	1.00	0.47-2.12				
Relationship problems	1.35	0.60-3.04	0.91	0.36-2.31	0.89	0.35-2.22				
Experience of inadequate social support										
No support	0.24	0.04-1.39	1.09	0.23-5.13	1.17	0.27-5.12			0.89	0.21-3.82
1-2 persons	0.81	0.22-2.97	0.17	0.05-0.61***	0.20	0.06-0.70*			0.17	0.05-0.58*
Working > 32 hours	0.57	0.33-0.97*	0.64	0.36-1.14	0.57	0.32-1.02^{+}				
Net family income < 1000 euro per month	2.62	1.56-4.39**	1.89	0.89-3.97	1.79	0.86-3.73			2.51	1.45-4.33**
Irredeemable financial debts	1.97	1.12-3.48*	1.39	0.66-2.94	1.43	0.68-2.98				
Partner unemployed	1.67	0.97-2.88^{+}	0.98	0.51-1.86	1.04	0.55-1.96				
Housing problems	1.88	0.91-3.88^{+}	0.90	0.36-2.21	0.91	0.37-2.21				
Communication through a translator	1.11	0.31-4.05	0.81	0.18-3.68	0.70	0.15-3.20				
Non-western ethnicity	1.82	1.28-2.58*	1.84	1.24-2.74***	1.91	1.29-2.81**			1.77	1.23-2.56**
Smoking during pregnancy -1st trimester	1.55	0.97-2.47**	1.67	0.96-2.90	1.65	0.95-2.86^{+}	1.56	0.94-2.58^{+}		
Alcohol use during pregnancy -1st trimester	0.87	0.25-3.06	0.68	0.16-2.90	0.76	0.19-3.08	0.86	0.21-3.48		
Drug abuse during pregnancy -1st trimester	1.79	0.42-7.54	0.89	0.16-4.89	0.98	0.18-5.45	0.74	0.14-3.91		
Vegetarian, vegan or macrobiotic diet	1.91	0.78-4.68	2.29	0.88-5.99	2.11	0.81-5.51	2.10	0.83-5.33		
No daily intake of vegetables	1.31	0.81-2.10	0.92	0.53-1.59	0.89	0.52-1.53	1.13	0.68-1.87		
Assisted reproduction	0.29	0.10-0.83*	0.39	0.13-1.11	0.38	0.13-1.08^{+}	0.35	0.12-1.00^{+}	0.34	0.12-0.98*
Teenage pregnancy (≤18 years)	2.73	1.11-6.70*	1.95	0.63-6.04	1.80	0.58-5.58	3.06	1.14-825*		
Advanced maternal age (>40 years)	1.89	0.85-4.21	1.69	0.66-4.32	1.69	0.69-4.16	1.82	0.74-4.47		
Late start antenatal care										
14-24 weeks of gestation	2.07	0.95-4.49^{+}	1.53	0.62-3.75	1.59	0.65-3.87	1.83	0.80-4.15		

Table 3. Associations between Rotterdam Reproductive Risk Reduction (R4U) risk factors and the incidence of any Big3-outcome°°, results from 5 imputed datasets for the total study sample (n=836). (continued)

	Model 1		Model 2 (R^2= 13%)		Model 3 (R^2= 7%)		Model 4 (R^2=8%)		Model 5 (R^2= 10%)	
	OR	95% CI	OR	95% CI	OR	95% CI	OR	95% CI	OR	95% CI
>24 weeks of gestation	0.24	0.03-1.82	0.19	0.02-1.52	0.18	0.02-0.21	0.18	0.02-1.44		
Prescribed medication	1.26	0.83-1.90	1.14	0.73-1.79	1.21	0.78-1.88	1.10	0.2-1.70		
Over-the-counter medication	1.41	0.93-2.15	1.49	0.95-2.34	1.50	0.96-2.34^{+}	1.46	0.94-2.26^{+}		
Recurrent miscarriage (2 or more)	1.30	0.78-2.15	1.14	0.59-2.19	1.25	0.66-2.37	1.04	0.55-1.99		
History of preterm birth	1.68	0.82-3.43	1.01	0.43-2.40			1.06	0.46-2.44		
History of small for gestational age < 10th percentile	3.83	1.80-8.15**	3.69	1.58-8.62**			3.63	1.62-8.13**	3.98	1.81-8.74**
History of perinatal mortality	2.93	1.03-8.37*	2.78	0.85-9.08			2.75	0.88-8.61*		
History of primary caesarean section	1.69	0.80-3.59	1.25	0.51-3.05			1.36	0.59-3.14		
Congenital anomaly in 1st degree relative	1.09	0.57-2.08	1.01	0.50-2.06	0.97	0.48-1.99	0.97	0.49-1.93		

Model 1: Crude OR; Model 2: OR adjusted for social risks, risks associated with ethnic descent and with language barriers, life style risks, health care behaviours, general medical risks, and obstetric risks (forced entry); Model 3: OR adjusted for social risks, risks associated with ethnic descent and with language barriers, life style risks, health care behaviours and general medical risks (obstetric domain not included) (forced entry); Model 4: OR adjusted for life style risks, health care behaviours, general medical risks, and obstetric risks ('social' and communication and ethnic descent' domain not included) (forced entry); Model 5: OR obtained with stepwise forward regression analysis;
*Significance: Level of significance:$^{+}$p<0.10, *p<0.05, **p<0.01, ***p<0.001.°° At least one of low Apgar, SGA and premature birth.*

entry model (history of preterm birth, history of SGA, history of perinatal mortality and history of primary caesarean section). Working more than 32 hours per week, smoking in the first trimester of pregnancy, assisted reproduction and over the counter medication then improved the model. Also the impact of non-Western ethnicity increased. In model 4 the risk factors from the psychosocial domains 'social' and 'communication and ethnic descent' were excluded from the model. This only led to subtle changes, with teenage pregnancy and perinatal mortality becoming significant risk factors. However, the Nagelkerke's R^2 of the model decreased from 13% to 8%. In the forward analysis (model 5) five predictors remained, namely a low family income (OR 2.51), non-Western ethnicity (OR 1.77), a prior child with SGA (OR 3.98), experience of inadequate social support (OR 0.17) and assisted reproduction (OR 0.34). However, the last two factors had a protective effect.

Table 4. Associations between Rotterdam Reproductive Risk Reduction (R4U) risk factors and the incidence of any Big3-outcome°° (stepwise forward regression analysis), results from 5 imputed datasets stratified for ethnicity and socioeconomic status.

	Stratified for ethnicity				Stratified for SES			
	Western (R^2= 4%) N= 545		Non-Western (R^2= 15%) N=291		High SES (R^2= 12%) N=293		Low SES (R^2= 9%) N=538	
	OR	95%CI	OR	95%CI	OR	95%CI	OR	95%CI
Experience of inadequate social support (<3 persons)							0.23	0.08-0.70^{+}
Net family income < 1000 euro per month					5.83	(1.63-20.84)$^{+}$	2.13	1.17-3.90^{+}
Non-western ethnicity							1.87	1.21-2.90**
Substance use during pregnancy -1st trimester (smoking, alcohol, drugs)[2]	2.43	1.43-4.12**					1.89	1.10-3.22*
Vegetarian, vegan or macrobiotic diet			5.91	0.96-36.27^{+}				
No daily intake of vegetables					3.30	1.28-8.48*		
Teenage pregnancy (≤18 years)			7.76	1.38-43.56*				
Advanced maternal age (>40 years)			3.07	1.05-9.00*				
Over the counter medication	1.85	1.07-3.18*						
History of preterm birth					5.21	1.47-18.40*		
History of small for gestational age <p10			5.78	1.81-18.51**			3.74	1.37-10.23*

*OR's obtained with stepwise forward regression analysis; Level of significance: $^{+}$p<0.10, *p<0.05, **p<0.01, ***p<0.001 °° At least one adverse outcome (low Apgar, SGA and/or premature birth).*

Table 4 shows the forward stepwise analyses stratified for Western / non-Western ethnicity and for low SES / high SES. (The univariate and forced entry models for these stratified analyses are reported in appendix 1 and 2.) The variables included in the models differed considerably per stratum. Most notably for Western women no variables from the obstetric history remained, in contrast to non-Western women. Teenage pregnancy was also a risk factor for non-Western women (OR 7.76), but not for any of the other strata. When looking at the socioeconomic factors, low family income was one of the predictors for women from low SES areas. In women from high SES areas this was also the case, but the effect was larger than in low SES women (OR 5.83 vs. OR 2.13). Importantly, for women from low SES areas having a non-Western ethnicity was an additional risk factor (OR 1.87).

Model fit

At the individual level, the model fit (Nagelkerke's R^2) was low but improved slightly after stratification. However at the group level, the calibration charts demonstrate that the predictive accuracy of the models in groups at high risk for Big3 outcomes was high (Figure 2, based on the full stratified models in table 4).

DISCUSSION

In this prospective cohort study investigating the associations between the R4U risk factors and Big3 outcomes under routine practice conditions, we observed that the presence of both medical and non-medical risk factors early in pregnancy predicted the occurrence of adverse outcomes at birth. These findings confirm our hypothesis that non-medical risk factors must be taken into account in obstetric care. Moreover, we demonstrated that risk profiles for Big3 outcomes were different according to SES and ethnicity. This also suggests that the underlying mechanisms leading to adverse outcomes differ for these groups, and that low SES and non-Western origin should not be treated equally. In the past 10 years the idea that non-medical risk factors may be important in the prediction and prevention of adverse birth outcomes has gradually gained support. However, the current system of risk detection and selection in the Netherlands is still mainly focused on medical-obstetrical risks. Our study provides evidence that non-medical risk factors are relevant too. The R4U scorecard can be used to detect these risk factors. The risk factors included in the R4U scorecard have all been derived from large published studies, in which associations were observed with Big3 outcomes. [11] However, in our study only a small number of both medical and non-medical risk factors surfaced as predictors. This is presumably caused by the low prevalence of many risk factors (e.g. domestic violence).

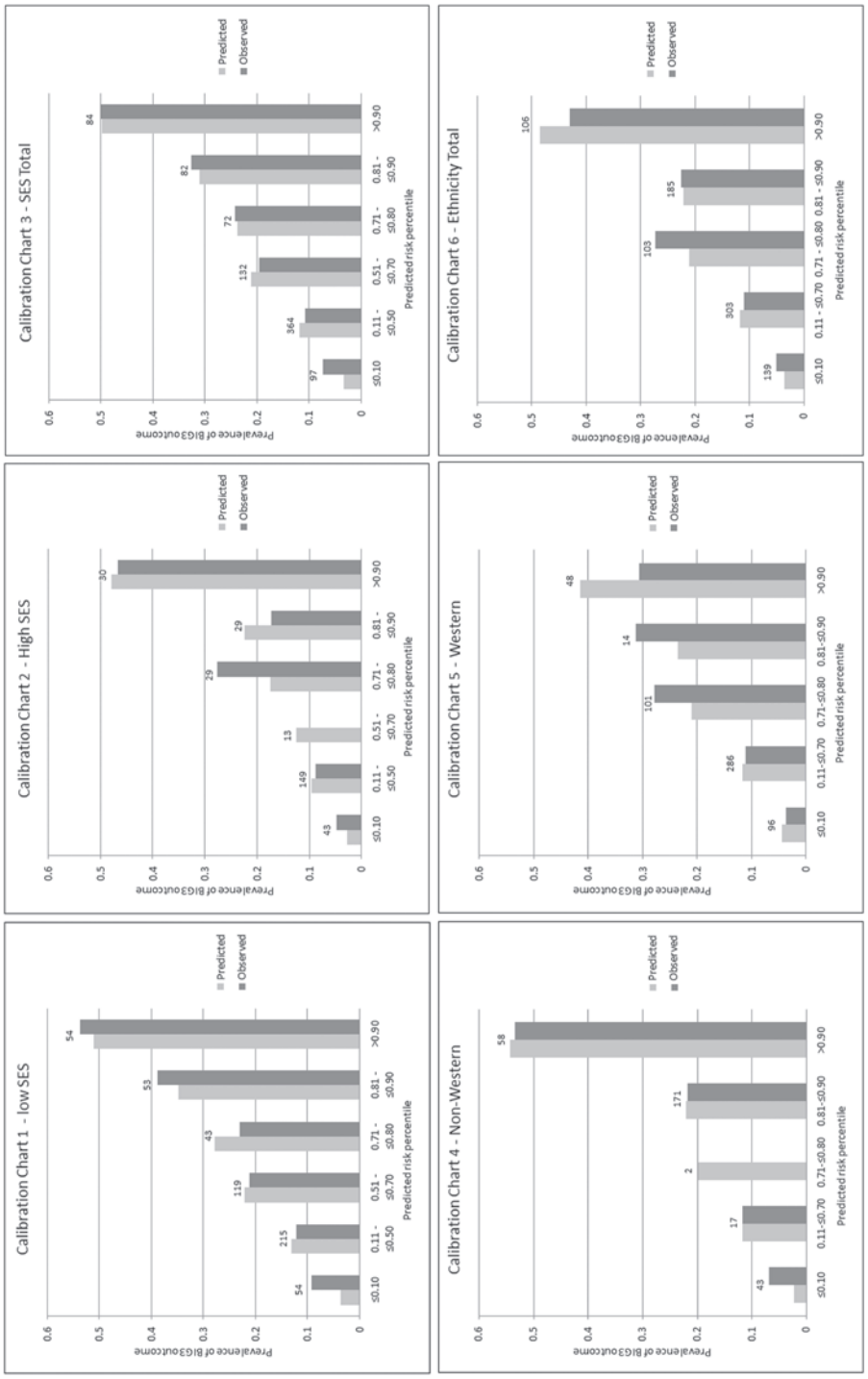

Calibration Chart 1 - low SES
Calibration Chart 2 - High SES
Calibration Chart 3 - SES Total
Calibration Chart 4 - Non-Western
Calibration Chart 5 - Western
Calibration Chart 6 - Ethnicity Total
Predicted
Observed
Prevalence of BIG3 outcome
Predicted risk percentile
≤0.10
0.11 - ≤0.50
0.51 - ≤0.70
0.71 - ≤0.80
0.81 - ≤0.90
>0.90

Figure 2.

Figure 2. Calibration charts for the observed and predicted prevalence of any Big3 outcome, based on the stepwise forward risk models. For each stratum (SES, ethnicity) women were divided into a risk category (low to high) based on the model-predicted probability of an adverse outcome (Big3), and expressing it as percentile.The prevalence of Big3 outcomes per risk category was then charted 1) as predicted by the model (summation of probabilities) and 2) as truly observed in the study sample (summation of Big3 counts). The height of the bar in the chart represents the prevalence; if heights are comparable, the predicted and observed prevalence are similar and the model is assumed to predict well. The numbers above the bars reflect the number of women in each risk category. Chart 1: Predicted and observed prevalence for low SES women. In this chart the highest risk category (predicted risk probability > 90) shows less discrepancy deviation between observed and predicted compared to the lowest risk group (predicted percentile ≤10). This suggests that the model fit is best for the highest risk group. Chart 2: Predicted and observed outcomes for high SES women; chart 3: Predicted and observed outcomes for the total population (by combining the 2 models stratified for low SES / high SES); chart 4: Predicted and observed outcomes for non-Western women; chart 5: Predicted and observed outcomes for Western SES women; chart 6: Predicted and observed outcomes for the total population (by combining the 2 models stratified for non-Western / Western ethnicity); Numbers displayed above the bars indicate the number of women in the risk percentile group.

Additionally it may be caused by the large number of risk factors in the R4U, many of which are not the same, yet are related at least empirically. Due to this data feature (collinearity) most risks add little extra explanatory power to initially significant predictors. However, it does not make these non-significant factors redundant. Apart from the question which risk factor is most relevant from a causal perspective, these factors are necessary for the practical application of the R4U scorecard. For each risk factor a standardized care pathway is available that helps to reduce a risk factor. [17] To decrease risks by means of these care pathways, the complete medical and non-medical situation must be mapped. For example, if a pregnant woman has little social support, it is important to know whether she also has a mental disability because this determines which organization is best equipped to support her.

Medical risk factors do continue to play an important part in the R4U: Factors concerning a prior history of Big3 outcomes were amongst the best predictors in all models. Past Big3 outcomes have large predictive effects because in part they cover R4U-risk factors that have led to the adverse outcome in a prior pregnancy. Additionally, they include the effects of unknown and unmeasured predictors of Big3 outcomes. Therefore these risk factors on a history of Big3 outcomes dilute the effect of other potential predictors. We visualized this effect by refitting the models, while excluding the entire obstetric history from the analysis. This led to the significance of new predictors.

Even though most predictors in the models were risk factors, a small number had protective or beneficial effects on outcomes. Most notably, assisted reproduction had a protective effect. This is in contradiction with the literature. [11] Underlying factors may explain this. For example, women who become pregnant by means of Artificial Reproductive Technologies (ART) have often had more years of education and a higher socioeconomic status than the general population. This may in turn moderate possible detrimental effects of ART on adverse pregnancy outcomes.

Our study demonstrated that risk factors for Big3 outcomes differed according to SES. This is in line with prior studies, including those in Rotterdam. [9,18] The effect of family income was significant in both low and high SES women, but the effect was greater in the latter. SES was determined according to neighbourhood of residence. Having a low income whilst living in a low SES area may be less detrimental because basic amenities in low SES areas tend to be cheaper and facilities targeted at poor people are more readily available. In our study low SES women from non-Western ethnic descent experienced additional risks for adverse outcomes. The literature shows contradictory results regarding the risks of these women. [18,19]

Moreover, we found that the risk factors for adverse outcomes in non-Western and Western women differ considerably. [21] For example, for non-Western women teenage pregnancy is a significant predictor. Because there are important differences in the views on teenage pregnancy between the largest non-Western ethnic groups in the Netherlands, [23] it is impossible to propose a single explanation for this finding. The higher prevalence of teenage pregnancies in non-Western women compared to Western women may also have led to significance of this risk factor for the first group.

Strengths and limitations

To our knowledge this study was the first to prospectively investigate the use of a medical and non-medical risk scorecard for the prediction of Big3 outcomes. By stratifying according to ethnicity and SES, we demonstrated that risk profiles differed considerably according to these two determinants. This insight may create the opportunity to customize care according to SES and ethnicity. Additionally this study was carried out in routine practice, as part of the comprehensive municipal 'Ready for a baby' programme. [12] Because the R4U scorecard was part of the programme the use of the scorecard could count on relatively broad support from policy makers, health researchers and caregivers. In collaboration with the participating caregivers, Van Veen *et al.* had already demonstrated the tool to be reliable and feasible. [10]

However there are also several limitations that merit discussion. First, the predictive power of the models we fitted was low. This is largely due to the low prevalences of both risk factors and adverse outcomes. At the group level the predictive power -and mostly so for the high risk groups- was higher. Being able to identify these high risk women is most important in light of adverse perinatal outcomes since it offers opportunities for the initiation of preventive measures / care pathways.

Future studies with larger sample sizes could give more insight into additional risk factors. We also believe that the prevalences of the risk factors we observed in this study are underestimations of the true prevalences. Women may not feel comfortable about sharing information with their caregiver at the booking visit on sensitive issues such as domestic violence because no relationship of trust has been developed yet. Filling out

the R4U scorecard again at a later date in pregnancy or using a self-report form may help to overcome this problem.

Also, based on their R4U risk factors women may initially have been at higher risk for adverse pregnancy outcomes than by the time of birth. Caregivers were not blinded for women's responses, and it is likely that some of them may have taken action if women reported serious risks (e.g. referral to a psychiatrist in case of psychological problems). These actions in turn may have led to reduced risks of Big3 outcomes. In our models this may have then weakened the association between determinants and outcomes, causing a lower goodness of fit, weaker coefficients (ORs closer to 1) and higher p-values.

Additionally, some degree of selection bias cannot be excluded. Women participated voluntarily and women with certain risks may have preferred not to participate because they did not want to share this information with their caregiver. Also, women with insufficient command of the Dutch language were often excluded by caregivers. However, the prevalence of Big3 outcomes in our study population was comparable to that of the general population in Rotterdam. [2] Because the study was conducted in a large urban setting, the generalizability to more rural communities may be limited.

Lastly, the crude dichotomization of ethnicity into Western and non-Western makes it impossible to distinguish between specific ethnic groups. Ethnic groups often have their own cultural practices and genetic make-up, possibly leading to distinct mechanisms affecting perinatal outcomes. Though the stratification admittedly is crude, it does provide new insights on differences in risk profiles.

Future implications

Our findings suggest that screening by means of the R4U scorecard for both medical and non-medical risk factors, preferably adjusted to the pregnant woman's ethnicity and socioeconomic status, is useful since it contributes to the prediction of Big3 outcomes in routine practice. Additionally it offers guidance in obtaining a complete picture of a pregnant woman's psychosocial situation. Care can then be adjusted to meet women's individual needs. To establish whether comprehensive risk detection can ultimately lead to better perinatal outcomes, additional research is necessary on the implementation of referral actions for risk reduction in midwifery and obstetric care.

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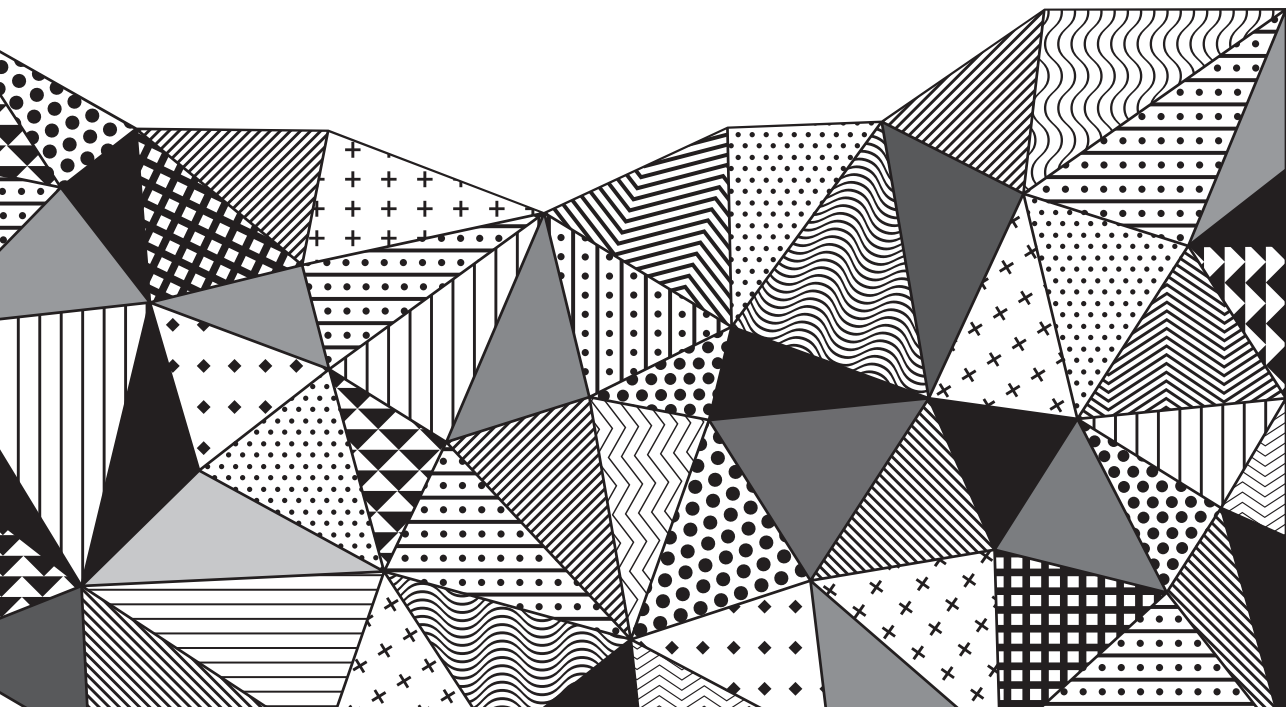

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Chapter 3

Deprived neighbourhoods and adverse perinatal outcomes: a systematic review and meta-analysis

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ABSTRACT

Objective: This study aims to summarize evidence on the relation between neighbourhood deprivation and the risks for preterm birth, small for gestational age (SGA), and stillbirth.

Design: Systematic review and meta-analysis.

Methods: Study selection was based on a search of Medline, Embase and Web of Science for articles published up to April 2012, reference list screening, and email contact with authors. We included studies that directly compared the risk of living in the most deprived neighbourhood quintile with least deprived quintile for at least one perinatal outcome of interest (prematurity, SGA, and stillbirth). Data on study characteristics, outcome measures, and quality were extracted by two independent investigators. Random-effects meta-analysis was performed to estimate unadjusted and adjusted summary odds ratios (ORs) with the associated 95% confidence intervals.

Results: We identified 2863 articles of which 24 were included in a systematic review. A meta-analysis (N = 7 studies, including 2 579 032 pregnancies) assessed the risk of adverse perinatal outcomes by comparing the most deprived neighbourhood quintile with the least deprived quintile. Compared to the least deprived quintile, ORs for adverse perinatal outcomes in the most deprived neighbourhood quintile were significantly increased for prematurity (OR 1.23, 95%-CI 1.18-1.28), SGA (OR 1.31, 95%-CI 1.28-1.34), and stillbirth (OR 1.33, 95%-CI 1.21-1.45).

Conclusion: Living in a deprived neighbourhood is associated with preterm birth, SGA and stillbirth.

INTRODUCTION

The association between socio-economic status and health has been recognized for a long time. [1] Socio-economic inequalities are associated with a decrease in life expectancy up to 10 years in developed countries. [2]

Perinatal mortality is a key indicator for population socio-economic inequalities. [3] Results from large cohort studies have shown that lifestyle risk factors (e.g. smoking) and social deprivation (e.g. household income, education level, or poverty) are strongly related to adverse perinatal outcomes such as preterm birth, low birth weight (LBW) and fetal growth restriction. [4-6] Over 75 percent of all causes of perinatal mortality are preceded by premature delivery and fetal growth restriction, which are conditions with different prevalences in different socio-economic groups. [7-9] Preterm birth and fetal growth restriction usually are the result of the concurrence of a large number of individual risk factors, known as risk accumulation. [10,11] Risk accumulation comprises the large influence of a number of smaller, seemingly less important risk factors, on the risk of adverse outcomes. [10-12] Such accumulation of risk factors is more common in deprived neighbourhoods, which generally show poor perinatal outcomes. [11]

The term 'neighbourhood deprivation' does not have a standard definition in literature. Rajaratnam *et al.* examined which neighbourhood characteristics are routinely addressed in perinatal health studies. This study found twelve broad categories of factors used to characterize neighbourhoods (e.g. education, employment, occupation, income). [13] Deprivation is often characterized by indexes with cut-off points to categorize the level of deprivation. The most common used indexes are the Carstairs-Morris score, Index of Multiple deprivation, Townsend deprivation index, and the Jarman score. The Carstairs-Morris score measures domestic overcrowding, male employment, car ownership and social class distribution. [14] The Index of Multiple Deprivation combines income, employment status, health and disability, education, housing problems and crime. [15] The Townsend Deprivation Index converts zip codes in deprivation scores by taking into account local unemployment, car ownership, overcrowding, and housing. [16] The Jarman score is a continuous measure which combines unemployment, overcrowding, lone parents, under-fives, elderly living alone, ethnicity, low social class and residential mobility. [17] However, often other self-composed indices are used.

To date it is unknown to what extent the effect of deprivation goes beyond the effect of poor individual level of socio-economic status of citizens in deprived neighbourhoods. [18,19] An additional effect of neighbourhood has been demonstrated in diseases in adulthood [20], and was suggested to occur in adverse perinatal outcomes. [3,21,22] For instance, a recent meta-analysis demonstrated such an additional role in the occurrence of LBW, which combines both growth restriction and premature cases. [23]

The newest systematic review takes the heterogeneous evidence into account by including studies with neutral, possible, and positive associations of deprivation with perinatal outcomes. [24] Here we present a systematic review and meta-analysis complementary to the existing LBW analysis, for other perinatal outcomes: preterm birth and fetal growth restriction separately, and stillbirth. It seems timely to show the broader evidence on the association of neighbourhood deprivation with other perinatal outcomes than LBW.

MATERIALS AND METHODS

Sources

We performed an electronic search on May 1st 2012 in Medline, Embase and Web of Science from inception to May 2012 for meta-analysis, randomized controlled trials, cohort studies, longitudinal studies and case-control studies. A search strategy was developed and adapted for each database. It included search terms regarding adverse perinatal outcome (e.g. "stillbirth" "fetal death*", "fetal mortalit*", "adverse pregnancy outcome*", "small for gestational age*", "low birth weight*", "dysmatur*", "intrauterine growth restrict*", "preterm deliver*", "preterm birth*", "prematur*"), and search terms regarding deprivation (e.g. "neighbourhood*", "neighbourhood*", "urban*", "city", "town*", "disadvantag*", "deprived", "pover*", indigen*", "disadvantaged communit*", "residential segregation"). The search terms regarding adverse perinatal outcome were restricted to 'prematurity', 'small-for-gestational-age' or 'intra-uterine growth retardation' or 'fetal growth retardation' 'stillbirth' and 'perinatal mortality.' Because the search term 'congenital anomaly' resulted in too much heterogeneity in the results (for both underlying cause as well as type of congenital anomaly), this search term was not used in the present study. Reference lists from main articles and relevant reviews were hand searched for additional eligible studies. The search was restricted to studies in humans. No language restrictions were applied. Ethical approval was not required in the Netherlands.

Study selection

For inclusion the studies had to meet the following criteria. They had to (1) be a randomized controlled trial, cohort (including longitudinal), cross-sectional or case-control study; (2) report how deprived neighbourhood or neighbourhood index was defined; (3) report data of perinatal outcomes on the whole neighbourhood population; (4) report any of the main outcome measures preterm birth, LBW, small for gestational age (SGA), stillbirth, and / or perinatal mortality; (5) report either prevalences, odds ratios, or relative risks; (6) be conducted in a developed country, defined as all countries listed by the World Bank. [25]

Two reviewers (AV, AP) independently examined titles, abstracts and full-text articles for eligibility. They independently extracted all relevant data into a preformatted spreadsheet. In case of discrepancies or uncertainties regarding the data extraction, the two reviewers aimed to achieve consensus together or by approaching a third party (the senior investigator (SD)). In case of missing tabular data in studies deemed eligible for meta-analysis, we contacted authors of the respective study. [26,27] We followed the procedures in accordance to the PRISMA statement. [28]

Two reviewers (AV, AP) assessed the quality of each included study independently by using the Newcastle-Ottawa scale. [29] Since no randomized controlled trials were retrieved from the search, we used a quality assessment scale suitable for observational studies. The Newcastle Ottawa scale was developed to assess the quality of non-randomized studies with regard to its design, content and ease of use directed to the task of incorporating the quality assessments in the interpretation of meta-analytic results. The scale was scientifically evaluated and is regarded suitable to use for quality assessment of observational studies. [30] We defined study quality as 'high' if the study was appointed the maximum of nine stars on this scale, 'medium' in case of seven or eight stars and 'low' in case of seven or less stars. Discrepancy in quality assessment was resolved by the two reviewers.

As LBW could not be distinguished in low birth weight related to preterm birth and low birth weight babies at term, we decided only to analyse results from studies when growth restriction was explicitly defined as SGA. Studies that met the inclusion criteria but in which the reported determinant or outcome measure was not eligible for meta-analysis (e.g. not using quintiles as cut-off point or LBW), remained eligible for the systematic review but were not incorporated in the meta-analysis. Statistical analysis was performed with Biostat Comprehensive Meta-Analysis (CMA) version 2. Higgins I^2 (with a significance level at $P < 0.05$) and tau^2 were calculated to assess statistical heterogeneity across studies. We used random-effects meta-analysis to estimate unadjusted and adjusted summary odds ratios (ORs) with the associated 95% confidence intervals. Adjusted ORs were obtained from fully adjusted models as presented in the original papers. If the risk estimate of interest was not explicitly stated, ORs were calculated with CMA. Because different indices were used to determine deprivation, a subgroup moderator analysis was performed to explore the effect of these different neighbourhood indices on the outcome of interest.

Assessment of deprivation

Apparently different cut-off points were used across studies in the categorizing of neighbourhood deprivation. We opted for categorization into quintiles (with the lowest quintile representing the least deprived neighbourhoods) because of three reasons. The most important reason was that the majority of studies applied a division into quintiles,

assuming the extreme categories to be large enough to be relevant and small enough to demonstrate contrasts if present. Other reasons were that we considered quintiles valuable for the cross-study comparability. We assume that the relative socio-economic position within a country is much more important as determinant than absolute measures. Thirdly, the key indicators of interest are summary risk estimates which themselves are relative indicators as well because baseline risk is set to one or zero. We asked 21 authors of papers with other than quintile divisions to re-categorize their determinants in quintiles accordingly, and to subsequently re-analyse their study data. One author was willing and able to do so. [27] In the meta-analysis, we evaluated the contrast between least and most deprived neighbourhood quintiles in preterm birth (birth before 37th week of gestation, SGA (birth weight below the 10th percentile for gestational age), and stillbirth (≥ 20 weeks).

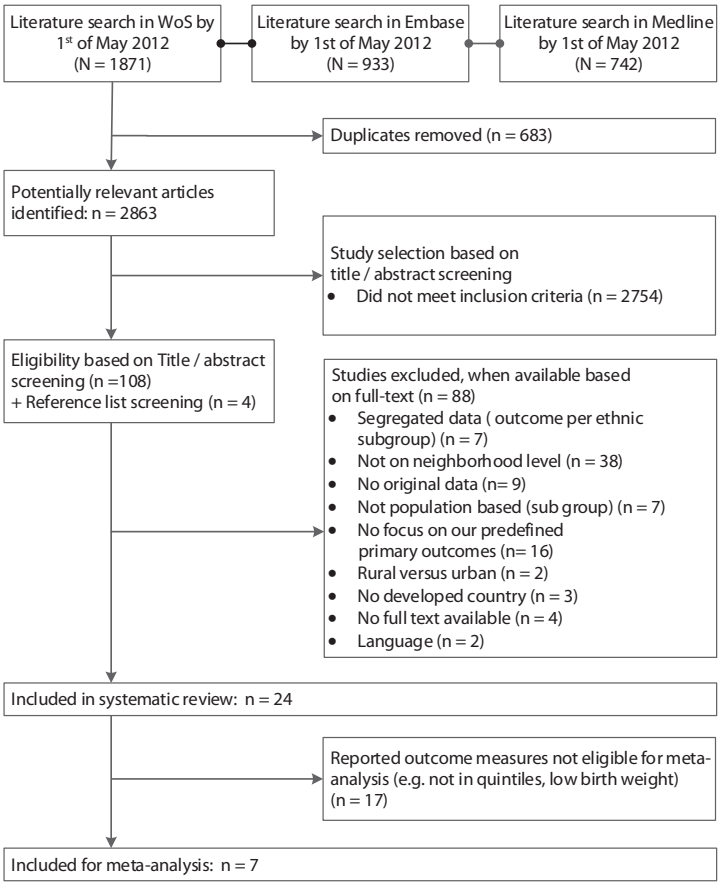

Figure 1. Flow diagram of included studies in the systematic review and meta-analysis.

RESULTS

The initial search identified 2 863 articles, which were potentially relevant based on title / abstract screening. All studies were in English except for one study, which was in Dutch. After exclusion of studies that did not meet our inclusion criteria, 108 articles remained of which the full texts were evaluated. We identified another 4 studies from reference list tracking, of which 2 met inclusion criteria. In total, 24 studies met the inclusion criteria for the systematic review and 7 studies were included in the meta-analysis (figure 1).

Table 1 [11, 21, 22, 26, 27, 31-49] summarizes the characteristics of the studies included in respectively the systematic review (n=17) and meta-analysis (n=7). Many

Table 1. Design, characteristics and quality assessment of included studies ordered by publication year (n = 24).

Study	Study design and participants	Index for deprivation	Primary outcome	Quality
Spencer *et al.*, 1999 [38]	Retrospective cohort study, 1991-1993, West Midlands, United Kingdom, N = 194081	Townsend deprivation index – deciles; Register Generals social class index – quintiles	LBW, VLBW	Medium
Smeeton *et al.*, 2004 [44]	Case control study,1996-1998, London, United Kingdom, N = 2735	Jarman score – continuous	Still birth, early neonatal death	Medium
Luo *et al.*, 2004 [49]	Birth cohort study, 1985-2000, British Colombia, Canada, N = 697477	Neighbourhood income – quintiles	PTB, SGA, still birth	High
Manning *et al.*, 2005[¥] [35]	Retrospective review of neonatal unit admission records, 1990-2002, place, United Kingdom, N = 47614	Townsend deprivation index – quartiles	Admission at neonatal unit	Low
Dibben *et al.*, 2006 [32]	Retrospective birth cohort study,1996-2000, United Kingdom, N = 306067	Index of multiple deprivation – quintiles	LBW, VLBW	High
Delpisheh *et al.*, 2006 [42]	Retrospective analysis, 1993, 1998 and 2001, United Kingdom, N = 4637	Townsend deprivation index – [-6–12]	Smoking, birthweight	Low
Janghorbani *et al.*, 2006[¥] [34]	Prospective case-record study, Plymouth United Kingdom, 1996-1997 N= 3834	Townsend deprivation index – tertiles	PTB	High
Collingwood Bakeo, 2006 [40]	Retrospective cohort study, 1991-2000, England and Wales, United Kingdom, N = 116261	Carstairs – quintiles	LBW	High
Luo *et al.*, 2006 [47]	Birth cohort study, 1991-2000, Quebec, Canada, N = 825349	Neighbourhood income – quintiles	PTB, SGA, still birth	High
Cubbin *et al.*, 2007 [41]	Case record study, 1997-1998, Washington and Florida, United States, N = 8359	Townsend deprivation index – tertiles	LBW	High

Table 1. Design, characteristics and quality assessment of included studies ordered by publication year (n = 24) (continued)

Study	Study design and participants	Index for deprivation	Primary outcome	Quality
Urquia *et al.*, 2007 [48]	Retrospective cohort study, 1996-2001, Toronto, Canada. N = 143030	Neighbourhood income – quintiles	PTB	High
De Graaf *et al.*, 2008¥ [22]	Retrospective birth cohort study, 2002 – 2006, the Netherlands, N = 877816	Dutch deprivation score – binary	PM	Medium
Gray *et al.*, 2008 [45]	Retrospective cohort study, 2000-2003, United Kingdom, N = 149690	Carstairs-Morris scores – quintiles	PTB	Medium
Beard *et al.*, 2009 [31]	Retrospective cohort study, 1994-2004, Australia, N = 877951	Index of relative socio-economic disadvantage – quartile	SGA < p3	High
Agyemang *et al.*, 2009¥ [21]	Prospective cohort study, 2003-2004, Amsterdam, The Netherlands, N = 7883	Neighbourhood income – quartile	PTB, SGA	Medium
Smith *et al.*, 2009 [37]	Prospective cohort study,1998-2007, United Kingdom, N = 7402	Composite neighbourhood index – quintiles	Very preterm birth (<33 weeks)	Medium
Janevic *et al.*, 2010 [43]	Case record study, 1998-2002, New York, United States, N = 517994	Messer neighbourhood deprivation index c quartile	Term LBW, PTB	High
Liu *et al.*, 2010 [46]	Retrospective birth cohort study, 2004-2006, Canada, N = 334231	Neighbourhood income Prevalences and risk estimates of the included studies ordered by publication year (n = 24) quintiles	PTB, SGA, still birth	High
Timmermans *et al.*, 2011¥ [11]	Retrospective birth cohort study, 2002-2006, Rotterdam The Netherlands, N = 8668	Dutch deprivation score – binary	PTB, SGA	Medium
Poeran *et al.*, 2011¥ [36]	Retrospective birth cohort study, 2000 – 2006, Rotterdam, The Netherlands, N = 50000	Dutch deprivation score – top 5 highest deprived neighbourhoods compared to top 5 lowest	PTB, SGA, PM	Medium
Sundquist *et al.*, 2011 [39]	Prospective cohort study, 1992-2004, Sweden, N = 720357	Composite neighbourhood index – tertiles	SGA < p2,5	High
Garcia Subirats *et al.*, 2011 [33]	Retrospective cohort study,2000-2005, Barcelona, Spain, N =61676	Contextual socioeconomic variables (e.g. unemployment) –quintiles	PTB, LBW, SGA < p3	High
Taylor-Robinson *et al.*, 2011 [26]	Retrospective cohort study 2002-2008, United Kingdom, N = 31785	Index of multiple deprivation – quintiles	PTB	Medium
Urquia *et al.*, 2011 [27]	Birth cohort study, Ontario, 2000-2007, Canada, N = 397470	Neighbourhood income – quintiles	PTB	High

LBW = low birth weight (< 2500 gram); PTB = preterm birth < 37 weeks unless otherwise specified, SGA = small for gestational age (birth weight < p10) unless otherwise specified; VLBW = very low birth weight (< 1500 gram); ¥ exclusion based on index subdivision (not in quintiles).

articles presented results for multiple outcomes. The included studies were conducted in either the United Kingdom (n = 10), Canada (n = 5), The Netherlands (n=4), United States (n=2), Spain (n=1), Sweden (n=1), and Australia (n=1), with data collected from 1985 up to 2008. Four of the included studies performed a multilevel analysis [21, 27, 31, 41], of which one study was included in the meta-analysis. [27] The remaining 20 studies assessed neighbourhood-level exposure.

Deprivation indicators varied across studies. One study used the Carstairs-Morris score, 5 studies used the Index of Multiple Deprivation, another 5 studies used the Townsend Deprivation Index, 1 study used the Jarman score, and 5 studies used neighbourhood income as a proxy for deprivation at the neighbourhood level.

Table 2 shows the prevalences and risk estimates of the included studies for respectively preterm birth, SGA and stillbirth. Twenty-one of the 24 included studies showed positive associations between adverse perinatal outcomes and neighbourhood deprivation. The prevalence of preterm birth ranged from 3.8% to 6.7% in the least deprived quintile and 5.6% to 11.9% for the most deprived quintile. For SGA this was respectively 4.8% - 10.4% versus 6.2% - 14.5%. Still birth rates ranged from 3.2 to 6.3 per 1 000 births in the least deprived quintiles and from 4.6 to 7.0 per 1 000 births in the most deprived quintile. All studies included in the meta-analysis used a wide variety of variables to adjust for potential confounders. One study did not report crude odds ratios, but we calculated these with CMA. [46]

Table 2. Prevalences and risk estimates of the included studies ordered by publication year (n = 24).

Study	Prevalence of the outcome of interest	Risk estimates (95% CI) for most deprived compared to least deprived neighbourhood	Covariates in fully adjusted model
Spencer *et al.*, 1999 [38]	*LBW* TDI MD: n=3578 (9,8%), LD: n=888 (5.1%) RGSC: MD: n=128 (11.3%), LD: n=63 (5.5%), *VLBW*TDI MD:n=329 (0.9%), LD:n=103 (0.6%); RGSC: NA	*LWB* TDI: RR 1.99 (1.85 - 2.18) RGSC: RR 2.04 (1.53 - 2.73) *VLBW* TDI: RR 2.11 (1.73-2.57) RGSC: NA	NA
Smeeton *et al.*, 2004 [44]	*Still birth* Overall: n = 351; *Early neonatal death* Overall: n = 198	*Still birth* not significant (results not reported) *Neonatal death*OR 0.947 (0.849, 0.997, p = 0.038)	NA
Luo *et al.* 2004 [49]	*PTB MD: n = 10163 (7.4%), LD: n = 5855 (6.3%); SGA LD: n=4461 (4.8%), MD: n=8515 (6.2%); Still birth LD: n=585 (0.63%), MD: n=961 (0.70%);*	*PTB OR 1.16 (1.09 - 1.23), aOR 1.26 (1.17 - 1.35) SGA OR 1.41 (1.33-1.49), aOR 1.50 (1.40-1.60) Stillbirth OR 1.17 (0.95-1.43), aOR 1.30 (1.04 - 1.63)*	Infant sex, parity, plurality, ethnicity, maternal age, marital status, abortion history, mode of delivery, maternal illness, community size, and distance to the nearest hospital with obstetricians.

Table 2. Prevalences and risk estimates of the included studies ordered by publication year (continued)

Study	Prevalence of the outcome of interest	Risk estimates (95% CI) for most deprived compared to least deprived neighbourhood	Covariates in fully adjusted model
Manning *et al.*, 2005¥ [35]	*PTB* MD: n = 334 (8.2%), LD: n = 156 (3.8%)	NA	NA
Dibben *et al.*, 2006 [32]	*LBW* Overall: 6.0%, MD: n=25005 (8.2%), LD: n=12946 (4.2%); *VLBW* Overall: 0.9%, MD: n=3672 (1.2%), LD: n=2020 (0.7%);	*LWB*OR: NA, aOR 1.03 (0.99 - 1.07) *VLBW* OR: NA, aOR 1.14 (1.12 - 1.16)	Age, social class of household, registration status, estimated household income, age–household income interaction, area income deprivation (AID), age–AID interaction.
Delpisheh *et al.*, 2006 [42]	*PTB* MD: 14%, LD: 9% *Term LBW*MD: 2%, LD: 0%; *LBW* MD: 8% LD: 2%	*PTB* NA *Term LBW*OR: NA, aOR 2.9 (0.9–9.6) *LBW* NA	Maternal smoking, household smoking, parents in paid employment, father's employment, maternal employment, unemployed parents; Townsend score
Janghorbani *et al.*, 2006¥ [34]	*PTB* Overall: n=202 (5.3%), MD: n=92 (6.1%), LD: n=49 (4.7%);	*PTB* RR 1.31 (95%-CI 0.94 - 1.84)	Townsend score, age, gender
Collingwood Bakeo, 2006 [40]	*LBW* Overall: n=3390 (5.8%) MD: n=297 (7.2%), LD: n=1388 (4.2%);	*LBW* OR: NA, aOR 1.78 (1.54-2.05)	Economic activity, number of people in the household, number of rooms in the household, household access to a car, housing tenure, region of usual residence carstairs deprivation quintile, ethnicity, limiting long term illness status.
Luo *et al.*, 2006 [47]	*PTB* MD n=14917 (8.2%), LD n=9939 (6.7%); *SGA* MD: n = 22376 (12.3%), LD: n=13500 (9.1%); *Still birth*MD: n = 836 (0.46%), LD: n=474 (0.32%);	*PTB* OR 1.23 (1.2-1.26), aOR 1.14 (1.10-1.17) *SGA* OR 1.40 (1.37-1.43), aOR 1.18 (1.15-1.21) *Stillbirth* OR 1.44 (1.29– 1.62), aOR 1.30 (1.13-1.48)	Infant sex, parity, plurality, maternal age, education, ethnicity, marital status, and neighbourhood income quintile.
Cubbin *et al.*, 2007 [41]	*LBW* Washington: Overall n= 171(4.4%) MD: n= 198(5.1%), LD n=151 (3.9%); *LWB* Florida: Overall n=290 (6.5%) MD: n=353 (7.9%), LD n=219 (4.9%);	*LBW* Washington OR 1.21 (0.61-2.40), aOR 1.21 (0.61 - 2.40) *LBW* Florida OR 1.34 (1.17-1.54), aOR 0.99 (0.85 -1.17)	Neighbourhood-level deprivation, income, education, paternal education, race/ethnicity, marital status, age, parity
Urquia *et al.*, 2007 [48]	*PTB* Overall: n = 7580 (5.3%) MD: n = 1605 (5.6%), LD: n = 1340 (4.7%);	*PTB* OR 1.19 (1.11-1.28); aOR 1.25 (1.15-1.37)	Infant sex, maternal age group, neighbourhood income quintile, and recent immigrant status
De Graaf *et al.*, 2008¥ [22]	*PM* MD: 13,5‰, LD: 9,3‰	NA	NA

Table 2. Prevalences and risk estimates of the included studies ordered by publication year (continued)

Study	Prevalence of the outcome of interest	Risk estimates (95% CI) for most deprived compared to least deprived neighbourhood	Covariates in fully adjusted model
Gray *et al.*, 2008 [45]	*PTB* Overall: n = 8394 (5.6%) MD: NA, LD: NA	*PTB* OR 1.15 (1.13-1.18); aOR 1.07(1.04-1.10)	Deprivation, age, height, parity, sex, smoking, and obstetric intervention
Beard *et al.*, 2009 [31]	*SGA(<p3)* Overall n=26592 (3.4%) MD: n=9879 (4.5%), LD: n=4171(2.4%);	*SGA* OR 1.88 (1.22-1.34), aOR 1.45(1.37-1.53)	Quartile of disadvantage, baby's gender, maternal smoking , mother's age , aboriginality , pre-existing diabetes, pre-existing hypertension , gestational hypertension, gestational diabetes, previous pregnancy, year of birth, onset antenatal care, ethnicity, season of birth
Agyemang *et al.*, 2009¥ [21]	*PTB* MD: n=138 (6.8%), LD: n=96 (5.4%); *SGA*MD: n=339 (16.6%), LD: n=150 (8.4%).	*PTB* OR NA, aOR 1.03 (0.76 - 1.40) *SGA* OR NA, aOR1.62 (1.25 - 2.08)	Age, parity, educational level, ethnicity, smoking and obesity
Smith *et al.*, 2009 [37]	*VPTB* Overall: n=103 (1.4%), MD: n=35 (1.8%), LD: n=10 (1.0%);	*VPTB*RR 1.91 (1.77 - 2.06)	
Janevic *et al.*, 2010 [43]	NA	*LBW* OR 1.99 (1.80-2.19), aOR 1.19 (1.11-1.27) *PTB* 32-36 weeks: OR 13.7 (1.30-1.44), aOR 1.06 (1.01-1.11) *PTB* <32 weeks: OR 1.55 (1.45-1.65), aOR 1.24 (1.13-1.36)	Age, education level, parity, ethnicity, nativity, and smoking.
Liu *et al.*, 2010 [46]	*PTB* MD: n=5026 (7.5%), LD: n = 4192 (6.3%); *SGA* MD: n = 7719 (11.6%), LD: n = 5046 (7.6%); *Stillbirth*MD: n = 434 (0.65%), LD: n = 300 (0.45%);	*PTB* OR 1.21 (1.16–1.26), aOR 1.17 (1.12 - 1.23) *SGA* OR 1.60 (1,54-1.66), aOR 1.51 (1.46–1.57) *Stillbirth* OR 1.45 (1.25–1.68), aOR 1.39 (1.19-1.62)	Maternal age, parity, smoking during pregnancy, maternal health problems, initiation prenatal care in 1st trimester
Timmermans *et al.*, 2011¥ [11]	*PTB*: MD: n=163 (5.9%), LD: n=219 (4.8%); *SGA*: MD: n=402 (14.5%), LD: n=476 (10.4%);	*PTB* aOR 1.22 (1.00–1.48) *SGA* aOR 1.41 (1.24 - 1.59)	Indicators for adverse perinatal outcome was related to all individual risk factors and the deprivation indicator
Poeran *et al.*, 2011¥ [36]	*PTB* Overall: n=3865 (7.7%), MD: n=204 (11.9%), LD: n=84 (4.7%) *SGA* Overall: n=4704 (9.4%), MD: n=378 (11,8%), LD: n=92 (4.7%) *PM*Overall: n=600 (1.2%), MD: n=53 (2.3%), LD: n=2 (0.2%)	NA	NA

Table 2. Prevalences and risk estimates of the included studies ordered by publication year (continued)

Study	Prevalence of the outcome of interest	Risk estimates (95% CI) for most deprived compared to least deprived neighbourhood	Covariates in fully adjusted model
Sundquist *et al.*, 2011 [39]	*SGA (<p2.5)* Overall n=20487 (2.8%) MD: n=4696 (3.5%), LD: n=3942 (2.5%);	*SGA* OR 1.38 (1.32-1.44), aOR 1.28 (1.22 - 1.34)	Age, marital status, family income, educational level, urban/rural status, employment, mobility
Garcia Subirats *et al.*, 2011 [33]	*PTB* Overall: 3395 (5.6%), MD: n=382 (7.1%), LD: n=197 (3.5%); *LBW* Overall: n=3931 (5.6%), MD: n=372 (6.9%), LD: n=708 (4.5%); *SGA(<p3)* Overall: n=1741 (2.3%), MD: n=197 (3.5%), LD: n=358 (2.2%);	*PTB*aOR 1.51 (1.27–1.79) *LBW*aOR 1.56 (1.37–1.78) *SGA* aOR 1.66 (1.29–1.12)	Maternal age, country of origin, parity, sex of newborn
Taylor-Robinson *et al.*, 2011 [26]	*PTB* Overall: n = 1612 (5.1%), MD: n = 1146 (5.6%), LD: n = 27 (4.1%);	*PTB* OR 1.55 (1.36 - 1.76), aOR 1.32 (1.12 - 1.55)	Maternal age, parity, smoking status, BMI, ethnicity
Urquia *et al.*, 2011 [27]	*PTB* Overall: n = 24623 (6.2%), MD: n = 5594 (7.0%), LD: n = 4559 (5.7%);	*PTB* OR 1.25 (1.20 - 1.30), aOR 1.26 (1.21 - 1.31)	Maternal age, parity and immigrant status

aOR = adjusted Odds Ratio, CI-95% = 95% confidence interval; LBW = low birth weight (< 2500 gram); LD = least deprived; MD = most deprived; NA = not available; OR = Odds Ratio; PM = perinatal mortality PTB = preterm birth < 37 weeks unless otherwise specified; SGA = small for gestational age (birth weight < p10) unless otherwise specified; VLBW = very low birth weight (< 1500 gram); VPTB = very preterm birth (<33 weeks).
**studies included in the meta-analyses. ¥ exclusion based on index subdivision (not in quintiles).*

Meta-analysis

The two most common reasons for exclusion in our meta-analysis were lack of results at neighbourhood level (e.g. results were provided for whole villages, counties or states, n = 38) or outcome measures were defined that were not eligible for our meta-analyses (e.g. LBW, data not reported in quintiles, n = 17). The meta-analysis eventually included cohort studies on adverse perinatal outcomes associated with neighbourhood deprivation. If outcomes for several years were reported, the most recent results were used for the meta-analysis. Assessment of study quality showed that five studies were of high quality [27, 46-49] and two of medium quality. [26, 45]

Figure 2 summarises the comparison of the least and most deprived neighbourhoods for preterm birth, SGA and stillbirth. None of the included studies reported data on perinatal mortality, but all reported stillbirth (> 20 weeks of gestation). The random effects model comprising all 7 studies suggests a positive association for preterm birth (crude OR 1.28 (95% confidence interval 1.20 to 1.37), adjusted OR 1.23 (95% CI 1.18 to 1.28). Heterogeneity was noted among the individual study effects (I^2 (crude) 94% (P< 0.001), I^2 (adjusted) 77% (P< 0.001)). Countries included in the meta-analysis have comparable

preterm birth rates. [50] For the outcomes SGA and stillbirth, only studies that indicate deprivation by means of the index neighbourhood income remained after the selection process. Similar positive associations between least and most deprived neighbourhood quintiles were found. The OR from crude results for SGA was 1.47 (95% CI 1.34 to 1.60), I^2 95%, P<0.001, adjusted OR 1.31 (95% CI 1.28 to 1.34), I^2 99%, P<0.001. For stillbirth, the crude OR was 1.38 (95% CI 1.23 to 1.54), and adjusted OR was 1.33 (95% CI 1.21 to 1.45) without marked heterogeneity (I^2 (crude) 41%, P = 0.185, I^2 (adjusted) 0%, P = 0.793). The studies in our meta-analysis showed a consistent association between living in a deprived neighbourhood and adverse perinatal outcomes.

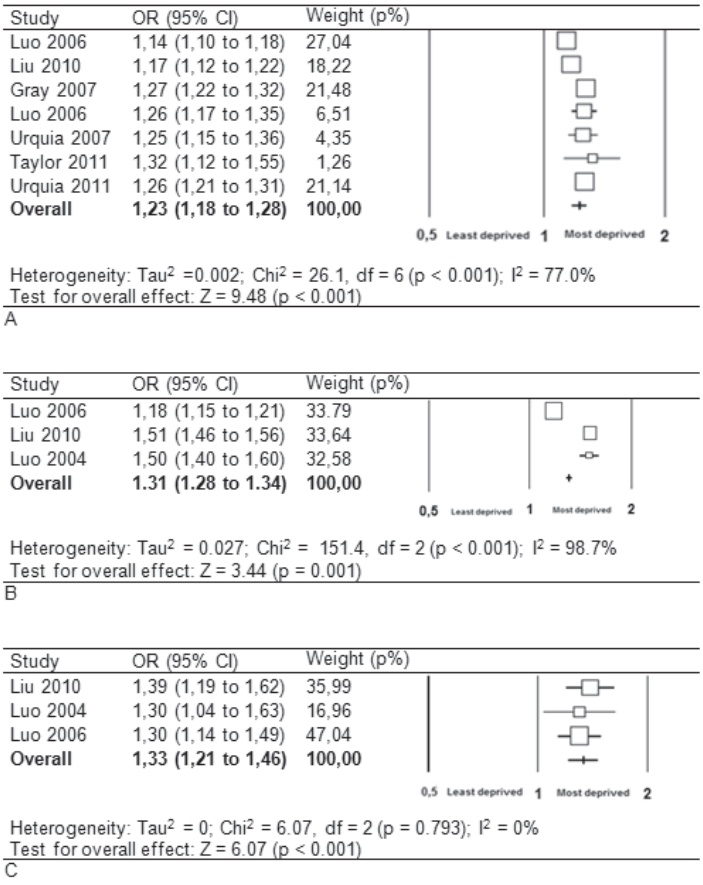

Figure 2. Forest plot of pooled random effects adjusted odds ratio (aOR) and 95% confidence intervals (CIs) of adverse perinatal outcome comparing the most deprived neighbourhood quintile with the least deprived neighbourhood quintile. White squares indicate the aOR in each study, with square sizes inversely proportional to the standard error of the OR. Horizontal lines represent 95% CIs. p-Values represent p for heterogeneity. (a) Pooled effects for preterm birth. (b) Pooled effects for small for gestational age. (c) Pooled effects for stillbirth.

Subgroup analysis

In a subgroup analysis comprising 5 studies that used neighbourhood income as measure of deprivation, we also found a positive association between the least and most deprived neighbourhood quintiles (crude OR 1.22 (95% CI 1.19 to 1.25), I^2 24%, P = 0.261), adjusted OR 1.21 (95% CI 1.15 to 1.27), I^2 78%, P = 0.001).

Since 6 studies were excluded based on how they categorized their neighbourhood index (e.g. cut-off point other than quintiles), we performed a univariate meta-regression analysis with neighbourhood cut-off point as moderator to assess the empirical relationship between neighbourhood cut-off point and the log of the observed OR. Crude ORs from 4 out of these six studies were available for this analysis in preterm birth [11, 21, 34, 35], and crude ORs from 2 studies were available for SGA. [11, 21] This figure indicates that we found no empirical relationship for the cut-off point in this analysis (figure 3).

A sensitivity analysis was performed for all outcomes to evaluate the stability of the results. We performed a subgroup moderator analysis to compare the mean odds ratio

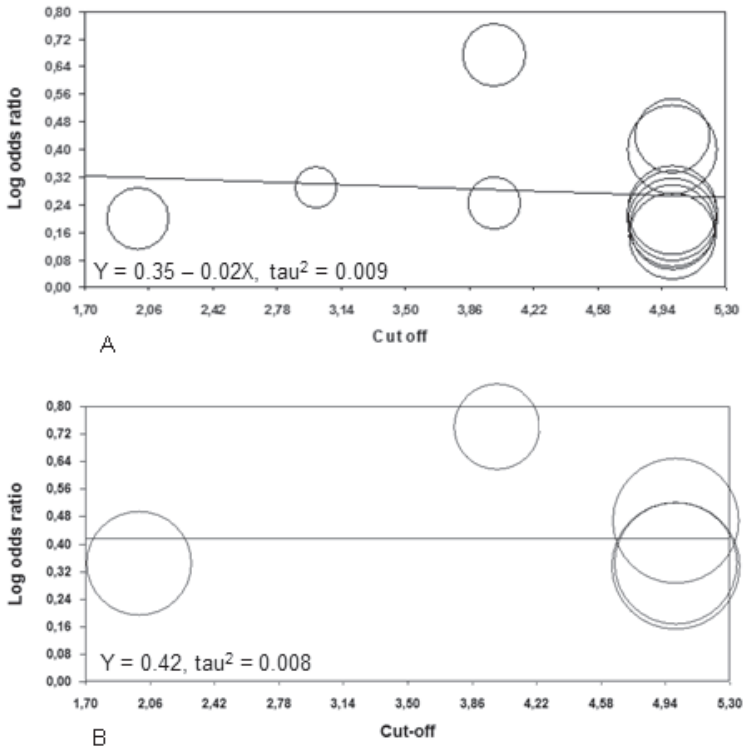

Figure 3. Scatter plot representing the meta-regression analysis to test the association between the cut-off point for neighbourhood index and the log adjusted odds ratio (aOR) of preterm birth and small-for-gestational age (SGA). The area of each circle is inversely proportional to the variance of the log relative risk estimate. (a) Preterm birth. (b) SGA.

for five studies using income as measure of deprivation and two other studies using another index in preterm birth: OR_{income}1.25 (95% CI 1.15 to 1.37) and OR_{other}1.38 (95% CI 1.25 to 1.70). These studies were also the studies rated as high quality. This difference was not statistically significant (Q = 0.70, p = 0.404).

Although no asymmetry was seen on the funnel plot (not shown), the largest analysis included only 7 studies. This number of studies is too small to perform an adequate assessment of publication bias. [51] We tried to minimize risks of publication bias with our search strategy. Firstly by including Web of Science as one of the search engines, because of its provision of conference abstracts. Secondly, we reviewed reference lists of all 108 studies which were eligible based on title or abstract, and of one meta-analysis and several reviews within this topic.

DISCUSSION

This systematic review and meta-analysis indicates that neighbourhood deprivation is associated with preterm birth, SGA and stillbirth. Compared to the least deprived neighbourhood quintile, ORs of adverse perinatal outcomes in the most deprived neighbourhood quintile were significantly increased for preterm birth (OR 1.23, 95%-CI 1.18-1.28), SGA (OR 1.31, 95%-CI 1.28-1.34), and stillbirth (OR 1.33, 95%-CI 1.21-1.45). This is the first meta-analysis in which preterm birth and SGA are analysed separately. While the previous analysis on LBW showed an excess prevalence due to deprivation effect of 11% [23], our meta-analysis – in which we analysed SGA and preterm birth separately – provided a prevalence of 31% and 23% respectively. Our findings suggest that these two disease entities only share part of the deprivation pathway, because the stratified ORs for SGA and preterm birth are higher individually than LBW in which preterm birth and SGA are combined. Stratification seems to distinguish both the risk pathways of preterm birth and SGA more than LBW alone. The aetiology of both outcomes is not always related to each other (preterm birth could be induced by infectious diseases whereas placenta insufficiency primarily induces SGA). Furthermore, preterm birth often has a strong care effect (iatrogenic preterm birth), which is absent in SGA. Stratification may therefore clarify the neighbourhood effect. Although such excess risks may seem small, it suggests the high attributable risk impact of deprivation through the high prevalence of deprivation.

The association between many adverse perinatal outcomes and low socio-economic status is known. This is thought to be induced though multiple pathways, most importantly low education and low income levels. [52] Although the present analysis did not focus on etiologic factors that could explain the relationship between non-medical risk factors and adverse perinatal outcomes, it is known from previous studies that decreased wealth and living conditions increase physiological stress [53], and low income

levels and deprivation are associated with poor housing, nutrition, and health care access. [3] If we assume that adverse perinatal outcomes are the result of the interrelationship between individual, environmental, and care-related factors [3,11], deprived areas could contribute to adverse outcomes in several ways. In deprived areas, so-called non-medical risk factors (e.g. lifestyle- and social risk factors) are much more common, especially in urban areas. [3, 23, 54]

Within patient care perspective it is important to acknowledge that risk accumulation not only includes the commonly measured standard risks, but also many unmeasured disadvantage or risk factors, which often escape standard epidemiologic research. Also the physiological (air pollution, noise) and psychological environment (safety) are part of the usually unmeasured risk burden in deprived neighbourhoods. [55]

The greatest challenge in the meta-analysis was to overcome heterogeneity. We believe this is mostly due to the variable cut-offs used in forming neighbourhood quintiles. In our meta-analysis, the results for preterm birth in our primary analysis did not differ from our subgroup analysis for income level. We approached all authors from potentially eligible studies to cooperate in our meta-analysis in order to pool pregnancy outcomes on individual level, so that we could investigate the comparability of the different indices (n = 11). Unfortunately, most authors did not respond so we were unable to perform analysis. Another reason for this heterogeneity might be the variety of used definitions to indicate neighbourhood deprivation. Some of these indices were compared in previous studies, and the use of area based deprivation indices is an accepted method for measuring social inequality in neighbourhoods. [18] Moreover, income seems to be a good proxy for area based deprivation related to health. [19] However, it is still unclear whether area based measures reflect the cumulated impact of individual socio-economic status, or represent the crude neighbourhood effect or a combination of both. [19, 49] Despite the high heterogeneity, we believe that pooling of the available data provides valuable information about neighbourhood deprivation and the risk of unfavourable pregnancy outcomes, and used random-effect models to calculate pooled risk estimates.

Strengths and limitations

A major strength of this study is that we performed the first a meta-analysis in which preterm birth, SGA, and stillbirth were analysed separately. In addition, we included all study types in the initial search to be able to identify the (cluster) randomized controlled trials. This did not result in inclusion of randomized controlled trials. However this effort is strength because if we had ignored this study type, we could have overlooked studies investigating the effect of deprivation on for example neighbourhood level.

Our analysis has some limitations. First of all, we were unable to answer our research question with only multilevel studies as in the previous meta-analysis we referred to.

[23] Some effect of clustering may be present if data was retrieved from true cluster designs in which clusters involve for example schools, hospitals or communities, and ignoring this effect – if present – might lead to some overestimation of the precision and statistical significance. However, in our study neighbourhoods are overall large and defined by different principles and therefore unequally sized. We assume that under these conditions no additional measures are needed to account for the study effect beyond the per study multilevel term.

Secondly, as we decided to use data presented in quintiles for prior mentioned reasons, we had to exclude 6 studies from meta-analysis because they did not report neighbourhood deprivation in quintiles. Risk estimates from these studies were mostly within the range of the risk estimates of studies pooled in the meta-analysis. In a meta-regression analysis we did not found an empirical relationship for cut-off point. Another limitation was that the definition of fetal growth restriction as 'low birth weight'. This was a reason for exclusion because we were unable to categorize findings into the LBW related to preterm birth outcome or the outcome of LBW babies at term (> 37 weeks of gestation). We only included results from studies when growth restriction was defined as 'small for gestational age below the 10th percentile.' We advocate separation of SGA and preterm birth, because both aetiology and long term consequences differ considerably between these outcomes. [56-58] For the association between neighbourhood deprivation and LBW (as a broad category) we refer to the meta-analysis by Metcalfe *et al.* [23]

Thirdly, we were not able to rank the included countries according to perinatal outcomes. The Euro-Peristat committee was able to make such an over country comparison. In their most recent published report, they compared perinatal outcomes of 29 European countries. [59] They reported marked differences between countries. However, such a report was not available for the non-European countries included in our study. Due to the absence of this information, we were not able to make an 'over country comparison' and relate our findings to the ranking of countries.

Lastly, we were not able to stratify for ethnicity. Although the included studies were adjusted for ethnicity, we missed information of other ethnic groups living in these neighbourhoods which were not included in their analysis. So these outcomes were not representative for the whole neighbourhood population. Confounding by ethnic differences is therefore unavoidable in this study. This is important because neighbourhood effects might not be consistent across ethnic groups. [24] Deprivation could have a stronger negative effect on Western women compared to non-Western women. [60] It seems that simple aggregation of particular individual effects does not explain our findings at neighbourhood level. It seems that other partly unknown underlying mechanisms influence both perinatal risk factors and outcomes at neighbourhood level.

Implications

Since poor maternal circumstances during pregnancy have both short and long term consequences, it makes sense to organize tailor-made antenatal healthcare responsive to women's needs by taking into account deprivation notions, preferably in combination with preconception care. In particular in large cities, this implies involvement of local initiatives and engagement of Public Health services. [61] A systematic approach in antenatal risk selection for both medical and non-medical risk factors with subsequent continuity of care might support early detection of potential high risk. More awareness regarding the medical impact of the non-medical domain should be advocated in healthcare professionals, but also in public health workers and policy makers. It may seem challenging in practice to reach women in deprived neighbourhoods for specific intervention programs, but research has shown that specific recruitment strategies can be used to achieve participation in these women. [62]

CONCLUSION

In summary, this systematic review and meta-analysis suggest that neighbourhood deprivation is associated with SGA, preterm birth, and stillbirth.

However, more methodological research is necessary to determine the comparability of several neighbourhood deprivation indices in relation to these perinatal outcomes. The included studies were not designed to explore mechanisms, so more etiological studies on a neighbourhood and an individual level are necessary to gain understanding of the effect of 'neighbourhood deprivation' on adverse perinatal outcomes. In the meantime this should not withhold us from designing new policies and programs for women living in deprived neighbourhoods where both social and medical risk factors are highly present.

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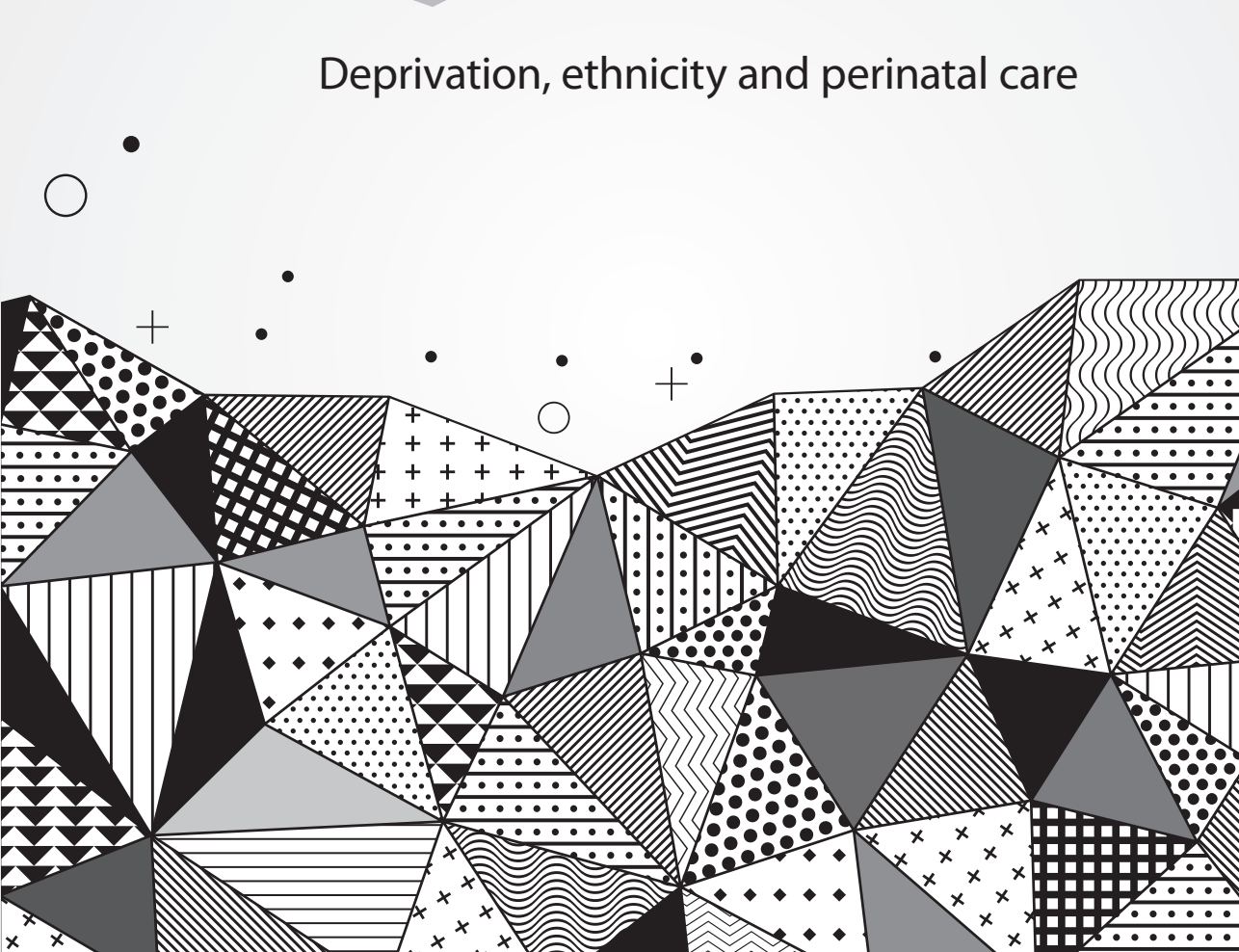
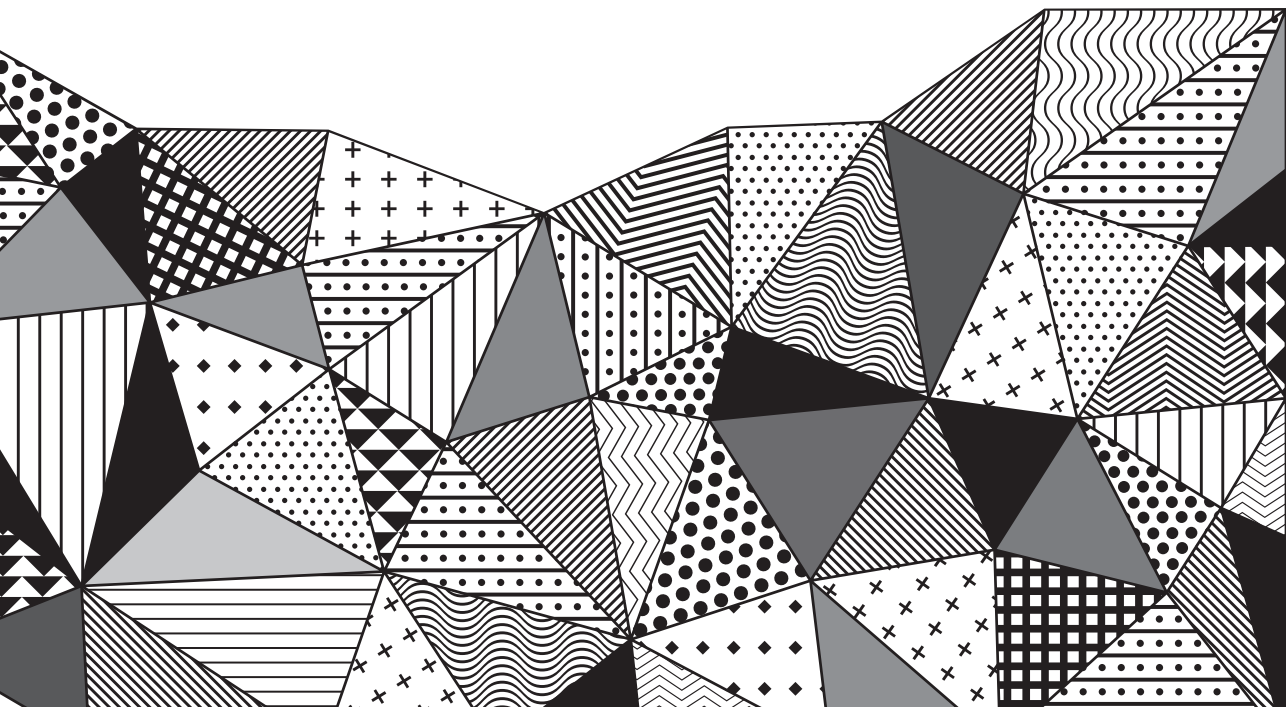
Part II

Deprivation, ethnicity and perinatal care





4

Chapter 4

Geographical, ethnic and socioeconomic differences in utilization of obstetric care in the Netherlands

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ABSTRACT

Background: All women in the Netherlands should have equal access to obstetric care. However, utilization of care is shaped by *demand* and *supply* factors. Demand is increased in high risk groups (non-Western women, low socio-economic status (SES)), and supply is influenced by availability of hospital facilities (hospital density). To explore the dynamics of obstetric care utilization we investigated the joint association of hospital density and individual characteristics with prototype obstetric interventions.

Methods: A logistic multi-level model was fitted on retrospective data from the Netherlands Perinatal Registry (years 2000-2008, 1,532,441 singleton pregnancies). In this analysis, the first level comprised individual maternal characteristics, the second neighbourhood SES and hospital density. The four outcome variables were: referral during pregnancy, elective caesarean section (term and post-term breech pregnancies), induction of labour (term and post-term pregnancies), and birth setting in assumed low-risk pregnancies.

Results: Higher hospital density is not associated with more obstetric interventions. Adjusted for maternal characteristics and hospital density, living in low SES neighbourhoods, and non-Western ethnicity were generally associated with a lower probability of interventions. For example, non-Western women had considerably lower odds for induction of labour in all geographical areas, with strongest effects in the more rural areas (non-Western women: OR 0.78, 95% CI 0.77-0.80, $p<0.001$).

Conclusion: Our results suggest inequalities in obstetric care utilization in the Netherlands, and more specifically a relative underservice to the deprived, independent of level of supply.

INTRODUCTION

It is generally accepted that all individuals should have equal *access* to health, and in order to attain this, equal *access to health care*. [1, 2] Equity in access to health care means equal access to care for people with equal conditions (*horizontal* equity). [3] In this context all pregnant women in the Netherlands have universal obstetric care access, regardless of insurance status or legal status (e.g. asylum seekers). Furthermore, women with higher risks for adverse outcomes qualify for obstetric care in hospitals instead of at community midwifery practices. This is known as *vertical* equity, in which the presence of severer conditions justifies the availability of more resources. [3]

Even with *horizontal* and *vertical* equity theoretically in place, access to and utilization of health care is also determined by the interaction between *demand* and *supply* factors. [4] *Demand* factors refer to health risks and health behaviours, including individual factors associated with higher risk for disease and more utilization of care. In the context of obstetric care, being of non-Western ethnic descent and living in deprived neighbourhoods are acknowledged demographic demand factors. [5] This is also true for the Netherlands. [6, 7] Supply factors in brief include the availability of care and its perceived quality. [4] One important supply factor is the geographical density of health care facilities. Density of these facilities often differs between urban and more rural areas, where living in a rural area often results in longer travelling distances and thus comprised access. Conversely, a high hospital density in the absence of other barriers bears with it the risk of causing *supplier induced demand*, with resulting unnecessary medical interventions. [8, 9]

This study investigated the utilization of obstetric care in the Netherlands, hypothesizing that higher hospital density is associated with an increased number of obstetric interventions (increased *supply*). A second hypothesis was that -due to individual risk patterns- 1) the probability of obstetric interventions is higher in non-Western women due to their increased risk of adverse outcomes compared to Western women, and 2) that at a higher aggregation level this similarly applies to women living in deprived neighbourhoods compared to women outside of these neighbourhoods (increased *demand*).

To test these hypotheses, we conducted multilevel analyses on the association of hospital density (*supply*) and individual level determinants (*demand*) with four prototype obstetric care interventions in the Netherlands. The analyses were performed separately for large urban areas, medium-sized urban areas and more rural areas.

METHODS

General

We conducted a multi-level observational study using retrospective data of all singleton births in the years 2000 to 2008 (n=1,532,441) in the Netherlands to investigate factors affecting utilization of obstetric care (see Figure 1 for exclusions). The national dataset on which we conducted secondary analyses was made available by the Netherlands Perinatal Registry (which covers over 97% of all pregnancies). [10] The use of the anonymized patient data for this study was approved by the Netherlands Perinatal Registry (project number 12.67) (additional information on the registry: www.perinatreg.nl/home_english). Written consent from pregnant women was not needed as the registry protects their anonymity. This research received no specific grant from any funding agency in the public, commercial, or not-for-profit sectors. We linked data on neighbourhood hospital density and neighbourhood socioeconomic status (SES) to individual perinatal records using the 4-digit postal codes.

Two levels of aggregation were defined. The first level consisted of individual maternal characteristics, and the second level of neighbourhood SES and neighbourhood hospital density. The four interventions used to represent utilization were selected because they cover different stages of pregnancy. The independent and dependent variables are described in more detail below.

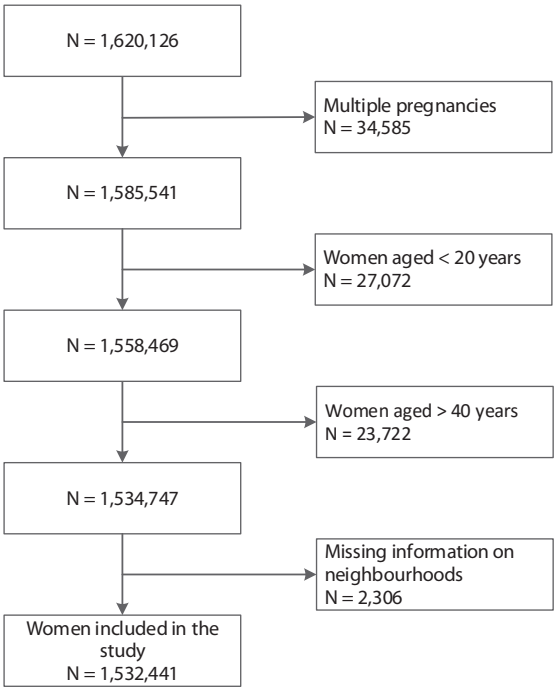

Figure 1. Flowchart of women excluded from the study.

Independent variables

First level: Individual Characteristics

Maternal age, parity and ethnicity were included. Maternal age was categorized into 20 to ≤ 24 years, 25 to ≤ 29 years, 30 to ≤34 years and ≥35 years. We categorized parity (prior births) into 0, 1, 2-3 and ≥4 births respectively. Maternal ethnicity was recorded by the obstetric care provider and was based on either self-declared ethnicity, race, or country of birth of the mother or her parents. It is not possible to retrace on which of these criteria the caregiver has based the filled out ethnicity for each individual woman. Because of the implied heterogeneity of definitions, we have dichotomized ethnicity into 'Western' or 'non-Western' ethnicity.

We excluded multiple pregnancies (n=34,585; 2.1%), women under 20 (n=27,072; 1.7%) or over 40 years of age (n=23,722; 1.5%). These groups were excluded because of their a priori increased risks of adverse pregnancy outcomes. [11-13] Additionally, we excluded pregnancies with missing information on neighbourhood characteristics (n=2306; 0.1%).

Second level: Neighbourhood Characteristics

Neighbourhoods were defined on the basis of the 4-digit postal code areas with on average 4000 inhabitants (±40 births annually), which are comparable in size to United Kingdom lower layer super output areas or United States of America Census tracts. [14, 15] Postal codes are commonly known as ZIP codes in the USA. In our analyses we included two neighbourhood level determinants, neighbourhood socio-economic status (SES) and neighbourhood hospital density.

Data on neighbourhood SES were obtained from the Netherlands Institute of Social Research. [16] A numeric SES-score created with principal component analysis is available for all 4-digit postal code areas with more than 100 inhabitants. The SES-score is updated every four years and for this study the scores for the year 2006 were used. The SES-score is based on the mean income per household, % households with a low income, % unemployed inhabitants and % households with an on average low education. The variance explained by the first principle component is 51.1%. There is a strong negative association between SES status and the % of households with a low income. The same is the case for SES status and the % of unemployed inhabitants and the % of households with an on average low education. There is a strong positive association between SES status and the mean income per household. [17] For the purpose of this study we categorized the continuous SES-scale into quintiles.

Neighbourhood hospital density (supply) was defined as the availability of hospital care specified per geographical area. It was calculated as the summation of all available hospital capacity (expressed as the average delivery volume per hospital per year).

Each individual hospital's capacity was discounted by the distance of each 4-digit zip code area to this hospital ('zip code centroid approximation'). This discount factor was inversely quadratic: triple the distance implied 1/9th of the capacity impact.

Dependent variables

Four care interventions were selected as a proxy for obstetric care interventions in general. The cohort size differed for each analysis because each focuses on a different subpopulation. These subpopulations are also specified below.

1. Referral during pregnancy from community midwife to obstetrician

Usually, midwives take care of women with an uncomplicated pregnancy, child birth and childbed and refer to an obstetrician if complications (threaten to) occur. This outcome indicator is defined as a dichotomous variable: referral versus no referral at any time during pregnancy before the start of labour.

2. Induction of labour in non-breech term and post-term pregnancies (≥ 37 weeks of gestation)

Labour may be induced if pregnancies are post-term or because of predefined high risk medical conditions. This outcome indicator is defined as a dichotomous variable: induction versus no induction of labour.

3. Elective caesarean section (CS) in term and post-term breech pregnancies (≥ 37 weeks of gestation)

In the Netherlands both a vaginal trial of labour (TOL) or an elective primary CS are accepted delivery options for a child in breech position. This outcome indicator is defined as a dichotomous variable: vaginal TOL or elective primary CS. Women who give birth by secondary CS (after the TOL failed) are assigned as vaginal TOL.

We deliberately used the CS rate in breech deliveries and not the overall CS rate, because the non-breech elective CS group and the emergency CS group, are both quite heterogeneous; sizeable true indication prevalence differences between hospital areas may exist, which are not covered by variables in the registry (e.g. there is no acute fetal risk information in the registry or fetal cardiotocography outcomes) but additional policy differences may also be present. Due to the mixed background of CS rate differences in the non-breech elective CS group and the emergency CS group (both medical/clinical background and policy background), the interpretation of any outcome would be vulnerable for opportunistic criticism.

4. Birth setting in low-risk pregnancies

Assumed low-risk pregnant women, can either deliver at home, in a birthing centre or in an out-patient clinic (located in a hospital) under supervision of their midwife. This outcome indicator is defined as a dichotomous variable: birth in an out-patient clinic (located in a hospital) or elsewhere (at home or in a birthing centre).

Analytical strategy

We employed multivariable multilevel logistic regression models with a random intercept for postal code areas. The GLIMMIX procedure in SAS version 9.3 was used for the analysis of the data of women (first level), nested within neighbourhoods (second level). GLIMMIX is a procedure for fitting generalized linear mixed models. These models allow for data that are not necessarily normally distributed. The model results are reported as odds ratios. First, we fitted a null-model to determine neighbourhood level variance, for all our outcome measures separately. To determine whether clustering was present we calculated the Intraclass correlation coefficient (ICC). If the ICC deviates from zero, the use of a multilevel model is appropriate. [18] We then fitted the full model for each care intervention, including an interaction term for parity*age.

The analyses were further stratified according to geographical area, because of known heterogeneity in population density and its interactions with the determinants included in the model. We distinguished three different types of areas: 1) urban areas, 2) semi-urban areas and 3) more rural areas. The first category contained all postal code areas in the four largest cities of the country (C4), the second contained the fifth up to and including the tenth largest city (C6) and the last contained all other areas (Cx). We have made the distinction between these groups of cities because in the Netherlands these distinctions are most often used in the political, scientific and policy fields. The cut-off at the C4 level was chosen because these large cities have significantly higher levels of adverse health outcomes, including perinatal outcomes in comparison to the rest of the country. [19] The number of postal code areas included in all analysis was 3422 (median 221, 20th percentile -80th percentile: 37-700).

RESULTS

A total of 1.532.441 singleton pregnancies were included in this study. Table 1 shows baseline characteristics of the study populations for the three geographical areas. Fifteen percent of births occurred in the four largest cities (C4). The highest numbers of non-Western women were recorded in the C4 (42%), as compared to 21% and 10% in C6 and Cx, respectively. At the neighbourhood level, 54% of the women in the C4 were living in the lowest SES quintile neighbourhoods compared to 27% and 13% in the other

Table 1. Descriptive statistics of individual variables and obstetric care interventions.
(Source: Netherlands Perinatal Registration, 2000-2008)

	Total	Urban areas (C4)	Semi-urban areas (C6)	Rural areas (Cx)	P-value
Average population density (people/km2)	489	4,120	2,053		
	N (%)	N (%)	N (%)	N (%)	
Total number of cases	1,532,441	231,886 (15)	104,358 (7)	1,196,197 (78)	
Individual determinants					
Maternal age					0.01
20 ≤ 24 years	161,800 (11)	34,705 (15)	12,285 (12)	114,810 (10)	
25 ≤29 years	456,108 (30)	61,134 (26)	30,294 (29)	364,680 (31)	
30 ≤34 years	620,399 (41)	85,097 (37)	41,652 (40)	493,650 (41)	
>34 years	294,134 (19)	50,950 (22)	20,127 (19)	223,057 (19)	
Parity					<0.01
Primiparous (no prior birth)	699,385 (46)	113,493 (49)	50,435 (48)	535,457 (45)	
Multiparous (1 prior birth)	558,658 (37)	74,538 (32)	37,393 (36)	446,727 (37)	
Multiparous (2-3 prior births)	247,818 (16)	37,978 (16)	15,034 (14)	194,806 (16)	
Multiparous (≥4 prior births)	26,580 (2)	5,877 (3)	1,496 (1)	19,207 (2)	
Ethnicity					<0.01
Western ethnicity	1,291,067 (84)	133,713 (58)	82,573 (79)	1,074,781 (90)	
Non-Western ethnicity	241,374 (16)	98,173 (42)	21,785 (21)	121,416 (10)	
Neighbourhood determinants					
Socio-economic Status					<0.01
0-20th percentile	305,922 (20)	126,222 (54)	28,565 (27)	151,135 (13)	
>20-40th percentile	306,888 (20)	28,424 (12)	25,948 (25)	252,516 (21)	
>40-60th percentile	306,133 (20)	17,276 (8)	8,212 (8)	280,645 (24)	
>60-80th percentile	308,175 (20)	18,817 (8)	12,933 (12)	276,425 (23)	
>80th percentile	305,323 (20)	41,147 (18)	28,700 (28)	235,476 (20)	
Hospital density (mean)	0.68	1.05	0.7	0.61	
Obstetric care interventions					
Referral (during pregnancy)					<0.01
Referral	522,946 (41)	83,089 (43)	39,957 (47)	399,900 (40)	
No referral	747,210 (59)	112,065 (57)	45,106 (53)	590,039 (60)	
Location of low- risk births					<0.01
Out-patient clinic	167,404 (34)	36,215 (52)	9,816 (35)	121,373 (31)	
Home	327,338 (66)	33,831 (48)	18,297 (65)	275,210 (69)	
Mode of delivery (breech)					<0.01
Primary Caesarean Section	32,367 (54)	3,873 (52)	2,188 (55)	26,306 (54)	
Vaginal Trial of labour	27,400 (46)	3,545 (48)	1,786 (45)	22,069 (46)	
Induction of labour (non-breech)					<0.01
Induction	191,704 (14)	26,069 (13)	12,599 (14)	153,036 (14)	
No induction	1,171,639 (86)	180,617 (87)	80,191 (86)	910,831 (86)	

areas. As expected, neighbourhood hospital density was highest in the C4 (1.05) and lowest in the Cx (0.61).

In the C4 48% of women delivered at home, as compared to 65% and 69% in the C6 and Cx, respectively. In term breech pregnancies a vaginal trial of labour (TOL) took place most often in the C4 (48%), followed by the Cx (46%) and C6 (45%). Concerning induction of labour, the differences according to geographical location were small.

Multilevel logistic regression models

The ICC in the null-models deviated significantly from zero, justifying the use of multilevel analysis. Table 2 shows the association of individual and neighbourhood level character-

Table 2. Multilevel logistic regression models of individual level maternal characteristics, neighbourhood SES and hospital density and referral during pregnancy°. (Odds ratios, 95% confidence intervals in parentheses)

N= 1,076,494 births		Total	C4[a]	C6[b]	Cx[c]
Individual level		OR (95%CI)	OR (95%CI)	OR (95%CI)	OR (95%CI)
Maternal age (Ref.=30-34 yr)	Overall	***	***	***	***
	≤ 24 years	0.96 (0.88-1.04)	0.89 (0.76-1.05)	0.97 (0.75-1.26)	0.96 (0.86-1.07)
	25-29 years	0.91 (0.89-0.94)	0.89 (0.84-0.95)	0.98 (0.88-1.09)	0.91 (0.88-0.94)
	>34 years	1.32 (1.29-1.34)	1.31 (1.26-1.36)	1.38 (1.29-1.49)	1.31 (1.29-1.34)
Parity (Ref.= multi-parous 1 prior birth)	Overall	***	***	***	***
	Nulliparous (0 births)	1.36 (1.34-1.37)	1.35 (1.32-1.38)	1.29 (1.24-1.33)	1.37 (1.35-1.38)
	Multiparous (2-3 births)	1.05 (1.03-1.07)	1.16 (1.12-1.20)	1.19 (1.12-1.26)	1.01 (0.99-1.03)
	Multiparous (≥3 births)	1.28 (1.17-1.40)	1.62 (1.37-1.92)	1.42 (1.08-1.86)	1.16 (1.04-1.31)
Ethnicity (Ref.= Western)	Non-Western	1.11 (1.10-1.13)***	1.13 (1.11-1.16)***	1.19 (1.15-1.23)***	1.09 (1.07-1.10)***
Neighbourhood level					
Socio-economic status (Ref.> 80th percentile)	Overall	***		*	***
	0-20th percentile	1.12 (1.08-1.17)	0.92 (0.85-0.99)	1.14 (1.03-1.26)	1.15 (1.10-1.20)
	>20-40th percentile	1.03 (1.00-1.07)	0.93 (0.84-1.03)	1.05 (0.95-1.16)	1.05 (1.01-1.09)
	>40-60th percentile	1.00 (0.97-1.04)	0.90 (0.80-1.02)	1.04 (0.90-1.21)	1.03 (0.99-1.08)
	>60-80th percentile	0.96 (0.93-1.00)	0.94 (0.84-1.05)	0.97 (0.85-1.10)	0.99 (0.95-1.03)
Hospital density		1.08 (1.03-1.28)***	0.85 (0.75-0.96)***	0.94 (0.77-1.14)	1.07 (1.00-1.13)*

°Referral during pregnancy versus no referral, reference category.
Stratification for three geographical areas: [a]C4= Urban areas; [b]C6=Semi-urban areas; [c]Cx = Rural areas.
*Levels of significance: * = p<0.10; ** = p<0.05; *** = p<0.01.*

istics with referral during pregnancy from the community midwife to an obstetrician, for the total population and stratified according to geographical area. On the individual level, higher age and non-Western ethnicity were associated with higher odds of referral. Non-Western women were referred more often, irrespective of area of geographical location. While in the C4 the lowest SES group (least affluent) was referred less often, the reverse was true in the rural and semi-urban areas with lower SES groups being referred more often. Interestingly, nulliparous women in the C4 and C6 were referred more often than multiparous women (≥3 births), whilst the opposite was the case in the Cx.

At the neighbourhood level, hospital density was associated with referral in the C4 and Cx only, demonstrating a negative association for the first and a positive association for

Table 3. Multilevel logistic regression models of maternal, child, process and hospital organizational characteristics on intrapartum, neonatal and total mortality. (Forced entry regression models)

N= 1,363,343 births		Total	C4[a]	C6[b]	Cx[c]
Individual level		OR (95%CI)	OR (95%CI)	OR (95%CI)	OR (95%CI)
Maternal age (Ref.=30-34 years)	Overall	***	***	*	***
	≤ 24 years	0.88 (0.78-0.99)	0.85 (0.69-1.04)	0.69 (0.41-1.18)	0.90 (0.77-1.05)
	25-29 years	0.99 (0.96-1.02)	0.90 (0.84-0.97)	1.00 (0.88-1.13)	1.01 (0.98-1.05)
	>34 years	1.08 (1.06-1.11)	1.13 (1.08-1.18)	1.08 (1.00-1.18)	1.08 (1.05-1.10)
Parity (Ref.= multiparous 1 prior birth)	Overall	***	***	***	***
	Nulliparous (0 births)	1.21 (1.20-1.23)	1.33 (1.28-1.37)	1.25 (1.19-1.31)	1.19 (1.17-1.21)
	Multiparous (2-3 births)	1.28 (1.25-1.31)	1.28 (1.22-1.35)	1.39 (1.28-1.51)	1.28 (1.25-1.31)
	Multiparous (≥3 births)	1.59 (1.40-1.79)	1.74 (1.41-2.15)	1.28 (0.74-2.19)	1.57 (1.34-1.85)
Ethnicity (Ref.= Western)	Non-Western	0.82 (0.81-0.83)***	0.93 (0.90-0.96)***	0.82 (0.78-0.87)***	0.78 (0.77-0.80)***
Neighbourhood level					
Socio-economic status (Ref.> 80th percentile)	Overall	***	***		***
	0-20th percentile	1.13 (1.08-1.18)	1.29 (1.16-1.44)	0.92 (0.82-1.03)	1.13 (1.07-1.19)
	>20-40th percentile	1.13 (1.08-1.17)	1.22 (1.06-1.40)	0.92 (0.82-1.03)	1.12 (1.07-1.18)
	>40-60th percentile	1.11 (1.06-1.16)	1.26 (1.07-1.48)	0.92 (0.78-1.09)	1.10 (1.05-1.15)
	>60-80th percentile	1.03 (0.99-1.08)	1.17 (1.01-1.35)	0.96 (0.84-1.11)	1.02 (0.98-1.07)
Hospital density		0.78 (0.74-0.83)***	0.79 (0.67-0.94)***	0.96 (0.77-1.20)	0.80 (0.75-0.86)***

°Induction of labour versus no induction of labour, reference category.
Stratification for three geographical areas:[a]C4= Urban areas;[b]C6=Semi-urban areas;[c]Cx = Rural areas.
*Levels of significance: * = p<0.10; ** = p<0.05; *** = p<0.01.*

the latter. A similar analysis in table 3 shows demand effects in the induction of labour in non-breech term pregnancies. Non-Western ethnicity was associated with considerably lower odds for induction in all geographical areas, with strongest effects in the Cx. The SES pattern however, resembled that of referral: higher odds of induction with lower SES in the C4 and Cx. Here, increased hospital density was associated with lower chances of induction in both the C4 and Cx. Likewise table 4 shows that non-Western women had substantially lower odds than Western women to receive a caesarean section (CS) in term breech pregnancies, particularly in the C4 (OR 0.86, CI 0.77-0.97). At the neighbourhood level, effects were variable. A 25% decreased odds for a CS was observed in women from the lowest SES quintile in the C4. Higher levels of hospital density were associated with lower odds for a CS in the Cx (OR 0.86, CI 0.76-0.98) and approximately the same but weaker associations were present in the C4.

Table 4. Multilevel logistic regression models of individual level maternal characteristics, neighbourhood SES and hospital density and primary caesarean sections (CS)° in term breech pregnancies (≥37 weeks of gestation). (Odds ratios, 95% confidence intervals in parentheses)

N= 1,363,343 births		Total	C4[a]	C6[b]	Cx[c]
Individual level		OR (95%CI)	OR (95%CI)	OR (95%CI)	OR (95%CI)
Maternal age (Ref.=30-34 years)	Overall	***	***	***	***
	≤ 24 years	0.81 (0.69-0.96)	0.93 (0.67-1.30)	0.52 (0.25-1.09)	0.80 (0.65-0.97)
	25-29 years	0.91 (0.86-0.97)	0.82 (0.69-0.98)	0.68 (0.51-0.91)	0.94 (0.88-1.01)
	>34 years	1.22 (1.16-1.28)	1.20 (1.04-1.38)	1.11 (0.89-1.37)	1.22 (1.15-1.29)
Parity (Ref.= multiparous 1 prior birth)	Overall	***	*	***	***
	Nulliparous (0 births)	1.11 (1.06-1.18)	1.10 (0.96-1.25)	1.02 (0.83-1.25)	1.13 (1.06-1.20)
	Multiparous (≥2 births)	0.67 (0.59-0.76)	0.84 (0.64-1.11)	0.38 (0.21-0.69)	0.66 (0.56-0.77)
Ethnicity (Ref.= Western)	Non-Western	0.93 (0.88-0.99)**	0.86 (0.77-0.97)**	0.86 (0.70-1.05)	0.98 (0.90-1.06)
Neighbourhood level					
Socio-economic status (Ref.> 80th percentile)	Overall	*	***		
	0-20th percentile	0.92 (0.85-1.00)	0.75 (0.64-0.88)	0.85 (0.69-1.05)	0.99 (0.90-1.09)
	>20-40th percentile	0.93 (0.87-1.00)	0.82 (0.68-1.00)	0.86 (0.70-1.06)	0.95 (0.88-1.03)
	>40-60th percentile	0.95 (0.89-1.02)	1.00(0.80-1.26)	0.92 (0.68-1.24)	0.97 (0.89-1.05)
	>60-80th percentile	0.90 (0.84-0.97)	1.04 (0.83-1.29)	0.86 (0.67-1.10)	0.91 (0.84-0.98)
Hospital density		0.86 (0.78-0.94)***	0.80 (0.63-1.02)*	1.18 (0.78-1.78)	0.86 (0.76-0.98)**

°Elective caesarean section versus vaginal trial of labour, reference category.
In this analysis parity was regrouped into three categories instead of four, due to low numbers.
Stratification for three geographical areas:[a]C4= Urban areas;[b]C6=Semi-urban areas;[c]Cx = Rural areas.
*Levels of significance: * = p<0.10; ** = p<0.05; *** = p<0.01.*

Lastly, table 5 shows the findings for birth setting in deliveries starting under supervision of the community midwife. Non-Western ethnicity was associated with high odds of delivering in an out-patient setting rather than at home in all geographical areas, mostly so in the Cx. Interestingly, the same pattern was present for women aged under 25, with a 40% excess in odds of delivering in an out-patient clinic. Overall, the association for SES with the odds of delivering in an out-patient clinic was U-shaped, with women from the middle SES quintile neighbourhoods being less likely to deliver in an out-patient clinic than women from low and high SES neighbourhoods. While in the overall analysis hospital density was strongly associated with more births in out-patient clinics, this effect disappeared after stratification into geographical areas.

Table 5. Multilevel logistic regression models of individual level maternal characteristics, neighbourhood SES and hospital density and location of birth° in low risk women. (Odds ratios, 95% confidence intervals in parentheses)

N= 1,363,343 births		Total	C4[a]	C6[b]	Cx[c]
Individual level		OR (95%CI)	OR (95%CI)	OR (95%CI)	OR (95%CI)
Maternal age (Ref.=30-34 years)	Overall	***	*		***
	≤ 24 years	1.44 (1.22-1.69)	1.47 (1.07-2.03)	1.61 (1.02-2.54)	1.44 (1.17-1.78)
	25-29 years	0.99 (0.94-1.04)	1.06 (0.95-1.18)	1.08 (0.87-1.35)	0.98 (0.92-1.04)
	>34 years	1.16 (1.13-1.20)	1.00 (0.94-1.08)	0.96 (0.83-1.11)	1.23 (1.18-1.27)
Parity (Ref.= multiparous 1 prior birth)	Overall	***	***	*	***
	Nulliparous	1.13 (1.11-1.15)	1.21 (1.17-1.27)	1.04 (0.97-1.11)	1.12 (1.10-1.14)
	Multiparous (2-3)	0.72 (0.70-0.74)	0.77 (0.73-0.82)	0.90 (0.80-1.00)	0.70 (0.68-0.72)
	Multiparous (≥3)	0.78 (0.66-0.93)	0.95 (0.68-1.32)	1.13 (0.69-1.85)	0.75 (0.60-0.93)
Ethnicity (Ref.= Western)	Non-Western	4.26 (4.18-4.35)***	3.28 (3.14-3.42)***	3.89 (3.61-4.18)***	4.65 (4.54-4.77)
Neighbourhood level					
Socio-economic status (Ref.> 80th percentile)	Overall	***		*	***
	0-20th percentile	1.40 (1.28-1.54)	1.10 (0.85-1.41)	0.96 (0.78-1.19)	1.44 (1.29-1.60)
	>20-40th percentile	0.99 (0.91-1.08)	0.92 (0.66-1.28)	0.91 (0.73-1.13)	1.00 (0.91-1.10)
	>40-60th percentile	0.93 (0.85-1.01)	0.83 (0.56-1.23)	0.72 (0.53-0.99)	0.94 (0.86-1.03)
	>60-80th percentile	0.82 (0.75-0.89)	1.14 (0.80-1.62)	0.76 (0.57-0.97)	0.82 (0.75-0.90)
Density		1.25 (1.11-1.40)***	0.89 (0.60-1.33)	0.77 (0.51-1.18)	1.03 (0.89-1.20)

°Location of birth: in an out-patient clinic (located in a hospital) versus elsewhere (at home or in a birthing centre, reference category).
Stratification for three geographical areas: [a]C4= Urban areas; [b]C6=Semi-urban areas; [c]Cx = Rural areas.
*Levels of significance: * = p<0.10; ** = p<0.05; *** = p<0.01.*

DISCUSSION

Main findings of this study

Our multilevel analyses investigated utilization of obstetric care in a nine-year national dataset relating supply and demand. Results reject hypotheses that more supply (hospital density) induces more interventions in obstetric care in the Netherlands. SES and ethnicity effects also partially contradict common belief: adjusted for maternal factors and hospital density, living in low SES neighbourhoods and being from non-Western ethnic descent were not universally associated with higher odds of medical interventions. This finding was consistent across the interventions studied, with two exceptions: women from low SES areas in the rural areas were more likely to give birth in an outpatient clinic than their counterparts from more affluent areas, and referrals were more often in rural areas. If we accept the existing evidence on the increased risk for adverse birth outcomes for non-Western women and women living in low SES neighbourhoods, our results suggest relative underservice to the deprived particularly in larger cities, with a potentially adverse impact on perinatal outcomes.

What is already known on this topic?

Higher supply is often associated with a higher probability of health care interventions and admissions. [20] Other studies contradict this. [21] In the Netherlands, Ravelli *et al.* have shown that for perinatal outcomes travelling time to facilities matters [22], suggesting that density might matter for outcome.

Inequalities in outcome may also be caused by inequalities in care utilization. Our findings on inequalities in care utilization rest on a large body of evidence. [23-25] Tudor Hart introduced the concept of the 'Inverse Care Law', meaning that those with low income -who need care most- receive least. [26] Studies within obstetrics that investigated the association between SES and care, have focused on time of entry into prenatal care and the uptake of prenatal screening rather than on interventions. [27, 28] Inequalities in utilization of obstetric care according to ethnic descent have also been described by many authors. [27, 29, 30] To our knowledge, no prior study included hospital density (as a proxy for supply), neighbourhood SES and ethnic descent (as a proxy for demand) in one analysis.

What this study adds

Our analyses, stratified according to three geographical areas, show that hospital density is not associated with more health care interventions. The lack of an empirical effect of hospital density in this study may be caused by 1) a relative shortage of obstetric facilities, implying that all facilities are in full use; 2) the effect of guideline-led care, translating into uniform supply at the regional level; 3) factors affecting interventions

somehow also affecting hospital density and 4) the current Dutch reimbursement system for obstetric interventions, which provides few economic incentives for 'oversupply' of care because it provides reimbursement for a whole 'care process' instead of a fee-for-service.

In absence of hospital density effects on the intervention rate, it was surprising to find inequalities according to neighbourhood SES and ethnicity. For such inequalities, several mechanisms have been postulated. First, the patients' cultural background may influence preferences. There is a stronger tendency amongst non-Western women to prefer hospital based care and non-Western women may feel less aversion against medical interventions. While birth setting in the C4 confirms this tendency, this appears to be an exception. Hence, cultural background plays no role in the inequalities we observed. Secondly, patients' unfamiliarity with the Dutch care system may underlie differences in intervention rates. Dutch patients are assertive in voicing their wishes to their physician and the same is probably expected from non-Western women. [31] If care providers are unaware of this difference in attitude, inequalities may arise. Lower levels of health literacy, which entails more than insufficient language proficiency, may add to this. [32]

The inequalities in induction of labour and primary caesarean sections however suggest a role for care providers too. Care providers may not be conducive to specific high risk populations. Sparse consultation time can also make care providers less eager to thoroughly explain all treatment options. This may be enforced by health literacy issues of the patient, as mentioned above. Based on prior experiences, care providers may then make false assumptions on a patient's risks or needs. In line with this, concordance in physician and patient ethnicity is associated with better perceived quality of care. [33]

In our analysis the urbanisation level apparently acted as a confounder, with three distinct categories. We observed a striking difference between the C4 and the other areas: despite the increased prevalence of high risk groups and ample supply, the C4 surprisingly showed low intervention rates. We hypothesize that this could be one of the underlying mechanisms for the poorer perinatal outcomes in the large urban areas compared to the rest of the country. More research is needed to specify the influence of an unhealthy environment and social interactions within neighbourhoods.

A major strength of this study is the use of the complete 9-year national perinatal dataset with very high coverage that enabled us to map out demand and supply within obstetric care in the Netherlands. A previous study has shown that there is no need to correct for the record year because the outcomes are relatively stable across the years. [34] A second strength is that unlike most evidence on inequality in care utilization, we corrected for two important supply factors which may interact with the presence of deprived neighbourhoods and high migrant prevalence: hospital density and degree of urbanisation. The use of multilevel regression techniques enabled us to account for

clustering of socio-demographic characteristics and other unknown effects (possibly health behaviours of women within neighbourhoods).

Limitations of this study

Our study has several limitations. First, we had little individual level data on lifestyle or morbidity of the women. Therefore we were unable to take the women's individual risk status into account and/or to adjust for it. Other factors that influence interventions such as patient preference, caregiver preference, or even other less tangible factors such as hospital policy could not be taken into account either. Hospital density was used as a proxy for density of all obstetric care providers. The Dutch system consists of both obstetricians and autonomously working community midwives. However, we do not have data on midwifery practice density at our disposal. Community midwives partly influence demand for hospital care by determining when to refer pregnant women under their supervision to hospital care. Referral is guided by the List of Obstetric Indications, which describes indications for referral. [35] Examples of these indications are haemophilia, hypertensive disorders, illicit substance abuse, and multiple pregnancies.

Also, the crude dichotomization of ethnic descent into 'Western' and 'non-Western' pools together diverse groups of women with different predispositions for adverse outcomes and possibly for interventions. Moreover, time spent in the 'host' country is of influence on language barriers and health literacy. Therefore data on migrant generation would have been desirable. [36, 37]

Additionally, because ethnicity could be based on self-declared ethnicity, the registered ethnicity of two women with precisely the same mixed background, may differ because one may feel predominantly 'Dutch' whilst another might feel 'Turkish'. This discrepancy may have influenced the effects we found in our analyses. However, this is likely to have led to a dilution and thus an underestimation of the true effect.

Finally, we assumed that women visit the hospital that is closest to their home. This does not always reflect true patient behaviour. [38] Attractive or repelling features of hospitals that we could not take into account may influence choice.

Despite the above mentioned limitations and the intrinsic limitations of observational data, the findings in this study give insight into the presence and size of inequalities in obstetric care utilization in the Netherlands. Further investigation is warranted to elucidate the underlying mechanisms, enabling the development of policy to reduce these inequalities.

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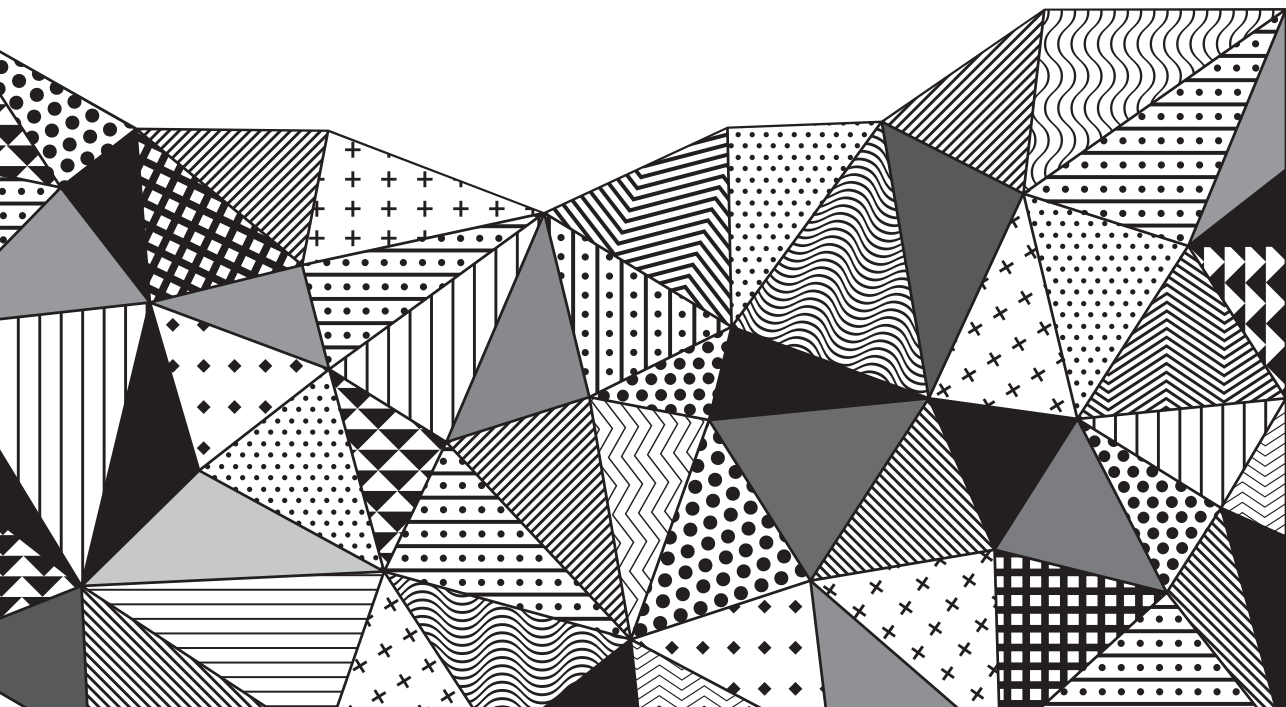

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Chapter 5

The association of ethnic minority density with late entry into antenatal care in the Netherlands

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ABSTRACT

In the Netherlands, non-Western ethnic minority women make their first antenatal visit later than native Dutch women. Timely entry into antenatal care is important as it provides the opportunity for prenatal screening and the detection of risk factors for adverse pregnancy outcomes. In this study we explored whether women's timely entry is influenced by their neighbourhood. Moreover, we assessed whether ethnic minority density (the proportion of ethnic minorities in a neighbourhood) influences Western and non-Western ethnic minority women's chances of timely entry into care differently. We hypothesized that ethnic minority density has a protective effect against non-Western women's late entry into care. Data on time of entry into care and other individual-level characteristics were obtained from the Netherlands Perinatal Registry (2000-2008; 97% of all pregnancies). We derived neighbourhood-level data from three other national databases. We included 1,137,741 pregnancies of women who started care under supervision of a community midwife in 3422 neighbourhoods. Multi-level logistic regression was used to assess the associations of individual and neighbourhood-level determinants with entry into antenatal care before and after 14 weeks of gestation. We found that neighbourhood characteristics influence timely entry above and beyond individual characteristics. Ethnic minority density was associated with a higher risk of late entry into antenatal care. However, our analysis showed that for non-Western women, living in high ethnic minority density areas is less detrimental to their risk of late entry than for Western women. This means that a higher proportion of ethnic minority residents has a protective effect on non-Western women's chances of timely entry into care. Our results suggest that strategies to improve timely entry into care could seek to create change at the neighbourhood level in order to target individuals likely of entering care too late.

INTRODUCTION

International studies have shown that pregnant women from ethnic minority backgrounds tend to enter antenatal care at a significantly higher gestational age than ethnic majority women. [1, 2] Research in the Netherlands points in the same direction. Women from all non-Western ethnic minorities except those with a Turkish or Hindustani-Surinamese background make their first antenatal visit later than their Native Dutch counterparts. For example, multiparous Creole-Surinamese women entered antenatal care after 14 weeks of gestation in 49% of cases, against 11% for multiparous Dutch women. [3]

Late entry into antenatal care is problematic, as it is associated with a higher risk for adverse birth outcomes. These include abruptio placentae, chorioamnionitis, preterm birth, low birth weight and fetal and neonatal death. [4] Pregnant women in the Netherlands are advised to enter antenatal care between 8 and 10 weeks of gestation. If they enter care too late, i.e. after 14 weeks of gestation, they miss the opportunity to receive prenatal screening for a range of syndromes and congenital anomalies. [5]

Commonly cited risk factors in international studies for late entry into care are single status, young maternal age, poor language proficiency, maternal education of less than 5 years, multiparity, unplanned and unwanted pregnancy, difficulty in arranging an appointment for antenatal care, and being uninsured. [6] In the Netherlands, research has shown that a lack of knowledge of the Western healthcare system and poor language proficiency are important reasons for inadequate antenatal care usage among non-Western ethnic minority women. [7] While studies conducted in the Netherlands on time of entry into antenatal care have focused on these individual-level determinants, previous research in the United States and Canada found associations between the area of residence and timing of entry into antenatal care. [3, 8-10] Neighbourhood characteristics may affect health outcomes over and beyond the influence of individual determinants. In other words, it is possible that certain neighbourhoods are more or less conducive to pregnant women's timing of entry into care.

In this study we explored the association between the proportion of non-Western ethnic minorities in a neighbourhood (i.e. ethnic minority density) and late entry into antenatal care in the Netherlands. Moreover, we assessed whether ethnic minority density has a different influence on Western and non-Western ethnic minority women's time of entry into care. We hypothesized that ethnic minority density has a protective effect on non-Western women's timely entry into care. This is based on the findings of a recent Dutch study by Schölmerich *et al.* who found that while non-Western ethnic minorities generally have more adverse birth outcomes compared to Western women, this trend is reversed in areas with high ethnic minority density. [11] This means that while non-Western ethnicity is a risk factor at the individual-level, residence in a neighbourhood

of high ethnic minority density is a *protective* factor for non-Western women's birth outcomes. A similar protective effect of high ethnic minority density has been found in studies on other health outcomes such as mental health and self-rated health and is known as the 'ethnic density effect'. [11-13]

Studies have explored possible mechanisms underlying this 'ethnic density effect'. One explanation is that ethnic minorities residing in neighbourhoods with high ethnic minority density exhibit better health outcomes than ethnic majority groups because they experience higher levels of *bonding social capital*. Bonding social capital refers to 'horizontal' ties between members of a network who see themselves as similar (homogenous networks, such as ethnic groups). [14, 15] Social capital has been conceptualized to influence health in several different ways - plausibly, these patterns also apply to *bonding* social capital: firstly, by promoting the exchange of resources between residents, secondly by residents engaging in collective action to improve access to local services and amenities, thirdly through social control over healthy behaviour, and lastly by more efficient diffusion of health related information. [16, 17]

While social capital is generally seen as having a positive influence on health (behaviours), studies have found that bonding social capital may promote health but may also act as a source of strain (and hence a detriment to health) in resource-poor settings. [18] Scholars have explained this phenomenon via two pathways. For one, bonding social capital may facilitate good health through the exchange of resources between neighbours, but high reliance on mutual exchange of reciprocity can result in excessive obligations placed upon residents to help each other, which might be detrimental to health. In addition, while bonding social capital can assist in the diffusion of information, the closed nature of social ties in such communities can also restrict the flow of information from the outside (e.g. new information about changes in the Dutch obstetric system) and maintain the circulation of unreliable information. [19] This could lead to less timely and adequate use of antenatal care. This means that neighbourhood ethnic minority density could either have a detrimental or beneficial effect on utilization of antenatal care.

As we assume that the neighbourhood characteristic ethnic minority density is a proxy for bonding social capital for *non-Western* residents, we also wanted to control for bonding social capital of *Western* residents. Based on a recent study by Schölmerich *et al,* we use a measurement of neighbourhood social capital for this proxy. [11] This measurement was derived from a nationally representative data set, of which 82.7% of the respondents were Western. Furthermore, we control for the following other neighbourhood characteristics: feeling of safety, socio-economic status, level of urbanity and home maintenance. We included these variables because prior studies in the Netherlands found an association between them and adverse birth outcomes as well as general health. [11, 20, 21] The causal pathways between neighbourhood influences on

(prenatal) health have not been completely unravelled and may be mediated by adverse health behaviours such as late entry into care.

The objective of our study was to explore the independent association between neighbourhood ethnic minority density and late entry into antenatal care in the Netherlands. Moreover we wanted to investigate whether neighbourhood ethnic minority density affects Western and non-Western women differently. We hypothesize that in line with the study by Schölmerich *et al.*, ethnic minority density will have a beneficial effect on time of entry into care for non-Western women when compared to Western women. [11]

DATA AND METHODS

To determine the association between ethnic minority density and the risk of late entry into antenatal care in the Netherlands, we extracted neighbourhood-level variables from three national datasets, and linked these with a large dataset on individual pregnancy cases using the four-digit zip code for neighbourhoods.

Ethics and consent

The use of the anonymized patient data for this study was approved by the Netherlands Perinatal Registry (project number 13.50) (additional information on the registry: www.perinatreg.nl/home_english). Written consent from pregnant women was not needed as the registry protects their anonymity.

Outcome variable

Timely entry into care was defined as entry at any time before 14 weeks of gestation; late entry into care was defined as starting after 14 weeks of gestation (0= not late, 1=late). The cut-off point of after 14 weeks of gestation was chosen because entry into care after 14 weeks of gestation excludes a woman from prenatal screening on Down, Edwards and Patau syndrome in the Netherlands and early detection and modification of other medical and non-medical risk factors (such as illicit drug use) for adverse pregnancy outcome. [5, 22]

Individual level determinants

The data on entry into care were acquired from the Netherlands Perinatal Registry, which contains 97% of Dutch pregnancies since the year 2000. Midwives, gynaecologists and neonatologists supply these data. Validation studies comparing the data from the Perinatal Registry and Statistics Netherlands (national statistics bureau [23]) have shown that underreporting of information by practitioners for the Perinatal Registry is negligible. However no specific validation has taken place for the data on time of entry into care. We will further elaborate on this in the discussion section.

For this study we selected singleton pregnancies in the datasets from 2000 up to and including 2008, because then both individual (i.e. pregnancy cases) and neighbourhood level data are derived from approximately the same time frame. The weeks of gestation at entry into care were regrouped dichotomously into 'up to and including 14 weeks of gestation' and 'after 14 weeks of gestation'. Based on previous studies on the association of maternal covariates and time of entry into care, we included the following maternal covariates: maternal age, parity and ethnicity.

In the Netherlands Perinatal Registry, ethnicity is divided into the following categories: Western Dutch, Western other, Mediterranean, Asian, African, South Asian, or other non-Western. Most non-Western immigrants in the Netherlands are from Turkey, Morocco, Surinam and the Dutch Antilles. The recording of ethnicity in the Netherlands Perinatal Registry is challenging for two reasons: 1) Maternal ethnicity is based on either self-declared ethnicity or country of birth of the mother or her parents causing heterogeneity in registration; 2) the categorization in the registry is not in line with international classifications, making comparisons difficult. Therefore we dichotomized ethnicity into being from 'Western' or 'non-Western' descent for the purpose of this study.

Neighbourhood level determinants

Four-digit zip code areas were used to define neighbourhoods. In 2006 the four-digit zip code neighbourhoods had - on average - 4080 residents. This makes the neighbourhoods comparable to Lower Layer Super Output Areas in the United Kingdom or census tracts in the United States. Because neighbourhoods in the Netherlands are sufficiently uniform in terms of their socio-cultural characteristics, the four-digit zip code areas are adequate units for contextual investigation. [24] Data on the neighbourhood characteristics were obtained from Statistics Netherlands, the Housing & Living Survey and the Netherlands Institute for Social Research. [23, 25, 26] These data were collected between 2005 and 2006.

As mentioned in the introduction, we included six neighbourhood characteristics in our analysis. A more detailed description of the characteristics is given in table 1. All neighbourhood characteristics were recoded into z-scores. The characteristics were constructed using the same aggregation techniques and data sets that Schölmerich *et al.* and Mohnen *et al.* applied in their respective studies. [11, 20]

In this study only women who started care with a community midwife (the 'first tier') were included. The Dutch obstetric care system consists of three 'tiers'. The first tier consists of autonomously working community midwives who take care of low risk women. [27] When complications (threaten to) occur, women are referred to the second tier of care, consisting of obstetricians in hospitals. The third tier of care consists of academic obstetric care. A quarter of women enter obstetric care immediately in the second or third tier because of medical risks or complications at the start of their pregnancy. [28]

Table 1. Detailed description of neighbourhood level variables included in the multilevel model.

Variable Name	Meaning	Measurement	Source	Ref.
Ethnic minority density	Concentration of people from ethnic minorities	% of residents from non-Western ethnic backgrounds per 4 digit zip code. Non-Western ethnicity is defined as an individual or at least one of the individual's parents originating from Africa, Latin America, Asia (except Indonesia and Japan) or Turkey. Higher values indicate a higher concentration of ethnic minorities.	Statistics Netherlands	[26]
Social capital	Access to resources that are generated by relationships between residents in a tightly knit and cohesive community	Five-point Likert scale (I totally agree – I totally do not agree). 1) Contact with direct neighbours; 2) Contact with other neighbours; 3) Whether people in the neighbourhood know each other; 4) Whether neighbours are friendly to each other; 5) Whether there is a friendly and sociable atmosphere in the neighbourhood. Social capital scores which were created using an 'ecometrics' procedure were provided by Schölmerich*et al.* The reliability of the scale was acceptable, with an estimator of 0.595 (in accordance with Hox). Higher values indicate higher levels of social capital.	House and Living Survey (items) Schölmerich*et al.* (Ecometrics score)	[11, 25]
Feeling of safety	Perception of safety in the neighbourhood	Five-point Likert scale (I totally agree – I totally do not agree). Statement: "I am scared of being harassed or assaulted in this neighbourhood." Higher values indicate higher levels of perceived safety.	House and Living Survey	[25]
Socio-economic status	A group's position within a hierarchical social structure	Average income, % of people with low income, % of people with a low education and % of unemployed people in a neighbourhood. Higher values indicate a higher socioeconomic status.	Netherlands Institute for Social Research	[23]
Level of urbanity of the neighbourhood	Degree of urbanity of the municipality a neighbourhood is situated in	Number of addresses per square kilometre (km2). 1) Rural, up to 499 addresses per km2; 2) Semi-rural, 500-999 addresses per km2; 3) Intermediate urban-rural, 1000-1499 addresses per km2; 4) Semi-urban, 1500-2499 addresses per km2; 5) Urban, more than 2499 addresses per km2. Higher values indicate higher levels of urbanity.	House and Living Survey	[25]
Home maintenance	Proxy for the environmental condition in a neighbourhood	Five-point Likert scale (I totally agree – I totally do not agree). Question: "Is your house in bad condition?" Higher values indicate better home maintenance.	House and Living Survey	[25]

We focused on the first tier population because immediate entry into care in the second and third tier is above all determined by the patients' medical and obstetric history. Typically these women have previously received explicit instructions about their antenatal care and the importance of timely entry. The women included in this study – the first tier population - form the greatest portion of all pregnant women in the Netherlands, namely 74%. These women are not just a low risk population because many of them will be referred to the second tier of care, either during pregnancy, labour or the postpartum period because of new risks or complications. [29] This means that the women included in this study are still heterogeneous in terms of their risk profile, making comparison to other studies possible.

The final analysis included 1,137,741 pregnancies and 3,422 neighbourhoods. 35,326 (2.2%) pregnancies were excluded because they were multiple pregnancies and 31,382 (1.9%) pregnancies because individual or neighbourhood characteristics were missing. Non-Western women were slightly more likely to have missing values than non-Western women (2.8% vs 2.7%). 580 neighbourhoods (14% of the total) were excluded because not all six neighbourhood characteristics were available (Figure 1). Most of the excluded neighbourhoods had too few inhabitants to be included in the study because they were rural or industrial areas.

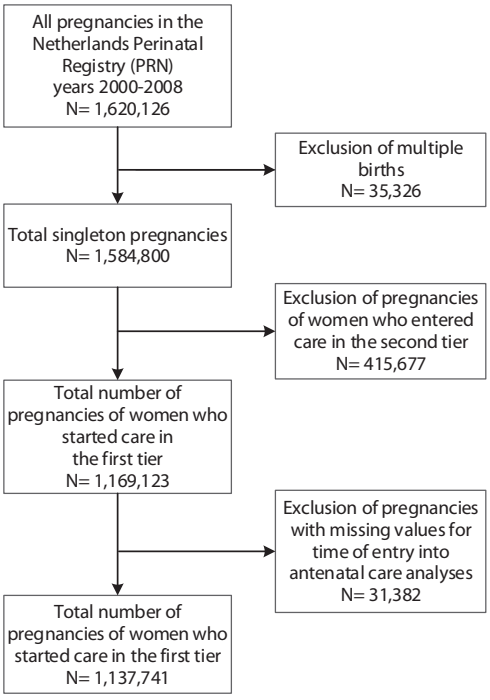

Figure 1. Exclusion of pregnancies.
This figure shows the number of pregnancies excluded from the multilevel logistic regression analysis.

Analytical strategy

Because of the hierarchical nature of the data, in which pregnant women (level 1) are nested within neighbourhoods (level 2) we performed multilevel logistic regression analyses. First, to determine whether clustering was present we fitted a "null-model" which only contained a random intercept. To establish the presence of clustering we calculated the intra-class correlation (ICC), using the following formula in which sigma-squared is the intercept variance: [30]

$$ICC = \frac{\sigma^2}{\sigma^2 + 3.29}$$

The ICC can range from 0 to 1. When it deviates from zero, it is appropriate to use multilevel analyses. [31] We found an ICC of 9.5% (results not shown) justifying this modelling approach. The null-model was then expanded to include the individual level characteristics age, parity and ethnicity as fixed effects to examine the influence of these on late entry into care (model 1). Thereafter, we separately added the neighbourhood contextual variables 'neighbourhood social capital' and 'ethnic density' (model 2 and 3) to investigate their specific influence, before adding the other neighbourhood variables (model 4). Consecutively an interaction term was included for non-Western ethnicity*neighbourhood social capital (model 5) and non-Western ethnicity*ethnic minority density (model 6) to investigate the potential difference in impact of these neighbourhood characteristics on Western and non-Western women. Although we were primarily interested in the interaction for non-Western ethnicity*ethnic minority density, we also tested the interaction with neighbourhood social capital because Schölmerich *et al.* found this interaction term to be significant in their analysis of birth outcomes in the Netherlands. [11] In the final model, all individual variables, neighbourhood contextual variables and interaction terms were included (model 7). All analyses were performed using SPSS version 20.

RESULTS

Between 2000 and 2008 the prevalence of entry into antenatal care after 14 weeks of gestation was 17.9%. Table 2 shows the demographic characteristics of the study population and table 3 shows the descriptive statistics of the neighbourhoods. The correlations between the neighbourhood variables are presented in appendix S1. Most importantly, neighbourhoods with higher socio-economic status generally had lower ethnic minority density (corr. -0.56, $p<0.001$).

Table 4 / model 1 shows the odds ratios for the individual level characteristics in our logistic regression analysis with 'late entry into care' as the outcome variable. Women

Table 2. Descriptive statistics of individual variables and time of entry into care.
(Source: Perinatal Registration Netherlands, 2000-2008)

	Total		Western		Non-Western		Significance (p-value)
	N	(%)	N	(%)	N	(%)	
Total singleton births - first tier of care	1,137,741 (100)	(100.0)	959,771	(84.4)	177,970	(15.6)	
Maternal age							<0.01
<25 years	141,239	(12.4)	93,239	(9.7)	48,000	(27.0)	
25-29 years	343,101	(30.2)	285,336	(29.7)	57,765	(32.5)	
30-34 years	451,282	(39.7)	403,838	(42.1)	47,444	(26.7)	
35-39 years	181,309	(15.9)	160,403	(16.7)	20,906	(11.7)	
>40 years	20,810	(1.8)	16,955	(1.8)	3,855	(2.2)	
Parity							<0.01
Primiparous (first birth)	541,117	(47.6)	465,825	(48.5)	75,292	(42.3)	
Multiparous (second or higher birth)	596,624	(52.4)	493,946	(51.5)	102,678	(57.7)	
Time of entry into care							<0.01
< 14 weeks of gestation	934,453	(82.1)	820,752	(85.5)	113,701	(63.9)	
≥ 14 weeks of gestation	203,288	(17.9)	139,019	(14.5)	64,269	(36.1)	

Table 3. Descriptive statistics of the neighbourhoods.

Neighbourhood characteristic	Low (%)	Medium (%)	High (%)
Ethnic minority density[1]	91.8	8.1	0.2
Neighbourhood social capital[2]	3.7	81.2	15.1
Socioeconomic status[3]	20.3	63.4	16.3
Feeling of safety[4]	1.4	22.1	77.4
Level of urbanity[5]	50.2	19.4	30.5
Home maintenance[6]	1.4	33.3	65.3

The figures presented in this table are crude proportions. For the purpose of our analyses we transformed these into Z-scores. The median number of deliveries per neighbourhood was 349 (range: 56-602, 20th-80th percentile).
[1] Low: <20%; medium: 20-80%; high >80% inhabitants from non-Western origin.
[2] Low: <3 on the 5-point Likert scale; medium: 3 on the 5-point Likert scale; high: >3 on the 5-point Likert scale.
[3] Low: <20th percentile; medium: 20-80th percentile; high >80th percentile.
[4] Statement: "I am scared of being harassed or assaulted in this neighbourhood." Low: on average inhabitants agree; Medium: on average inhabitants don't agree and don't disagree; high: on average inhabitants don't agree.
[5] Low: <1000 addresses per km2; medium: 1000-1500 addresses per km2; high: >1500 addresses per km2.
[6] Question: "Is your house in bad condition?" Low: on average inhabitants agree; Medium: on average inhabitants don't agree and don't disagree; high: on average inhabitants don't agree.

in the age category of 30 to 35 years were most likely to enter antenatal care late. Non-Western ethnicity was also strongly associated with higher risk for late entry into care. Contrarily, we found no significant association of parity and time of entry into

Table 4. Multilevel logistic regression models of ethnic minority density and other individual and neighbourhood characteristics on late entry into care (after 14 weeks of gestation). (Odds ratios, 95% confidence intervals in parentheses).

n = 1,137,741 nb = 3422		Model 1	Model 2	Model 3	Model 4	Model 5	Model 6	Model 7
Intercept		0.15 (0.1-50.15)***	0.15 (0.1-50.15)***	0.15 (0.1-50.15)***	0.15 (0.1-50.15)***	0.15 (0.1-50.15)***	0.15 (0.15/ 0.15)***	0.15 (0.1-50.15)***
Individual level								
Maternal age (Ref.=25-29 years)	*<25yr*	1.80 (1.7-71.83)***	1.80 (1.7-71.83)***	1.80 (1.7-71.83)***	1.80 (1.7-71.83)***	1.80 (1.7-71.82)***	1.79 (1.7-71.82)***	1.79 (1.7-71.82)***
	30-34yr	3.06 (2.9-63.15)***	3.05 (2.9-63.15)***	3.05 (2.9-63.15)***	3.06 (2.9-73.16)***	3.06 (2.9-63.15)***	3.05 (2.9-63.15)***	3.05 (2.9-63.15)***
	35-39yr	1.06 (1.0-51.07)***	1.06 (1.0-51.07)***	1.06 (1.0-51.07)***	1.06 (1.0-51.07)***	1.06 (1.0-51.07)***	1.06 (1.0-51.07)***	1.06 (1.0-51.07)***
	>40yr	1.56 (1.5-41.59)***	1.56 (1.5-41.59)***	1.56 (1.5-41.59)***	1.57 (1.5-41.59)***	1.56 (1.5-41.59)***	1.56 (1.5-41.59)***	1.56 (1.5-41.59)***
Parity (Ref.= multiparous)	*Primi-parous*	1.00 (0.9-91.01)	1.00 (0.9-91.01)	1.00 (0.9-91.01)	1.00 (0.9-91.01)	1.00 (0.9-91.01)	0.99 (0.9-81.01)	0.99 (0.98/-1.01)
Ethnicity (Ref.= Western)	*non-Western*	2.63 (2.6-02.67)***	2.62 (2.5-92.66)***	2.62 (2.5-82.65)***	2.61 (2.5-82.65)***	2.68 (2.6-42.72)***	2.72 (2.6-82.77)***	2.73 (2.6-92.77)***
Neighbourhood level								
Ethnic minority density				1.07 (1.0-41.09)***.09)***	1.16 (1.1-11.20)***	1.16 (1.1-21.21)***	1.21 (1.1-61.26)***	1.21 (1.1-61.26)***
Neighbourhood social capital			1.00 (0.9-71.02)		1.01 (0.9-81.04)	1.00 (0.9-71.03)	1.02 (0.9-91.04)	1.01 (0.9-91.04)
Socio-economic status					0.97 (0.9-51.00)*	0.97 (0.9-51.00)*	0.97 (0.9-51.00)*	0.97 (0.9-51.00)*
Level of urbanity					0.88 (0.8-60.90)***	0.88 (0.8-60.90)***	0.87 (0.8-50.90)***	0.87 (0.8-50.90)***
Home maintenance					0.97 (0.9-50.98)***	0.97 (0.9-50.99)***	0.97 (0.9-50.99)***	0.97 (0.9-50.99)**
Feeling of safety					1.00 (0.9-81.02)	1.00 (0.9-81.02)	1.00 (0.9-81.02)	1.00 (0.9-81.02)
Neigh. social capital*non-Western						1.06 (1.0-51.08)***		1.01 (1.0-01.03)
Ethnic minority density*non-Western							0.97 (0.9-60.98)***	0.93 (0.9-10.94)***

*n=number of pregnancies; nb = number of neighbourhoods; significance (p-value): *p≤0.05, **p≤0.01, ***p≤0.001.*

care. Moreover, the estimates for all of these individual level variables showed minimal change across the models.

In model 2 of our analysis, neighbourhood social capital was added (table 4). The association of this variable with late entry into care was not significant and remained so in all other models. In contrast, ethnic minority density (model 3) was significantly associated with late entry into care. This effect remained present after controlling for the other neighbourhood contextual variables in model 4. Though feeling of safety had no effect, higher levels of socioeconomic status, home maintenance and level of urbanity were associated with lower risks of late entry into care. The latter showed the most notable effect of these three. Model 5 and 6 include the interaction terms for neighbourhood social capital*non-Western ethnicity and ethnic minority density*non-Western ethnicity, respectively. Though the interaction term for neighbourhood social capital*non-Western showed a significant effect in model 5, this effect was no longer present in the full model (model 7). However, the interaction term for ethnic minority density*non-Western ethnicity did remain significant in the full model. From this follows that ethnic minority density is associated with 1.21 times the odds of late entry into care for Western women and 1.13 times the odds for non-Western women (calculated: exp (ln(1.21) + ln(0.93)). In the full model, again neighbourhood level of urbanity showed

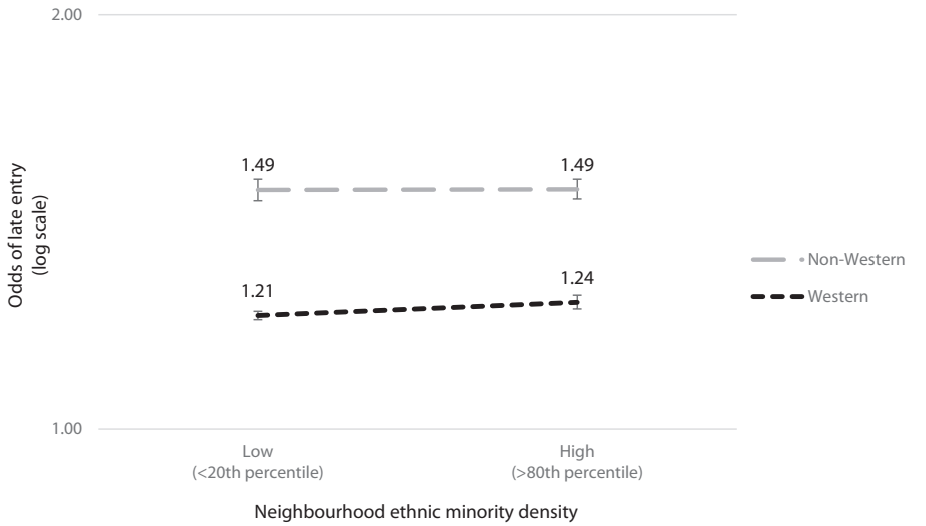

Figure 2. The interaction between ethnic status and neighbourhood ethnic minority density level for the odds of late entry.

This figure demonstrates that higher proportions of ethnic minority density in a neighbourhood have a less detrimental effect on non-Western women than on Western women in terms of their risk of late entry into care. Low ethnic density: 20 percent neighbourhoods with the lowest proportions of non-Western inhabitants; high ethnic density: 20 percent neighbourhoods with the highest proportions of non-Western inhabitants.

the most notable association (OR 0.87, 95%CI 0.85-0.90, p≤0.01). Figure 2 illustrates the interaction effect between ethnic status (non-Western or Western) and the level of ethnic minority density in a neighbourhood for risk of late entry into care.

DISCUSSION

We found that neighbourhood contexts influence timing of entry into antenatal care in the Netherlands. In particular, higher rates of neighbourhood ethnic minority density are associated with a higher risk of late entry into antenatal care in the Netherlands. However, our analysis also shows that for non-Western women, living in high ethnic minority density areas is less detrimental to their timing of antenatal care than for Western women.

Similar to our study, Heaman *et al.* reported higher risks of inadequate antenatal care use for women living in neighbourhoods with higher numbers of residents with an indigenous minority background. [9] It should be noted that inadequate use of care, the outcome measure of their study, was broader than our outcome measure. Inadequacy of care entails late entry into care and / or an insufficient number of antenatal appointments. There is no international consensus on the appropriate number of antenatal visits. Nevertheless, inadequacy of antenatal care is used in a number of studies because it is believed that it may be associated with adverse pregnancy outcomes. [1, 32-34] We were unable to analyse the number of antenatal visits each woman had because this is not recorded in the Netherlands Perinatal Registry. However, a systematic review by Feijen *et al.* showed that both late entry and an insufficient number of antenatal appointments share the same set of risk factors. [6] Therefore we believe that it is valid to compare our results with other studies focusing on inadequate use of antenatal care.

In line with previous studies, being of non-Western ethnic descent was amongst the most important predictors for late entry into care. This supports the commonly held view that 'ethnicity' (meaning a non-Western ethnic minority status) is a risk factor for health behaviour, including adequate use of care. [35, 36] However, our analysis shows that for non-Western women, living in high ethnic minority density areas is less detrimental to their risk of late entry into antenatal care than for Western women. This means that while ethnic minority status is indeed not a protective factor in and of itself at the *individual* level, it seems to act as a protective factor for time of entry into care at the *neighbourhood* level in areas where ethnic minorities are in the majority. Our results are in line with a recent study by Schölmerich *et al.* who found the same pattern for birth outcomes. [11] Similar to our study, Cubbin and colleagues found that place of residence influences ethnic minority and majority groups differently in terms of their risk for late entry into antenatal care. [37] The results were stratified for neighbourhood deprivation

levels instead of neighbourhood ethnic minority density levels. But prior research – as well as our study (see appendix S1) - has shown a relation between higher levels of neighbourhood deprivation and higher levels of ethnic minority density. [38] Cubbin and colleagues found that African American women in the least deprived areas (and presumably areas of lower ethnic minority density) were at higher risk of delayed entry into antenatal care than African American women living in moderately deprived areas. Contrastingly, in the most deprived areas (and presumably areas of higher ethnic minority density) the risk of late / no initiation of antenatal care was only elevated among European American women.

Various studies have suggested that for ethnic minority groups, ethnic minority density could be seen as a proxy for bonding social capital. [11, 39, 40] Applied to our study, this would mean that the non-Western women in our study have higher levels of bonding social capital than their Western counterparts in areas with high ethnic minority density. As outlined in the introduction, higher levels of *bonding* social capital have been associated with both*higher and* lower risk of adequate health care use. The findings from our study suggest that *bonding* social capital has a positive effect on time of entry into care of non-Western women. For these women, bonding social capital might enhance the chances of timely entry into care: firstly by promoting the exchange of resources between residents (for example money to take public transport to an antenatal care provider); secondly by having residents engage in collective action to improve access to local antenatal services; thirdly through social control over healthy behaviour (in this case on timely entry into antenatal care); and lastly by more efficient diffusion of health related information (on the importance of timely entry into care, and access to antenatal care). [16, 17]

Neighbourhood social capital showed no effect in our analysis. This was an unexpected finding. In the literature higher levels of neighbourhood social capital are associated with more adequate use of care of Western women. [41] Moreover, based on a recent Dutch study on birth outcomes we had expected that this variable would act as a proxy for bonding social capital of Western residents. Our observations suggest that if Western women have access to bonding social capital, it does not protect them from late entry into care. In contrast, non-Western women benefit from their access to bonding social capital in terms of protection from late entry into care.

In line with previous studies in the Netherlands on other neighbourhood effects, we found that home maintenance (reflecting the environmental conditions in a neighbourhood) and level of urbanity were associated with slightly better outcomes. [11, 20] Similarly, Larson *et al.* reported that living in rural areas was strongly associated with late entry into antenatal care in the United States. [42] An explanation mentioned in this study that could also be plausible for our setting is longer travelling distances to care providers in rural areas. Lower neighbourhood socioeconomic status was associated with a higher risk of late entry into care in all of our models. Two previous studies

also reported that lower neighbourhood socioeconomic status was associated with inadequate use of antenatal care. [9, 10]

Strengths and limitations

This study has a number of strengths and limitations that merit discussion. An important strength of our study was that it was conducted with a national dataset, with high coverage (97%) and a large number of participants (n=1,137,741). Second, in our analyses we used appropriate and sophisticated techniques (multi-level analyses) to account for the clustering of women within neighbourhoods. Our study should also be viewed in the light of its limitations. Due to the retrospective nature of the data no inferences could be made about causation, only about associations. The use of a dichotomous variable for ethnicity is both a strength and a weakness. As described in the methods section, it is less misclassified than the multiple categories in the Dutch Perinatal Registry. Yet, collapsing ethnicity into a dichotomous variable leads to grouping women together from heterogeneous backgrounds and with different health behaviours. Therefore the identification of different underlying mechanisms for different ethnic groups is not possible within this study. Moreover, in this study we did not have information on the migrant status of women. Although non-Western ethnicity is often associated with language barriers and lower health literacy levels, time spent in the 'host' country and the degree of acculturation influence health care behaviour. [43, 44] Despite the lack of data on ethnic groups and migrant status, we hope to have shown with our study that 'ethnicity' can be beneficial and is not merely a risk factor.

As described in the methods section, the data on time of entry into antenatal care in the Netherlands Perinatal Registry has not been validated. In our data set, 17.2% of pregnancy cases were registered as late entry into care. This is comparable to a large Dutch cohort study - the Rotterdam-based Generation R study, which registered 19.8% of cases as entry into care after 14 weeks of gestation. [3]

The Netherlands Perinatal Registry database only contains information on individual births. Therefore we were unable to account for clustering of births within mothers. It is conceivable that mothers repeated their health care behaviour (that is: time of entering care) across their consecutive pregnancies. Moreover, we were not able to control for certain maternal factors that have been associated with late entry into care in previous studies, such as an unwanted pregnancy, illicit drug use, individual socioeconomic status, level of education and language proficiency. [6, 7] Research in an urban group of Dutch pregnant women showed that 0.5% of them continued using illicit drugs throughout pregnancy. [22] A little less than six percent of pregnancies in the Netherlands are unwanted, of which only a part is carried to term. [45] Based on these figures, unwanted pregnancies and illicit drug use are only present in a small portion of the population and are therefore less likely to have an important impact on our findings.

Lastly, we could not take other neighbourhood characteristics into account that may also have influenced timing of entry into antenatal care in our study. Prior studies have demonstrated that quality of public transport and the density and accessibility of care facilities in neighbourhoods influence timing of entry into care. [7, 10, 46]

Future recommendations

This study shows that place of residence and ethnic background matter for antenatal health care use in the Netherlands. Future research could concentrate on teasing apart the beneficial mechanisms within areas of high ethnic minority density leading to early entry into care (e.g. information sharing, financial support or other factors). Moreover, our results suggest that strategies to improve timely entry into care could seek to create change at the neighbourhood level (e.g. increase social bonding) in order to target individuals likely of entering care too late. Also the relative disadvantage of Western women living in areas of high ethnic density needs to be considered, interventions should also focus on Western women living in these areas.

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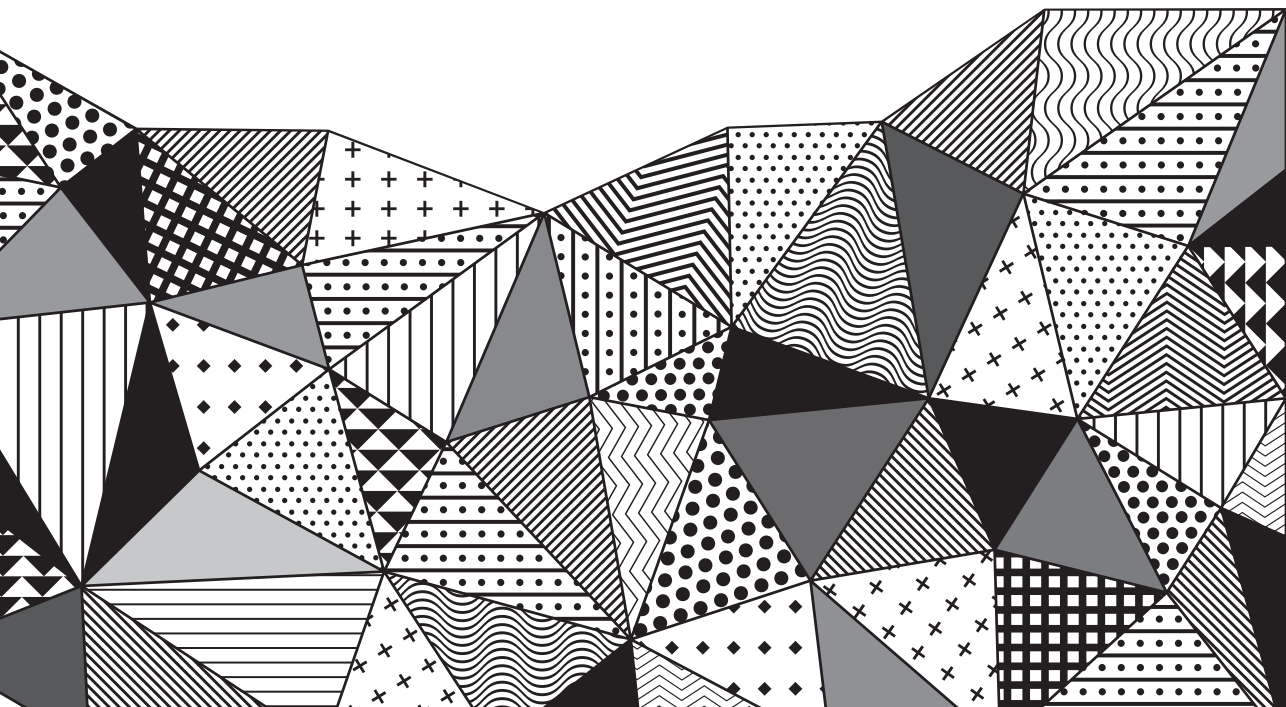
APPENDIX:

Correlations of neighbourhood variables included in the analyses.

Neighbourhood variables	1	2	3	4	5	6
1. Ethnic minority density	1	-	-	-	-	-
2. Neighbourhood social capital	-,565**	1	-	-	-	-
3. Socio-economic status	-,562**	,346**	1	-	-	-
4. Urbanity	,588**	-,505**	-,237**	1	-	-
5. Home maintenance	-,281**	,278**	,323**	-,183**	1	-
6. Feeling of safety	-,412**	,385**	,293**	-,320**	,264**	1

3,422 neighbourhoods were included in the analysis.
**p≤0.05, **p≤0.01, ***p≤0.001.*



6

Chapter 6

Inequalities in uptake of prenatal screening according to ethnicity and socio-economic status in the four largest cities of the Netherlands

Posthumus AG, Peters IA, Borsboom GJ, Knapen MFCM, Bonsel GJ

Submitted

ABSTRACT

Objectives: In the Netherlands all women are claimed to have equal access to prenatal screening tests (PS), being the first trimester combination test, and the second trimester fetal anomaly scan. Prior research demonstrated substantial uptake of PS inequalities associated with socioeconomic status (SES) and ethnic background. The suggested pathway was a lack of preference for PS among these subgroups. We studied the background of inequalities in PS participation, challenging the background of preference heterogeneity as the single explanation. Client data were from the four largest cities in the Netherlands, therewith excluding the urban environment as modifying or separate factor.

Methods: Multivariable logistic regression analyses of the national PS registry Peridos, stratified according to SES. Outcome measures: any uptake of PS (yes/no) and uptake (one /two tests) for women who preferred both tests. Determinants included ethnicity, preference, age and gravidity.

Results: Of non-Western women 85.7% were screened vs. 89.7% of Western women. Low SES women participated in 87.9%, compared to 88.8% of high SES women ($p<0.01$). Preference was an important explanatory factor in all models. However, after correction for preference, ethnicity remained a significant determinant for differences in uptake of PS. Practice emerged as an additional determinant. Ethnicity and SES also interacted, indicating that non-Western women in low SES areas had the lowest uptake of PS (corrected for preference heterogeneity).

Conclusion for practice: SES and ethnicity related inequalities in the uptake of PS are only partially explained by preference heterogeneity; other pathways, in particular provider-related determinants, play a role.

INTRODUCTION

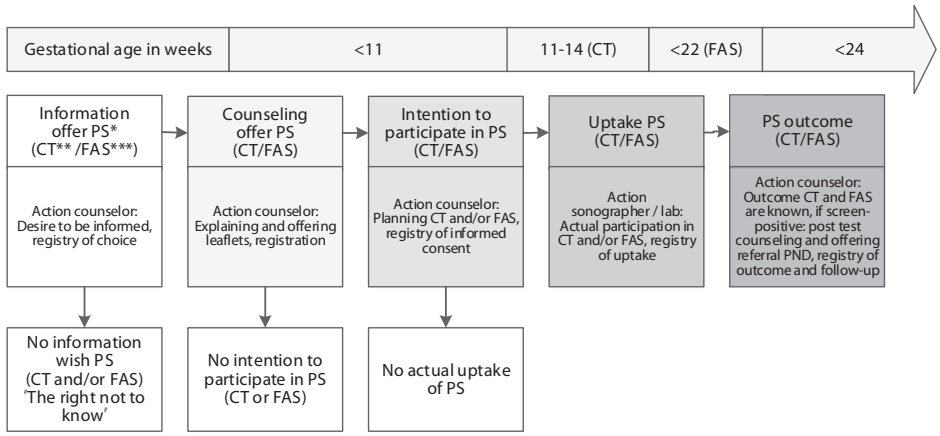
In 2007, a nationwide programme on prenatal screening (PS) for congenital anomalies was introduced in the Netherlands, supported by a legislative framework (the Population Screening Act). [1] PS informs pregnant women and their partners in a timely manner about the likelihood of having a child affected by Down's syndrome or structural congenital anomalies. If the foetus is diagnosed with a syndrome or disorder, prospective parents have the opportunity to either prepare for the birth of a child with this disorder or to consider termination of pregnancy.

Under Dutch law, all pregnant women should be offered the opportunity to receive information from a certified counsellor, on the possibility of having PS. [2] Only if the pregnant woman indicates she wants to be informed on PS, the initial consultation is followed by counselling on the first trimester Combined Test (CT) and the second trimester Fetal Anomaly Scan (FAS). This information 'triage' stage, preceding the actual screening, embodies the principle of 'the right not to know'.

For those consenting, the first option, the CT calculates the chance of carrying a child with Down's syndrome or the lethal syndromes of Patau and Edwards based on biochemistry, serum concentrations of PAPP-A and fβ-hCG, the sonographic fetal nuchal translucency measurement, and maternal age. [3] The FAS, an ultrasound screening test for fetal anomalies at 20 weeks of gestation, primarily aims at the detection of fetal neural tube defects. [4] If the result of the PS is suggestive for a syndrome or disorder, women are offered additional prenatal diagnostic tests.

All women have to pay approximately €165 for the participation in CT; however, before 2015 (data shown in this paper) women over 36 years were exempted from this co-payment because of their supposed higher chances of having a positive test. The FAS is freely available. See figure 1 for an overview of the Dutch PS program.

Despite the assumption of a barrier free choice for PS in the Netherlands, available data suggest selective barriers to exist as substantial heterogeneity in participation rates are present. Fransen *et al.* showed that non-Western women were less likely to make an informed choice and were less likely to participate in the CT, without any evidence of a different attitude to PS as such. [5, 6] In other Western countries women from low socioeconomic status (SES) or non-Western ethnic backgrounds were less likely to receive PS, even in the absence of out-of-pocket costs. [7-11] Generally, contributing factors to these inequalities could be patient-related (i.e. language barriers, the inability to afford the deductible, or preference effects following one's cultural or personal background) and provider-related (lack of time for proper counseling, logistic barriers, personal view of the professional). Only heterogeneity due to true preference of the client should be present.



* PS: prenatal screening
** CT: Combined Test
*** FAS: Fetal anomaly scan

Figure 1. Dutch prenatal screening on Down's syndrome and congenital anomalies.

The aim of this study was to investigate the presence of inequalities in the actual uptake of both CT and FAS as related to SES and ethnicity in the four largest cities in the Netherlands. These cities harbour large non-Western subpopulations (>15%). Also substantial SES gradients are present in these cities. Because prior studies revealed significant differences in perinatal health outcomes and care utilization within these areas [12, 13], registry data on PS in these cities were regarded suitable to investigate whether ethnicity- and SES-related PS inequality were present here, and whether heterogeneity in preference of these groups was the single explanation for inequalities.

METHODS

To investigate the presence of inequalities in women's uptake of PS in relation to SES and ethnicity in the four largest cities in the Netherlands, we extracted records with a small set of individual-level variables from the national Peridos database for the years 2012 to 2013. This web-based database contains data on different aspects of PS in the Netherlands. [14] This includes information on patient characteristics, counselling, informed choice (preference), and actual uptake of the CT and of the FAS. Data are provided by healthcare professionals involved in PS (counsellors and sonographers). Not all data fields in Peridos are mandatory and internal validation of the data is yet to be carried out.

The completeness of recording showed practice variation. We excluded practices with more than 10% missing overall information in the client records, as for our analyses data

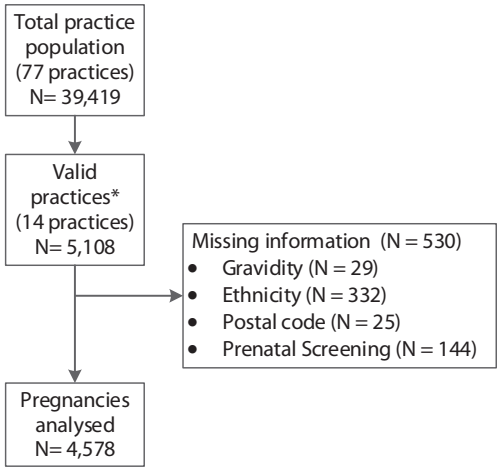


Figure 2. Exclusion of pregnancies.
This figure shows the number of pregnancies excluded from the analysis.

needed to be reasonably complete on the procedural steps. Additionally we excluded individual cases with missing information on gravidity, ethnicity, postal code and uptake of prenatal screening. See figure 2 for an overview of exclusions.

Outcome variable

In our analyses we focused on two outcome variables. The first variable was 'actual uptake of PS'. The response variable was dichotomous (non-participation in PS: 0; having participated in some form of PS: 1). The latter could be the CT solely, the FAS solely, or both tests.

As an intermediate variable we included the woman's preference for PS as expressed after being counselled. The options were: no screening, CT, FAS, or both tests.

The second dichotomous outcome variable was the 'comprehensiveness of PS' in women who preferred both forms of screening after counselling (uptake of both the CT *and* the FAS: 1; uptake of only one test (CT *or* FAS): 0).

Determinants

Based on previous studies on the association of maternal covariates and actual uptake of PS, we included the following maternal covariates: maternal age (in categories, as a strictly linear relationship could not be assumed in the statistical models) and ethnicity. In Peridos the ethnic categories were not mutually exclusive. Therefore we dichotomized ethnicity into being from 'Western' or 'non-Western' descent. Moreover this dichotomization usually provides the most contrasting results in the Netherlands. Gravidity was in-

cluded because prior experience with pregnancy is known to influence behaviour in the current pregnancy. Data on neighbourhood SES were obtained from the Netherlands Institute for Social Research. [15] The status scores were calculated based on (1) average income, (2) proportion of people with low income, (3) proportion of people with a low education and (4) proportion of unemployed people in a neighbourhood. Higher values of this continuous variable indicate a higher SES. Because the maternal zip codes were missing in 85% of the records, we used the address of the counselling practice as a proxy for the woman's neighbourhood of residency.

Lastly, an uptake variable at the practice level was included. For each counselling practice in the study we calculated a CT-ratio: number of women who participated in the CT divided by the total number of women in this counselling practice. In this way, we obtained an indication of uptake of PS at practice level. This may be relevant because caregivers may unintentionally influence uptake themselves.

Ethics and consent

The legal use of Peridos data is based on 'implied consent'. [16] Pregnant women who received an information offer on PS were informed about the use of the anonymized data for quality assessment and research purposes and the right to object to information disclosure for this purpose (opt out). Permission for the current analysis was obtained from the 'Centraal Orgaan Prenatale Screening', the national steering committee.

Analytical strategy

We started with descriptive analyses of the maternal demographic characteristics. Hereafter in all explanatory analyses the study population was stratified according to SES (low SES: ≤50th percentile of all SES values, high SES: >50th percentile of all SES values). The first set of explanatory analyses was based on the entire study population. Univariate logistic regression analyses established the crude odds ratios (OR, 95% CI) between the demographic characteristics and the uptake of PS (model 1). The same determinants were subsequently included in a multivariable logistic regression model (model 2).

Our second set of analyses focussed on the subgroup of women who preferred both forms of PS (CT *and* FAS). Again, at first univariate logistic analyses were performed to determine the crude odds ratios (OR, 95% CI) between the demographic characteristics and the participation in either one (CT *or* FAS) or both tests (CT *and* FAS) of PS (model 3). The determinants were subsequently included simultaneously in a multivariable logistic regression model. All analyses were performed using IBM SPSS Statistics version 20.0 (IBM Corp., Armonk, NY, USA) or SAS 9.3 (SAS Institute, Cary, NC, USA).

RESULTS

Demographic characteristics

Between 2012 and 2013, 96.6% of pregnant women in our study sample had indicated after counselling that they wanted any PS. 88.3% actually received either one or both tests.

Table 1 shows the demographic characteristics of the study population. Western women received PS slightly more often than non-Western women (89.6% versus 85.7%, p<0.01). In non-Western women, the uptake of CT was only 12.2%. This was 31.4% in Western women. A similar, yet more subtle pattern was seen for SES with CT uptake being lower in low SES women. The proportion of women preferring a CT (with or without FAS) increased with age. Additionally in primigravid women, the uptake of PS was slightly higher than in multigravid women.

The stated screening preference was strongly associated with the actual uptake of screening. In advance 37.7% of women preferred both CT *and* FAS: in these women the

Table 1. Population characteristics.

		Actual uptake of screening at 24 weeks of gestation				
4578	Total N (column %)	Combined Test (CT) N (row %)	Fetal Anomaly Scan (FAS) N (row %)	Both CT and FAS N (row %)	No Screening N (row %)	p-value
Age		138 (3.0)	3030 (66.2)	876 (19.1)	534 (11.7)	<0.01
<20 years	89 (1.9)	0 (0)	75 (84.3)	1 (1.1)	13 (14.6)	
20 - 30 years	1640 (35.8)	19 (1.2)	1267 (77.3)	137 (8.4)	217 (13.2)	
≥30 - 36 years	2155 (47.1)	84 (3.9)	1327 (61.6)	526 (24.4)	218 (10.1)	
≥36 years	694 (15.2)	35 (5.0)	361 (52.0)	212 (30.5)	86 (12.4)	
Gravidity						<0.01
Primigravida	2042 (44.6)	64 (3.1)	1347 (66.0)	424 (20.8)	207 (10.1)	
Multigravida	2536 (55.4)	74 (2.9)	1683 (66.4)	452 (17.8)	327 (12.9)	
Ethnicity						<0.01
Non-Western	1563 (34.1)	19 (1.2)	1176 (75.2)	145 (9.3)	223 (14.3)	
Western	3015 (65.9)	119 (3.9)	1854 (61.5)	731 (24.2)	311 (10.3)	
Socioeconomic Status						<0.01
SES <50th percentile	2224 (48.6)	48 (2.2)	1571 (70.6)	335 (15.1)	270 (12.1)	
SES ≥50th percentile	2354 (51.4)	90 (3.8)	1459 (62.0)	541 (23.0)	264 (11.2)	
Stated screening preference at 10 weeks of gestation						<0.01
FAS	2711 (59.2)	0 (0)	2332 (86.0)	58 (2.1)	321 (11.8)	
CT + FAS	1727 (37.7)	138 (8.0)	652 (37.8)	813 (47.1)	124 (7.2)	
Unknown	140 (3.1)	0 (0)	46 (32.9)	5 (3.6)	89 (63.6)	

Table 2. Stated screening preference at 10 weeks of gestation, according to ethnicity and socioeconomic status.

	Total N (column %)	FAS* N (row %)	Both tests (CT**+FAS*) N (row %)	Unknown N (row %)	p-value
Total	4578	2711 (59.2)	1727 (37.7)	140 (3.1)	<0.01
Ethnicity					<0.01
Non-Western	1563 (34.1)	1197 (76.6)	317 (20.3)	49 (3.1)	
Western	3015 (65.9)	1514 (50.2)	1410 (46.8)	91 (3.0)	
Socioeconomic Status					<0.01
SES <50th percentile	2224 (48.6)	1602 (72.0)	553 (24.9)	69 (3.1)	
SES >50th percentile	2354	1109 (47.1)	1174 (49.9)	71 (3.0)	

**FAS: Fetal anomaly scan, **CT: Combined Test.*

uptake of both tests was 47.0%, the uptake of CT *or* FAS was 45.8%, and 7.2% declined all tests. This means that more than half of the women who preferred both tests after counselling, participated in only 1 or none. Also, women who had not stated their preference after counselling, did not receive screening in 63.6% of the cases. In table 2 the stated screening preference at ten weeks of gestation is indicated per SES stratum and per ethnicity stratum. A considerably lower proportion of non-Western women wanted both screening tests, in favour of FAS only. Preference in low SES women showed the same pattern.

Logistic regression

Tables 3a and 3b show the univariate and multivariable logistic regression analyses for the outcome variable 'no screening' in low SES (Table 3a) and high SES (Table 3b) women respectively. In low SES women non-Western ethnicity was strongly associated with higher odds of receiving no PS (OR 1.77). Advanced maternal age, primigravity and a preference for either FAS or both types of screening were associated with reduced odds of no screening. Counselling practice appeared to be a strong provider related determinant as well. Univariate and multivariable regression results were comparable. In high SES women, the individual's preference and the counselling practice both were significant determinants, and only the first remained significant in the multivariable model. Unlike the low SES model, other determinants showed little effect. Therefore, the patterns in significant determinants for non- participation in screening were quite different for the two SES strata.

Table 4a shows the univariate and multivariable logistic regression analyses on 'uptake of one or two types of screening tests' for low SES women who preferred two types of screening after counselling. Non-Western women had higher odds of participating in

Table 3a. Logistic regression models of individual level determinants and uptake of prenatal screening (no / yes, reference category) for low socioeconomic status women. *(Odds ratios, 95% confidence intervals in parentheses)*

	N = 2224	Model 1 (crude)		Model 2 (Forced entry)	
Determinants		**OR**	**95% CI**	**OR**	**95% CI**
Age (ref. 20 – 30 years)	**30 - 36 years**	0.68	(0.51-0.92)*	0.69	(0.51 - 0.95)$^{+}$
	≥36 years	0.86	(0.58-1.28)	0.79	(0.51 - 1.22)
Gravidity (ref. Multigrav.)	**Primigravida**	0.54	(0.41 - 0.72)**	0.58	(0.43 - 0.78)**
Ethnicity (ref. Western)	**Non-Western**	1.77	(1.33 - 2.35)**	1.47	(1.09 - 1.98)*
Preference (ref. Other)	**SEO**	0.19	(0.11 - 0.31)**	0.15	(0.09 - 0.26)**
	Both	0.14	(0.08 - 0.25)	0.13	(0.07 - 0.23)
Practice		0.00	(0.00 - 0.00)**	0.00	(0.00 - 0.00)**

*Level of significance: $^{+}$ p<0.10, * p<0.05, ** p<0.01.*

Table 3b. Logistic regression models of individual level determinants and uptake of prenatal screening (no / yes, reference category) for high socioeconomic status women. *(Odds ratios, 95% confidence intervals in parentheses)*

	N = 2354	Model 1 (crude)		Model 2 (Forced entry)	
Determinants		**OR**	**95% CI**	**OR**	**95% CI**
Age *(ref. 20 – 30 years)*	**30 - 36 years**	0.80	(0.59 - 1.10)	1.02	(0.71 - 1.46)
	≥36 years	1.02	(0.69 - 1.50)	1.35	(0.84 - 2.16)
Gravidity *(ref. Multigrav.)*	**Primigravida**	1.04	(0.81 - 1.35)	1.14	(0.85 - 1.53)
Ethnicity *(ref. Western)*	**Non-Western**	1.34	(0.86 - 2.09)	1.40	(0.86 - 2.28)
Preference *(ref. Other)*	**SEO**	0.03	(0.01 - 0.05)**	0.03	(0.01 - 0.05)**
	Both	0.01	(0.01 - 0.02)	0.01	(0.01 - 0.03)
Practice		0.10	(0.02 - 0.64)*	0.40	(0.06 - 2.93)

*Level of significance: $^{+}$ p<0.10, * p<0.05, ** p<0.01.*

only one type of screening test than Western women. The opposite effect was seen for primigravida, who had lower odds of participating in one type of screening test. These effects remained significant in the multivariable model. Counselling practice again was a significant provider related factor in both models.

The same analyses for the high SES stratum is presented in table 4b. Non-Western ethnicity and advanced maternal age were associated with higher odds of receiving only one type of screening in the univariate model. However this effect did not remain significant after correction for the other determinants. This means that non-Western ethnicity was not an additional factor for the uptake of PS in high SES women.

Table 4a. Logistic regression models of individual level determinants and uptake of one or two forms of prenatal screening (CT or FAS / CT and FAS, reference category) in low socioeconomic status women who preferred both types of screening. *(Odds ratios, 95% confidence intervals in parentheses)*

	N = 553	Model 1 (crude)		Model 2 (Forced entry)	
Determinants		**OR**	**95% CI**	**OR**	**95% CI**
Age *(ref. 20 – 30 years)*	**<20 years**	1.12	(0.24 - 5.28)$^{+}$	8.88	(1.09 - 72.32)
	30 - 36 years	0.25	(0.05 - 1.27)	0.49	(0.31 - 0.79)**
	≥36 years	0.62	(0.13 - 3.07)	0.73	(0.43 - 1.23)
Gravidity *(ref. Multigrav.)*	**Primigravida**	0.31	(0.16 - 0.60)**	0.78	(0.52 - 1.16)
Ethnicity *(ref. Western)*	**Non-Western**	2.24	(1.23 - 4.08)**	2.37	(1.59 - 3.52)**
Practice		0.00	(0.00 - 0.00)**	0.00	(0.00 - 0.00)**

*Level of significance: $^{+}$ p<0.10, * p<0.05, ** p<0.01.*

Table 4b. Logistic regression models of individual level determinants and uptake of one or two forms of prenatal screening (CT or FAS / CT and FAS, reference category) in high socioeconomic status women who preferred both types of screening. *(Odds ratios, 95% confidence intervals in parentheses)*

	N = 1174	Model 1 (crude)		Model 2 (Forced entry)	
Determinants		**OR**	**95% CI**	**OR**	**95% CI**
Age *(ref. 20 – 30 years)*	**30 - 36 years**	2.16	(1.28 - 3.67)*	0.69	(0.46 - 1.04)
	≥36 years	2.19	(1.10 - 4.34)	0.65	(0.41 - 1.04)
Gravidity *(ref. Multigrav.)*	**Primigravida**	0.84	(0.52 - 1.36)	0.79	(0.61 - 1.02)$^{+}$
Ethnicity *(ref. Western)*	**Non-Western**	3.02	(1.42 - 6.42)**	1.41	(0.80 - 2.50)
Practice		0.14	(0.00 - 4.70)	0.00	(0.00 - 0.00)**

*Level of significance: $^{+}$ p<0.10, * p<0.05, ** p<0.01.*

DISCUSSION

Our study demonstrated that inequalities in the actual uptake of PS are present in pregnant women living in the four largest cities of the Netherlands. These inequalities persisted after correction for screening preference. Ethnicity and SES showed an interacting effect: women with a non-Western ethnic background from low SES areas were the least likely to take PS. Stratifying for SES showed different patterns for the remaining risk factors, essentially suggesting that participation in the tests in women with low SES was due to material and personal constraints, and was more personal in the high SES group.

Our findings concerning a barrier effect of lower SES and a lower preference for and uptake of PS in women with a non-Western ethnic background (corrected for SES) are both in line with previous studies. Dormandy *et al.* investigated attitudes on and uptake of PS in the UK and also concluded that participation was less in low SES women. [8] Alderdice *et al.* reported that individual level SES did not significantly predict uptake of

screening, but area level deprivation did. [7] In our study we used area level deprivation to define SES as well.

By contrast, in another study from the UK in pregnancies affected by Down's syndrome, there was no significant difference between the SES quintiles in uptake of PS. [10] However, this group of women carrying a foetus with proven Down's syndrome is possibly not comparable to the general pregnant population. Rowe *et al.* did not find a difference according to SES either. [17] This study also investigated ethnicity and found that in the UK Asian women were less likely to prefer PS. A Dutch study focussing on the CT found a lower uptake in Non-Western women after adjustment for SES. [6] This study was carried out in part of the same geographical area as our study. Dormandy *et al.* investigated attitudes and uptake of PS in the UK and also found that participation was lower in non-Western women. [8]

Lastly, a recent Dutch study by Gitsels *et al.* also found contrasting results, with non-Western women being more likely to prefer screening. [18] This study included participants by means of purposive sampling, therefore the study population may not reflect the general population. Moreover, in this study no results were reported on preference.

Preference was an important determinant for participation in PS in our study. Compared to Western women, a smaller proportion of non-Western women preferred to receive PS. This has previously been attributed to lower levels of education, lower levels of knowledge and religious background. [11] We do not have information on these determinants in our study population, but it is plausible that these factors also play a significant role in our study population. Concerning preference, we also saw that low SES women preferred FAS only (without CT), more often than high SES women. One of the possible explanations for this difference is the costs of the CT for younger women. High SES women may experience less of a financial threshold to participate, thus leading to an inequality in access. However this inequality is unlikely to have major implications: Until 2015 the CT was reimbursed in pregnant women of advanced maternal age (>= 36 years of age) as an alternative for invasive prenatal testing.

Our study showed that preference is not the only explanation for differences in the uptake of PS. After correction for preference, the unequal outcome for non-Western women remained. In these women a stronger deviation was present than in Western women between stated preference for PS after counselling and the actual uptake of PS at the time of testing. There are a number of possible explanations. First, women might reconsider their initial choice after discussing it with her partner, family or peers. Because family ties in many non-Western cultures are often stronger, opinions of significant others mays be valued more. Secondly, in non-Western women language-barriers are more prevalent. Women may not always understand the counselling, make a non-informed choice and then opt out at the time of testing. [5] Another underlying mechanism may be that these women have difficulties navigating the health care system. The actual PS

test is performed on a separate appointment, mostly at another location than where they were counselled. This may form an extra barrier for some women, which they will not always discuss with their care provider.

Our data suggest that health care professionals also play a role in the inequalities. By failing to reduce potential logistic barriers experienced by women, they may unintentionally make access to care more difficult for certain groups of women. Additionally, because of an experienced lack of time to explain what PS entails and what the results mean, or by overestimating the understanding women have of PS, care providers may contribute to the deviation between preference and realization. By knowing that these women are at higher risk of receiving less care, and that this is not solely based on their preference, care providers may place more emphasis on guiding women through the counselling process. However, improving support should not merely depend on the goodwill of health caregivers directly involved. Structured support by means of culturally competent leaflets are available, but not widely used. Innovative methods such as audio-visual tools are currently being explored and show promising results.

In all models except the high SES yes/no screening model, practice was a significant determinant for PS, albeit with a very small effect size. In high SES women no effect was found. This was either because caregiver support was perfectly in accordance with their needs concerning PS or if this was not the case, these women still managed. For the other groups of women this was less so, even though the influence was minimal.

Our study has a number of strengths that merit discussion. Firstly, the Peridos registry is filled out at the time of counselling and at the time of screening. Therefore there is little risk of recall bias and there is no need to depend on self-report by the participating women. Secondly, by using a stratified approach to SES in our analysis, we were able to tease apart the interaction between SES and ethnicity.

Our study should also be viewed in the light of its limitations. The large number of missing values may reduce the generalizability of our findings to the rest of the population. The proportion of women with non-Western ethnicity and a low SES status are however comparable to the numbers in other national databases, suggesting the population may be comparable. [19] The large number of missings in Peridos is partly caused by the newness of the system, and registration is expected to improve in the coming years. Additionally, only women who gave consent for counselling on PS and gave permission to use their data are included in the database. Therefore we have no information on the number and characteristics of the women who did not wish to receive information on PS or of those who denied the use of their data (following informal communication the latter is a small fraction).

Because postal codes were missing in the majority of the records, we assigned the postal code of the practice or hospital to the pregnant woman. It is reasonable to assume that women seek obstetric care in their direct vicinity. Especially for low SES women, the

travelling distance to a practice of choice would entail an additional financial burden. If high SES women did choose to travel a greater distance to a 'low SES' practice, this would mean that the effect we found in the study is a dilution of the true effect. Concerning information on prior pregnancies, the registry only contained information on gravidity, not parity. Ideally both would be available, because it gives insight in the occurrence of fetal demise. This may in turn influence choices in PS. The information on gravidity is however a good starting point.

Because the ethnic categories were not mutually exclusive, we had to reduce ethnicity to a dichotomous variable (crude dichotomization). This may have led to grouping together women from distinctively different ethnic and cultural backgrounds. Different backgrounds may in turn have led to differences in uptake of PS, as was demonstrated by Fransen *et al*. [6] Our inability to distinguish between these subgroups, does not detract from the fact that overall substantial differences in uptake between Western and non-Western women are present, justifying dichotomization if - like here - focus is on the potential role of provider factors.

CONCLUSIONS FOR PRACTICE

In all, our study rejects the assumption that the WHO universal health care coverage principle is applicable to PS in the Netherlands. There is unequal participation in PS between non-Western and Western women and women from low and high SES areas, at least in the four largest cities of the Netherlands that cover about 15% of all pregnancies. The pattern of observed effects suggest cumulative disadvantage for women combining vulnerability characteristics. Most disturbing is that these inequalities exist after full account of the womans' preference. In a health system that claims equal access, these outcomes urge for further follow-up and improvement, in particular as these inequalities are part of the perinatal outcome gap in the four large cities. All stakeholders should take responsibility here, caregivers, screening organizations and health insurance parties.

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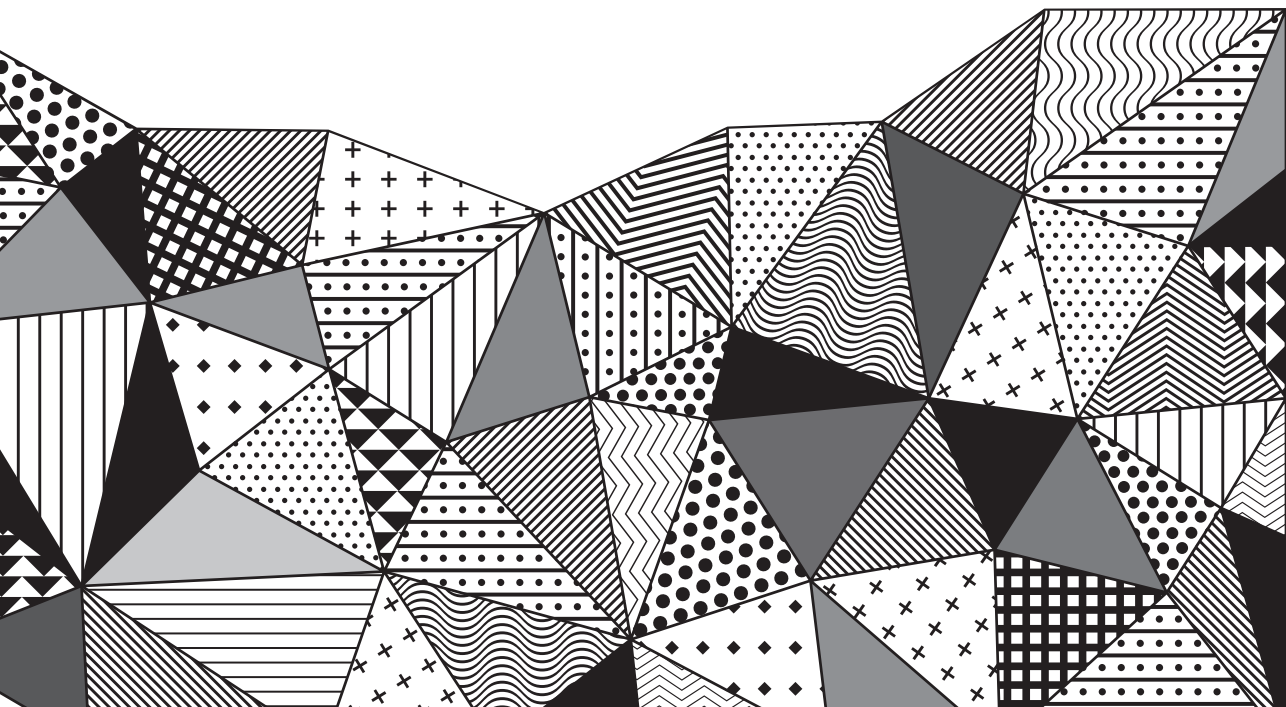

7

Chapter 7

Influence of maternal, child, process and organizational characteristics on intrapartum and neonatal mortality

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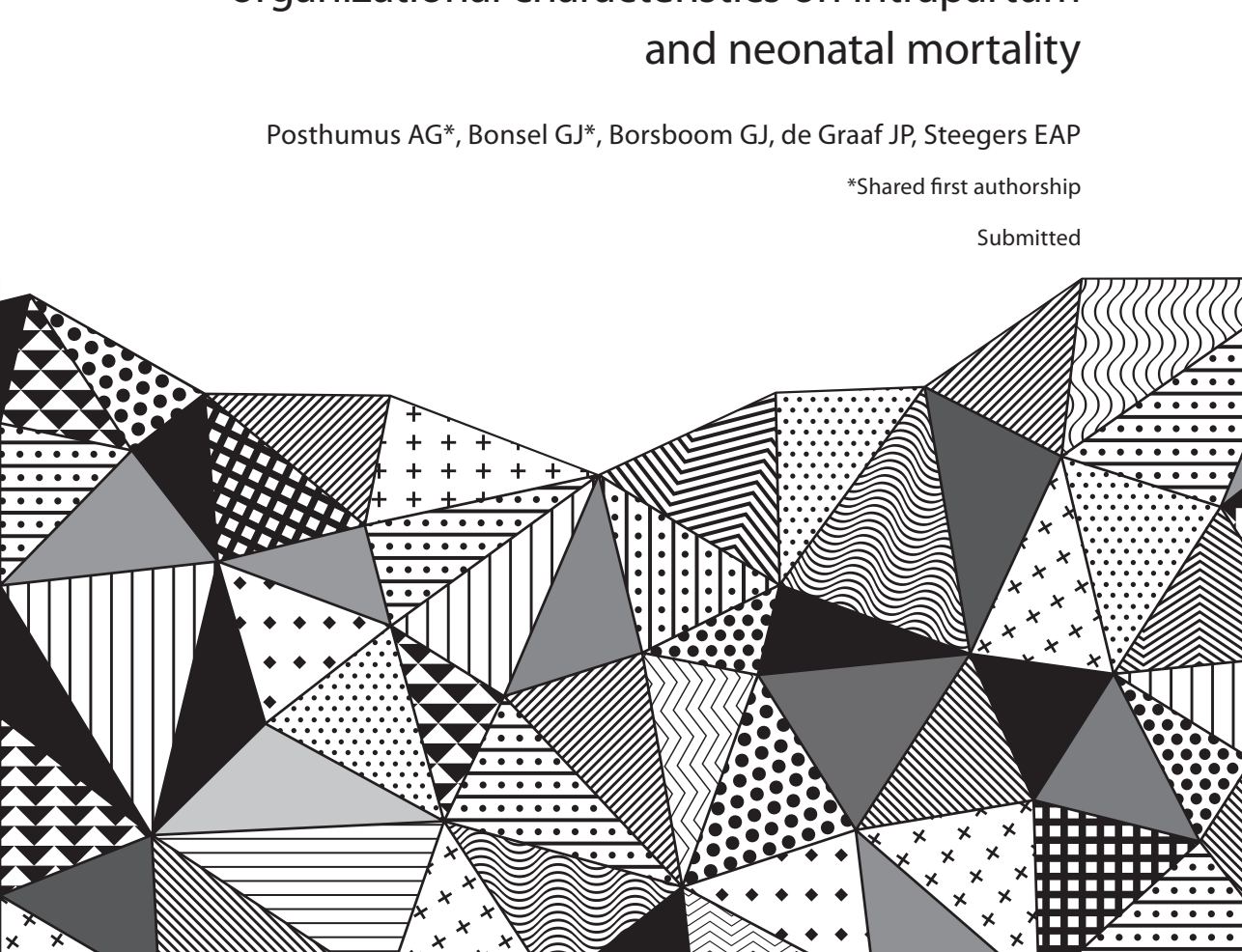
Submitted



ABSTRACT

Organisational characteristics of hospitals influence perinatal morbidity and mortality. This is also the case in the Netherlands, where perinatal outcomes have come under closer scrutiny because these lag behind in comparison to the surrounding countries. In already vulnerable pregnancies, the impact of hospital organizational characteristics may be even larger, leading to higher odds of mortality. To investigate this impact, a logistic multi-level model was fitted on retrospective data from the Dutch Perinatal Registry (years 2000-2008, coverage 97%). The first level comprised individual maternal, child and process characteristics, the second level comprised hospital organizational characteristics: the scale size of the hospital, 24*7 equality of staff level, travelling time of obstetricians to the hospital when on call, and elective caesarean section rates in breech pregnancies (as an assumed proxy for pro-activeness of intervention strategies). Interaction terms for these organizational characteristics with the presence of 'major Big'-disease were included. Major Big diseases encompass being small for gestational age (< 2.3rd percentile), very preterm birth (<34 weeks of gestation) and/or a major congenital anomaly (those with a mortality and/or NICU-admission rate ≥ 20%). All of these are associated with an increased risk of perinatal mortality. Outcomes of interest were intrapartum mortality and neonatal mortality. The effects of all hospital organizational characteristics on perinatal mortality were significant, but the interaction terms (hospital organizational characteristics*major Big3-disease) were significant for *non*-Big3 children only. Our results suggest that an improvement in hospital organizational characteristics is desirable to reduce perinatal mortality in non-extreme risk cases. In major Big3 children, lowering mortality requires other measures, preferably prevention.

INTRODUCTION

Perinatal outcomes in the Netherlands have come under close scrutiny because comparative research in 2004 and 2008 demonstrated that the perinatal mortality rate was relatively high in comparison to other European countries. [1] To a lesser degree this also applied to perinatal morbidity.

Within perinatal morbidity we distinguish 3 groups of overlapping key conditions: Big4 disease, Big3 disease and *major* Big3 disease. The so-called Big4 diseases are key conditions in the context of perinatal outcomes as 85% of perinatal mortality cases are preceded by one or more of these diseases. [2, 3] Big4 refers to preterm birth (before 37 weeks of gestation), small for gestational age (SGA, birth weight below the 10th percentile for gestational age), any congenital anomalies (single or combined) and a low Apgar score (a score of less than 7 at five minutes after birth). When the latter is excluded (i.e. when analysing intrapartum mortality), these are referred to as the Big3 diseases. An extremely vulnerable subgroup of the Big3 disease group is the major Big3 disease group, consisting of children born small for gestational age (< 2.3rd percentile), born very preterm (<34 weeks of gestation), or with major congenital anomalies.

The incidence of Big4 diseases is substantial: they occur (single or combined) in 16.3% of pregnancies. [2] Even though perinatal mortality is frequently preceded by Big3 or Big4 diseases, the risk of mortality varies greatly depending on the type and combination of these diseases (0.02% in SGA children with no other risk, 95.5% in children with all four Big4 diseases, where in particular SGA multiplies the mortality risks of any of the other 3 conditions). [2, 3]

Prior research has demonstrated that a large number of factors influence perinatal morbidity and mortality. These include maternal factors (e.g. ethnic background, socioeconomic status, age, parity, and a list of specific risk factors like smoking and specific diseases), neonatal factors (gender), and the organization and process of health care delivery. [4-8] In the Netherlands, de Graaf *et al.* demonstrated the relevance of the type of hospital (teaching / non-teaching hospital) and the importance of seniority of staff during in- and out-of-office-hours for perinatal outcomes, the latter adding to the general risk-increasing effect of out of office hours. [9] This study suggests that factors do not simply add but show a complex interplay of risk factors on the client side and vulnerability factors on the care provision side. Following on from these findings, a recent study by Poeran *et al.* demonstrated that specifically measured hospital organizational and care delivery factors accounted for one-third of perinatal mortality. [10] While Poeran elaborated the findings of de Graaf into more detailed and modifiable factors, an acknowledged weakness of both studies was the ignorance of the interaction of maternal, neonatal and organizational factors. Such knowledge is needed to improve guidelines or referral schemes. More generally, interaction information is required to

target change, and to convince stakeholders to take the associated efforts, which as a rule are non-trivial.

The present study started from the hypothesis that in children with a Big3- or Big4 disease, hospital organizational factors influence the risk of mortality, aggravating the adverse outcome. Therefore we explored the influence of hospital organizational characteristics on the occurrence of intrapartum and neonatal mortality in specifically *major* Big3 and non-*major* Big3 children, whilst taking maternal determinants (including SES and ethnic background), child determinants, and care process determinants into account. Because this study focusses on hospital organizational characteristics, midwifery home births were beyond the scope of this study.

METHODS

General

To establish the association of hospital organizational characteristics with mortality in Big3 and non-Big3 children, taking other maternal, child, and process determinants into account, we carried out a multi-level observational study on all singleton pregnancies in the Dutch Perinatal Registry (years 2000-2008). This national dataset covers over 97% of all pregnancies in the Netherlands. The use of the anonymized patient data for this study was approved by the Dutch Perinatal Registry (project number 10.102) (additional information on the registry: www.perinatreg.nl/home_english). Written consent from pregnant women was not needed as the registry protects their anonymity. The primary study data could not be blinded for hospital or midwifery practice identity, but study approval included a non-disclosure requirement in data reports with regard to individual care providers.

The pregnancy records were linked through the hospital ID to extensive available information on organizational characteristics of the hospitals in the Netherlands of the same period. This information was in part public, in part derived from the registry data (e.g. hospital size in terms of annual number of deliveries, and in part derived from a questionnaire sent to all 99 participating Dutch hospitals. Data were collected to add detail to the principal finding of de Graaf *et al.* that size, seniority of staff, and being a teaching hospital matters. [9] Rather than using this structure-of-care approach we looked into processes which are the potential consequences of structural differences, as the latter are more tangible and suitable for modification if they appear relevant. As first reported by Poeran *et al.*, these questions covered a broad scope of organizational topics, including the number of staff (obstetricians, clinical midwives, and residents), shift hours, 24*7 presence of specialists (obstetrician, paediatricians, anaesthesiologists) and type of hospital (teaching hospital, yes / no). The data were collected by means of a

standardized interview by a senior professional (JdG) with the support of the Dutch Society of Obstetricians and Gynaecologists. For the complete questionnaire see appendix 1.

In the current multilevel analyses, we distinguished two levels of aggregation. The first level consisted of the individual maternal, child and delivery process characteristics. The second level comprised the hospital with its characteristics. The primary outcomes of interest were intrapartum and early neonatal mortality (within 7 days after birth). Foetal mortality was beyond the scope of this study because hospital organization determinants are less likely to impact this outcome, and midwifery practice features should then be added. The Big3 outcomes were regarded as intermediate factors in the analyses. The determinants and outcomes in our analyses are described in more detail below.

Determinants

First level: Individual level maternal, child and delivery process characteristics

Maternal characteristics included were age category (<25, 25-39, > 39 years), parity (nulliparous, multiparous), 6 combined categories for ethnicity (Western / non-Western, preeclampsia (yes / no), and socio-economic status (< 20th percentile=poor, 20-80th percentile, >80th percentile). The socioeconomic status was derived from socioeconomic status (SES)-scores calculated by the Netherlands Institute of Social Research. [11] A numeric SES-score is available for all 4-digit postal code areas with more than 100 inhabitants and is based on the mean income per household, percentage of households with a low income, percentage of unemployed inhabitants and percentage of households with an on average low education. [12] For the purpose of this study we categorized the continuous SES-scale into three categories.

For the child characteristics we calculated a dichotomous composite score for the presence of any major form of Big3 to be distinguished from any other occurrence of a Big4 condition. A *major* Big3 condition was defined as the presence of any of the following: small for gestational age (< 2.3rd percentile), and / or very preterm birth (<34 weeks of gestation), and / or a major congenital anomaly (those with a mortality and/or NICU-admission rate of ≥ 20%, based on the Dutch perinatal registry). We did so because for the children at the highest risk of mortality it is most relevant to establish whether hospital organizational characteristics matter, as we expected. The inclusion of 'minor' Big3 categories such as small for gestational age (2.3-10th percentile) and preterm birth (34-37 weeks of gestation) could dilute this hypothesized effect. The Apgar score was included as a separate dichotomous variable and included only if neonatal mortality was the outcome. We used an Apgar score of 7 at 5 minutes after birth as threshold.

To characterize the delivery process, we included the time of birth (a weekday or in the weekend; during the day, the evening, or at night), the travelling distance between the mothers' 4-digit postal code and the hospital 4-digit postal code, and her referral

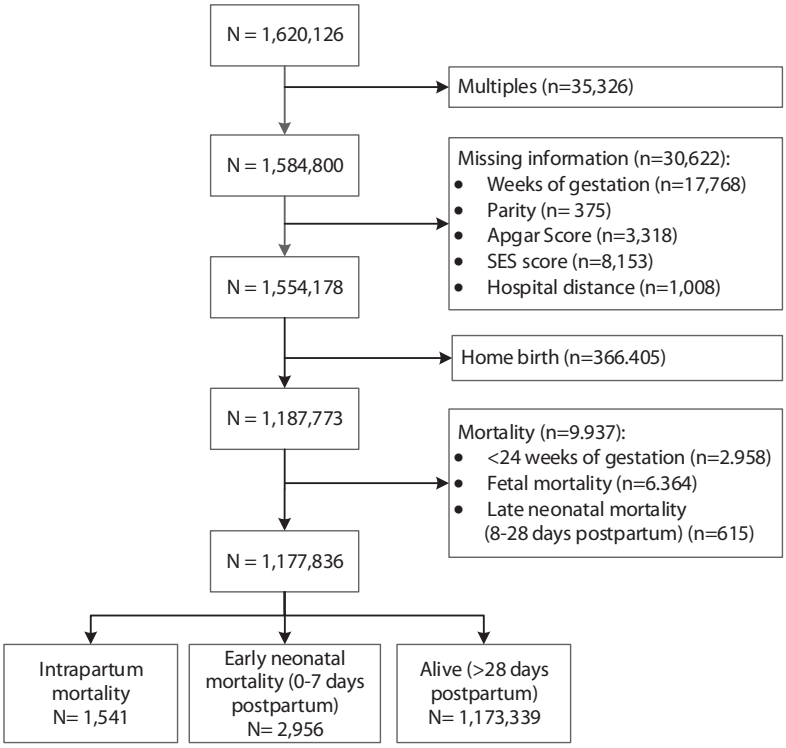


Figure 1. Cases excluded from the study.

state. The Dutch system supports home and hospital facility deliveries by independent midwives apart from obstetricians, hence transport matters. [13] In our analyses we included 3 referral categories: 1. labour under supervision of a community midwife in a hospital setting (no referral); 2. start of labour under supervision of an obstetrician; 3. start of labour under supervision of a community midwife (either at home or in a hospital setting) with referral to an obstetrician in hospital.

We excluded multiple pregnancies (n=35,326; 2.2%), and cases with missing information on maternal characteristics (n=8,528; 0.5%), child characteristics (n=21,086; 1.3%) or on delivery process characteristics (n=1,008; 0.1%). Because the purpose of this study was to examine organizational characteristics of hospitals, home births (n=366,405; 22.6%) were also excluded. See figure 1 for an overview of exclusions.

Second level: Hospital characteristics

Thirty different characteristics were covered by the hospital questionnaire. (Appendix 1) To reduce these to a smaller number of more meaningful overarching concepts, we applied Principal Components Analysis (PCA). Because our data included both nominal

and ordinal variables, we used the PRINCALS technique in SAS version 9.3 (SAS Institute Inc. Cary, USA), that extends the application of PCA to variables on an ordinal or nominal measurement level. [14] The selection of components was based on the scree-plot, Eigenvalues, and the interpretability of the components. After inspection of this information, 3 components were retained. Together, these explained 75.5% of the variance (Figure 2). The first component (variance explained 54.9%) concerned the 'scale size of the hospital' (number of obstetric staff and number of deliveries). The second component (variance explained 12.5%) covered the '24*7 equality of staff level' (the presence of medical specialists -including paediatricians and anaesthesiologists- and the degree of the training of the doctor on call, resident or specialist). The last component (variance explained 8.2%) entailed the travelling time of obstetricians to the hospital when on call (and not continuously present in hospital). Note that none of the questionnaire items contained outcome information: all three factors were descriptive only. To each hospital, we allocated a score for each of the 3 principal components based on questionnaire response.

Additionally we calculated the elective caesarean section rates in breech term and breech preterm pregnancies for each hospital as an assumed proxy for the degree of pro-activeness in intervention policy. [10] The underlying data and the principal components were, with permission, derived from the study of Poeran *et al.* They included the first two principal components for their study purposes, and we chose to include the third (travelling time of obstetrician) too, as this matters in this context of potential high risk case treatment delays.

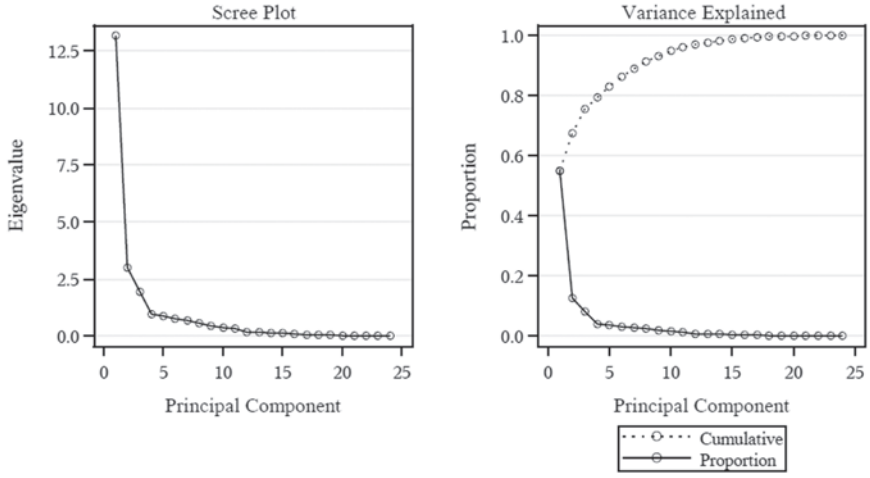


Figure 2. Variance explained of the three principal components in the model.
Component 1: variance explained 54.9% (scale size of the hospital); Component 2: variance explained 12.5% (24*7 equality of staff level); Component 3: variance explained 8.2% (travelling time to hospital of obstetrician-on-call)

Outcome variables

Our outcomes of interest were intrapartum foetal death and early neonatal death (within 7 days after birth). Intrapartum foetal mortality was defined as the foetus still being alive at the beginning of labour. All outcome variables were dichotomous (mortality / no mortality).

Only in the unexpected case of correspondence of result patterns of both the intrapartum and the foetal mortality analyses, we intended to add a third model combing the two outcomes.

Analytical Strategy

Primary data analysis rested on logistic multilevel models with a random intercept for each hospital, using the GLIMMIX procedure in SAS version 9.3 (SAS Institute Inc. Cary, USA) for women (first level) nested within hospitals (second level). The β-coefficients are reported as odds ratios. If the determinant is dichotomous interpretation is straightforward, if the determinant is numerical, the beta reflects mortality increase per unit change of the determinant.

Interaction terms were included for the four organization level determinants (component 1, 2, 3 and the caesarean section rate) with the major Big3 diseases (yes/no) to investigate the potential difference in impact of these hospital organizational characteristics on major Big3 children and non-major Big3 children.

We rejected any model where coefficients of accepted well-known determinants showed unlikely effects (e.g. a healthy effect of age<20 years) to avoid spurious results. We also present only those model results if these were robust, that is, if size and direction of coefficients remained the same under variants of the model. When describing results we assume that literature evidence is sufficient to expect the following organisational characteristics to be beneficial (all other things equal): no referral, less travelling distance, greater seniority of staff, and 24*7 equality of staff level. Thus we aimed at avoiding over-interpretation of results.

RESULTS

Table 1 shows the demographic characteristics and principal outcomes of the study population. Between 2000 and 2008 the prevalence of major Big3 disease was 35.5‰. The prevalence of Big4 disease was 19.6%. Additionally, 1.4% of the live-born children had a low Apgar score (1-6) at five minutes after birth. In 15.4‰ of the cases with a major Big3 disease intrapartum death occurred. Forty point five per mille of major Big3 resulted in neonatal mortality. Taken together this implies about a 6-fold risk increase compared to the average mortality risk.

Table 1. Descriptive statistics of individual variables and perinatal outcomes.

	Total population N (%)[1]	Intrapartum mortality N (‰)[2]	Neonatal mortality N (‰)[2]
Total	1,177,836 (100)	1,541 (1.3)	2,956 (2.5)
Maternal			
Age			
<25 years	152,286 (12.9)	209 (1.4)	421 (2.8)
25-39 years	992,608 (84.3)	1277 (1.3)	2,432 (2.5)
>39 years	32,942 (2.8)	55 (1.7)	103 (3.1)
Parity			
Nulliparous	598,900 (50.8)	818 (1.4)	1,431 (2.4)
Multiparous	578,936 (49.2)	723 (1.2)	1,525 (2.6)
Ethnicity*SES			
Western, SES <p20	195,726 (16.6)	243 (1.2)	457 (2.3)
Western, SES p20-80	584,734 (49.6)	763 (1.3)	1,455 (2.5)
Western, SES >p80	178,707 (15.2)	207 (1.2)	425 (2.4)
Non-Western, SES <p20	125,982 (10.7)	181 (1.4)	391 (3.1)
Non-Western, SES p20-80	73,452 (6.2)	116 (1.6)	183 (2.5)
Non-Western, SES >p80	19,235 (1.6)	31 (1.6)	45 (2.3)
Preeclampsia			
Preeclampsia	20,365 (1.7)	41 (2.0)	86 (4.2)
No preeclampsia	1,157,471 (98.3)	1,500 (1.3)	2,870 (2.5)
Child			
Weeks of gestation			
24-27+6 weeks	2,856 (0.2)	251 (87.9)	803 (281.2)
28-31+6 weeks	8,210 (0.7)	187 (22.8)	359 (43.7)
32-36+6 weeks	75,284 (6.4)	264 (3.5)	609 (8.1)
37-41weeks	1,014,077 (86.1)	780 (0.8)	1091 (1.1)
>41 weeks	77,409 (6.6)	59 (0.8)	94 (1.2)
Congenital anomalies			
Minor	29,159 (2.5)	173 (5.9)	692 (23.7)
Major	2,489 (0.2)	131 (52.6)	488 (196.1)
Apgar score			
Low Apgar score (1-6)	16,082 (1.4)	-	2,099 (130.5)
High Apgar score (>6)	1,160.213 (98.5)	-	857 (0.7)
Small for Gestational age (<p2.3)	28,928 (2.5)	196 (6.8)	274 (9.5)
Birth weight for gestational age ≥2.3	1,148,908 (97.5)	1,345 (1.2)	2,682 (2.3)
Any major Big3	41,823 (3.6)	646 (15.4)	1,694 (40.5)
Any Big4	231,291 (19.6)	-	2,768 (12.0)

Table 1. Descriptive statistics of individual variables and perinatal outcomes. (continued)

	Total population N (%)[1]	Intrapartum mortality N (‰)[2]	Neonatal mortality N (‰)[2]
Care process			
Referral chain			
Referral during labour	326,451 (27.7)	437 (1.3)	506 (1.6)
Start second tier	678.283 (57.6)	1,028 (1.5)	2,328 (3.4)
Birth in hospital under supervision of a midwife	173,096 (14.7)	70 (0.4)	122 (0.7)
Time of birth			
Outside office hours	699,439 (59.4)	1,058 (1.5)	1,910 (2.7)
During office hours	478,397 (40.6)	483 (1.0)	1,046 (2.2)

[1]*Percentage of total number of births.*

[2]*Permillage of deaths within the subcategory, i.e. in the subcategory of age <25 years 1.4‰ of children died intrapartum. For the calculation of the permillages we arbitrarily used the same denominator (i.e. the total population). However in the neonatal mortality group the intrapartum mortality cases have been excluded.*

Of the women in the study, 27.7% had been referred from the midwife to the obstetrician during labour, i.e. they changed from a midwife-led delivery in the hospital to a gynaecologist-led delivery. The neonatal mortality rate was 0.7‰ if labour started under midwife supervision and 3.4‰ if it started under obstetrician supervision. Note that intra-uterine deaths prior to arrival in the hospital were excluded. Fifty-nine percent of the total study sample gave birth outside office hours. Both intrapartum and neonatal mortality rates were higher in this group than in births during office hours.

Table 2 shows the results from the univariate logistic regression analyses for the association with intrapartum and neonatal death. The presence of a major Big3 disease and a low Apgar score showed the largest effects (neonatal mortality: OR 20.73 and OR 203.07 respectively). Nulliparity showed an unexpected lower than average risk for neonatal mortality. Preeclampsia was associated with increased odds in both mortality categories. All subcategories of non-Western ethnicity were associated with increased odds of one or more forms of mortality when Western high SES women were the reference category. Concerning the care process, referral during labour from midwife to gynaecologist supervision was associated with higher odds in both categories of mortality (total mortality: OR 2.61).

The hospital organizational characteristics were all associated with the risk of mortality. A higher elective caesarean section rate in term breech pregnancies, as an assumed proxy for pro-active intervention strategies was significantly associated with lower levels of perinatal mortality in all deliveries. For an increase in the 'scale size of the hospital' (number of obstetric staff and number of deliveries) we found an inverse association, with lower odds of mortality with an increase in hospital size (apart from the other

Table 2. Univariate logistic regression analyses of maternal, child, process and hospital organizational characteristics on intrapartum, neonatal and total mortality.

	Model 1 Intrapartum mortality OR (95% CI)	Model 2 Neonatal mortality OR (95% CI)
Maternal		
Age (ref. 25 - 39 years)		
<25 years	1.07 (0.92 – 1.24)	1.13 (1.02 – 1.25)*
>39 years	1.30 (0.99 – 1.70)+	1.26 (1.05 – 1.56)*
Parity (nulliparous) (ref. multiparous)	1.09 (0.99 – 1.21)+	0.91 (0.84 – 0.98)***
Ethnicity*SES (ref. Western, SES >p80)		
Western SES <p20	1.07 (0.89 – 1.29)	1.05 (0.88 – 1.25)
Western SES p20-80	1.13 (0.97 – 1.31)	0.98 (0.72 – 1.34)
Non-Western SES <p20	1.24 (1.02 – 1.52)*	0.98 (0.86 – 1.12)
Non-Western SES p20-80	1.36 (1.09 – 1.71)**	1.05 (0.94 – 1.17)
Non-Western SES >p80	1.39 (0.95 – 2.03)+	1.31 (1.14 – 1.50)***
Preeclampsia (ref. no preeclampsia)	1.56 (1.14 – 2.13)**	1.71 (1.38 – 2.12)***
Child		
Any Big3 worse (ref. no Big3 worse)	20.73 (18.72 – 22.95)***	38.55 (35.81 – 41.49)***
Low Apgar 5 min (1-6) (ref. Apgar score 7-10)	-	203.07 (187.24 – 220.25)***
Care process		
Referral (ref. Birth in hospital under supervision of a midwife w/o referral)		
Referral during labour to obstetrician (from home / hospital with midwife supervision)	3.32 (2.58 – 4.27)***	2.20 (1.81 – 2.69)***
No referral, start obstetrician supervision	3.78 (2.97 – 4.82)***	4.89 (4.08 – 5.87)***
Time of delivery (ref. office hours)		
Outside office hours	1.50 (1.35 – 1.67)***	1.25 (1.16 – 1.35)***
Travelling distance	1.00 (1.00-1.00)	1.00 (1.00-1.00)**
Organization		
Caesarean Section policy[1]	0.86 (0.78 – 0.95)**	0.79 (0.73 – 0.85)***
PCA1	0.74 (0.67 – 0.83)***	0.44 (0.41 – 0.48)***
PCA2	0.87 (0.79 – 0.96)**	0.46 (0.43 – 0.50)***
PCA3	1.17 (1.06 – 1.30)**	1.97 (1.83 – 2.13)***

[1] *Elective caesarean section policy in breech pregnancies as an assumed proxy for intervention policy.*

*+ = <p<0.10, * = p <0.05, ** = p <0.01, *** = p <0.001.*

organisational factors). An increase in the 24*7 equality of staff level was also associated with lower odds of mortality. A comparable association was found for organization factor 3, which means that less travelling time of obstetricians to the hospital when on call, is associated with lower odds of neonatal mortality. Note that the underlying PCA technique separated these 3 organisational features into statistically independent constructed variables.

Table 3 shows the results from the multivariate logistic regression analyses for the association with intrapartum and neonatal mortality. After correction for all other determinants, major Big3 disease, a low Apgar score at 5 minutes after birth, and delivering outside of office hours consistently increased neonatal mortality. Preeclampsia had an unexpected protective statistical effect in all models. None of the organisational characteristics, showed a significant effect for intrapartum mortality, after correction for the other factors. In the neonatal mortality analysis, however, organisational factors generally continued to be of importance. A higher elective caesarean section rate in term breech pregnancies was associated with lower odds of mortality for all deliveries. An increase in the 24*7 equality of staff level and a lower travelling time of obstetricians to the hospital when on call were also all associated with lower odds ratios for neonatal mortality.

The interaction terms (hospital organizational characteristics connected to the presence of major Big3 disease) showed different patterns, depending on either outcome measure. Even though none were significant for intrapartum mortality, the trends in the odds ratios for factor one, two and three contrasted the direction of effects in the analysis for neonatal mortality. In neonatal mortality, the interaction term implied that non-major Big3 children rather than major Big3 children showed comparatively better results if hospital organizational characteristics were better. The effects of these

Table 3. Multilevel logistic regression models of maternal, child, process and hospital organizational characteristics on intrapartum, neonatal and total mortality. (Forced entry regression models)

	Model 1 Intrapartum mortality OR (95% CI)	Model 2 Neonatal mortality (0-7 days postpartum) OR (95% CI)
Maternal		
Age (ref. 25-39 years)		
<25 years	0.96 (0.82 - 1.11)	1.06 (0.93 - 1.20)
>39 years	1.13 (0.86 - 1.49)	0.83 (0.66 - 1.04)
Parity Nulliparous (ref. Multiparous)	1.02 (0.91 - 1.13)	0.73 (0.67 - 0.80)*
Ethnicity*SES (ref. Western, SES >p80)		
Western SES <p20	0.89 (0.73 - 1.08)	0.74 (0.64 - 0.87)*

Table 3. Multilevel logistic regression models of maternal, child, process and hospital organizational characteristics on intrapartum, neonatal and total mortality. (Forced entry regression models) (continued)

		Model 1 Intrapartum mortality OR (95% CI)	Model 2 Neonatal mortality (0-7 days postpartum) OR (95% CI)
Western SES p20-80		1.03 (0.88 - 1.20)	0.87 (0.77 - 0.99)*
Non-Western SES <p20		1.07 (0.87 - 1.33)	0.84 (0.71 – 1.00)
Non-Western SES p20-80		1.20 (0.95 - 1.51)	0.72 (0.59 - 0.88)*
Non-Western SES >p80		1.32 (0.90 - 1.93)	0.72 (0.50 - 1.03)
Preeclampsia (ref. No preeclampsia)		0.74 (0.54 - 1.02)	0.50 (0.39 - 0.63)*
Child			
Any major Big3 (ref. no major Big3)		19.3 (17.30 - 21.62)***	11.67 (10.56 - 12.90)***
Low Apgar score (1-6) (ref. Apgar score 7 - 10)		-	102.30 (93.43 - 112.01)***
Care process			
Referral chain (ref. Birth in hospital under supervision of a midwife)			
Referral during labour		3.27 (2.51 - 4.27)*	1.68 (1.34 - 2.11)*
Start second tier		2.89 (2.23 - 3.73)*	2.10 (1.70 - 2.59)*
Time of delivery (ref. between office hours)			
Outside office hours		1.53 (1.37 - 1.70)	1.08 (0.99 - 1.17)
Travelling distance (ref. median)		1.00 (0.99 - 1.01)	1.01 (1.01 - 1.02)
Organization			
PCA1 (ref. < median)		0.92 (0.75 - 1.12)	0.88 (0.75 - 1.04)
PCA2 (ref. < median)		0.99 (0.81 - 1.20)	0.78 (0.66 - 0.91)*
PCA3 (ref. < median)		0.97 (0.81 - 1.17)	1.19 (1.02 - 1.38)*
CSP (ref. < median)		0.91 (0.76 - 1.09)	0.85 (0.73 - 0.98)*
Organization * Interaction (ref. < median)			
CSP	Big3 yes	1.00 (0.80 - 1.25)	0.90 (0.75 - 1.08)
	Big3 no	0.83 (0.68 - 1.01)	0.80 (0.68 - 0.94)*
PCA1	Big3 yes	0.80 (0.62 - 1.02)	0.96 (0.79 - 1.18)
	Big3 no	1.05 (0.84 - 1.31)	0.81 (0.67 - 0.96)*
PCA2	Big3 yes	0.93 (0.74 - 1.18)	0.84 (0.69 - 1.02)
	Big3 no	1.05 (0.85 - 1.30)	0.72 (0.60 - 0.86)***
PCA3	Big3 yes	1.09 (0.87 - 1.38)	1.15 (0.94 - 1.40)
	Big3 no	0.86 (0.70 - 1.05)	1.23 (1.04 - 1.45)*

*+ = <p<0.10, * = p <0.05, ** = p <0.01, *** = p <0.001.*

interaction terms were all in the same order of magnitude. Additionally we conducted an analysis including interaction terms for the Apgar score (low/high) and all four hospital organizational characteristics. This did not yield new insights.

DISCUSSION

Conclusion

In our multilevel analyses investigating the influence of hospital organizational characteristics on the occurrence of perinatal mortality, taking account for the complex interaction of maternal, child, and process determinants, we observed that hospital organizational characteristics consistently mattered primarily for neonatal mortality, but not for intrapartum mortality. More specifically, we observed that, unlike our prior expectation, children *without* major Big3 disease benefited (in terms of neonatal mortality) from more optimal hospital organizational characteristics. If true, organizational characteristics matter less in the cascade from Big3 disease to perinatal mortality, perhaps because the intrinsic risk level dominates. Our results suggest that better organisation is reflected in better results in moderately high risk children, which includes a much bigger interest group. It is intriguing that the more a hospital policy tends to apply an elective caesarean in case of breech presentation (within the national range), the better mortality outcomes are for all deliveries.

Primary findings

Hospital organizational characteristics were associated with neonatal but not intrapartum mortality. This may either be caused by independent patterns of underlying mechanisms, or by carry-over effects from intrapartum to neonatal mortality. We believe the latter to be the correct interpretation. Suboptimal hospital organizational characteristics may lead to a delay in diagnosing risk conditions or a delay in interventions in case of adverse events. In the intrapartum period this will only result in immediate foetal death in a minority of cases (i.e. total placental abruption). But in many other cases, delay will greatly diminish the foetal reserves in absence of direct intrapartum death. Due to its resilience, the neonate is then born alive, probably with a low Apgar score. The latter in turn is strongly associated with neonatal death. In a related way, registration may partially record intrapartum mortality as neonatal mortality if resuscitation has taken place of infants born with extremely poor Apgar score. We therefore hypothesize that neonatal death is an expression of less optimal organizational factors *during* labour, and not so much as an indicator of postpartum care. This also explains why *intrapartum* factors such as the rate of elective caesarean sections in term breech pregnancies and 24*7 equality of staff level are associated with *postpartum* adverse outcomes up to seven

days after birth (early neonatal mortality). Our findings build on those of De Graaf *et al.* and Poeran *et al.* who did not differentiate between intrapartum and neonatal mortality in terms of hospital organizational characteristics. [9, 10]

Moreover we demonstrated that hospital organizational characteristics mattered for the odds of neonatal mortality in children *without* major Big3 conditions only. This tells us something about the gravity of the condition of children *with* major Big3 disease. Their *a priori* odds of mortality cannot be improved significantly anymore by the hospital organizational characteristics we explored in this study. In other words: they are too sick to save by improving general organizational prerequisites only. If children are suspected to have major congenital anomalies, SGA below the 2.3rd percentile or threaten to be born before 34 weeks of gestation, very pro-active tailored intervention strategies are appropriate. In the Netherlands children with major congenital anomalies and threatening preterm births before 32 weeks of gestation are mostly transferred to tertiary care hospitals as guidelines prescribe. Organisational characteristics may thus be more optimal already. Also in non-tertiary centres, extra precautions may be taken (e.g. senior staff present) if for example a very small for gestational child is being delivered. In such high risk cases the organisation adapts itself. This could however not be taken into account in this study.

The scale size of the hospital (and number of births) demonstrated neither an association with intrapartum nor with neonatal mortality in the multivariate analyses. A number of international studies found similar results [15, 16], while others found that a lower scale size was associated with increased risks for vulnerable subgroups (such as very low birth weight infants). [17-19] The inclusion of tertiary care hospitals in our analyses may have diluted the impact of organisational features: the high mortality rates are in part explained above by providing care to the most severe cases not described sufficiently by our risk factors (confounding by indication).

The increase of 24*7 equality of staff level was associated with lower odds of mortality. However Woods *et al.* found no effects of shift patterns on the management of birth, as Apgar scores were not lower and neonates were not admitted more often to an intensive care department during the weekend than during weekdays. [20] Freites *et al.* described no association either, with Apgar scores and still births rates not being higher when consultants were on call from home. [21] That study, however, did not have the statistical power to investigate intrapartum and neonatal mortality, and no differentiation was made according to travelling time of the consultants. We found that less travelling time of obstetricians-on-call to the hospital was associated with lower odds of neonatal mortality. In case of an obstetric emergency it may be necessary to act fast. Some interventions, such as a caesarean section, can only be conducted by an obstetrician (as opposed to a resident). Therefore the proximity of the obstetrician-on-call matters to reduce the time-to-intervention.

To gain better insight in the relevance of pro-activeness in interventions, we investigated the elective caesarean section rates in breech term pregnancies. Breech term pregnancies represent a minority of the deliveries in any hospital, and absolute risk is small. It is therefore safe to conclude that the lower overall levels of neonatal mortality we found in association with higher elective caesarean section rates for breech term pregnancies, reflect the positive impact of a more general pro-active attitude and intervention style, at least in the Dutch contexts. The potential drawbacks of (too) active management were not taken into account. For example women who did deliver by caesarean section are at higher risk for complications in consequent pregnancies. [22]

In our analyses we demonstrated that the odds of perinatal mortality are higher in women who start labour in the second tier of care (under supervision of an obstetrician in hospital) or who are referred during labour (from community midwife to an obstetrician in hospital). Based on the obstetric care system in the Netherlands, women in the first tier of care are by definition at lower risk of experiencing adverse outcomes including perinatal mortality. This is also reflected in our findings. Ideally, no high risk women give birth in the first tier of care. That risk selection proves to be difficult is demonstrated by the fact that up to 6.5% of women who planned to deliver at home under supervision of a community midwife at the onset of labour, had a Big4-outcome. [3] Preeclampsia was positively associated with mortality in the univariate analyses (as expected), but showed a protective effect on mortality in the multivariate analyses. The explanation of this statistical artefact lies in the fact that mortality due to preeclampsia is often preceded by intra-uterine growth restriction. [23] When the major Big3 determinant (which includes SGA) is removed from the analyses (results not shown), preeclampsia regains its elevated odds for mortality.

In the univariate analyses, the time of delivery (during office hours or not) was significant for both categories of mortality, whilst in the multivariate analyses this was only the case in intrapartum mortality. This may be explained by the fact that part of the children who die in the neonatal period are born at out-of-office hours. Their actual death may have occurred later (this may vary from minutes to days after birth); see also the general remark on the carry-over effect from intrapartum to neonatal mortality. The death may then have no relation with the time of birth (office or out of office hours). The literature on perinatal mortality in relation to time of birth has been largely inconsistent, with some studies finding significantly increased risks for weekend-day, off hours and evening or night time deliveries, whilst others found no such effect. [9, 24-27] Gijsen *et al.* found that increased perinatal mortality rates during the evening and nights were mostly concentrated in subpopulations of women with induced or augmented labour or an emergency caesarean section. [25] In our analyses we did not conduct such subgroup analyses.

Strengths and limitations

Our study has a number of strengths and limitations. The use of a large national database with an almost complete coverage of pregnancies in the Netherlands contributes to the strength of our results. Second, in our investigation on the relevance of organizational factors, we made the distinction in both children *with* and *without* major morbidity, and into intrapartum and neonatal mortality. This allowed us to explore potential differences in relevant hospital organizational characteristics between these groups of children. Additionally, we had a large number of measured hospital organizational characteristics at our disposal, which had been developed specifically for the purpose of this type of analysis, building on existing reports from professional, hospital, and governmental organisations.

Despite the detailed measurement of obstetric organisation, the power of the study sometimes was not sufficient to demonstrate direct effects of organisation. Some statistical remarks apply here. First, the number of deaths is small compared to the number of predictive factors; the major biological factors (e.g. Big3) explain a large part of the variance. Moreover, as Poeran *et al.* already showed, the coefficients of the random effects models show that hospitals exert a non-trivial effect, not modelled by our organisation factors. We believe other research methods, like audit and causal root analysis [28, 29] are needed to complement statistical analysis, also on the breech CS rate effect.

A limitation of our study is the retrospective nature of the data. The typical approach of a randomized controlled trial is difficult to achieve in practice: randomized assignment to intentionally manipulated organisations is demanding, and -most important- the outcome mortality is too rare to be useful. Thus we have to rely on an observational design with key description of hospital features being done prior to analysis, and with a predefined analytical strategy building on previous evidence.

Concerning the determinants in our analyses, the nature of the available data forces us to use small-for-gestational age (SGA) as determinant, as opposed to the preferred and intended intrauterine growth restriction (IUGR). SGA starts from birth weight, which is related to all new-borns of the same gestational age, corrected for weeks of gestation, sex and parity. Apart from the fact that one would prefer the distribution of all children, born and still in utero, as reference, the concept of IUGR is a little different from SGA. A neonate may not be SGA compared to the rest of the population, but still have had a larger individual growth potential that was restricted during pregnancy (IUGR). [30]

Another determinant in our models was the interaction between ethnicity and SES. Our division of ethnicity within this determinant into Western and non-Western was quite crude. It may do insufficient justice to the subtle differences between different ethnic minority groups and time spent in the host country. Women classified as Western may recently have arrived from another European country and may be unfamiliar with the language or the healthcare system. Contrastingly, part of the non-Western women

may have lived in the Netherlands all their lives and have assimilated in terms of culture and customs. This may have led to a dilution of the effects we found.

In our analyses we did not take the organizational characteristics of midwifery practices into account. However investigations for the Dutch version of the Adverse Outcome Index (AOI) in obstetrics, have demonstrated that hospitals with their collaborating midwifery practices (the so called 'obstetric collaborations') can be seen as one entity in terms of organizational outcomes. By leaving midwifery organizational characteristics and home births out of the scope of this article, comparability with other countries is possibly better.

Lastly, the data on perinatal determinants and outcomes dates back to the years 2000 to 2008. We chose to do so because the survey on hospital organizational characteristics was conducted in 2008 and concerned the years 2000-2006. Because organizational changes tend to occur very slowly it seems reasonable to assume that the hospital organisational characteristics, and more specifically the interaction between these characteristics and foetal / neonatal morbidity we explored are still relevant today.

In all, this study shows that hospital organizational characteristics matter in the occurrence of neonatal mortality, but not in intrapartum mortality, and that children *without* major Big3 disease benefit significantly more from optimal hospital organizational characteristics than children *with* Big3 disease. To reduce mortality in children *with* Big3 disease, modifiable determinants above and beyond the organizational characteristics in this study must be investigated. Ideally the occurrence of Big3 disease is prevented altogether. A number of projects targeting the risk factors leading to Big3 disease (such as smoking, illicit drug use and teenage pregnancy) are currently being evaluated. [31-33] For the majority of the children (those *without* Big3 disease), optimization of hospital organizational characteristics does seem to be beneficial in the reduction of mortality rates. Even though we found no effect for children *with major* Big3 disease, it is reasonable to assume that they too may benefit. Currently the organizations responsible for obstetric care are under closer scrutiny. Many hospitals now strive for so called day-time obstetrics, for example by planning the starting time of inductions of labour in a way that increases the chances of birth during office hours. Additionally more obstetricians stay in hospital when on call. The importance of such developments is underscored by this study.

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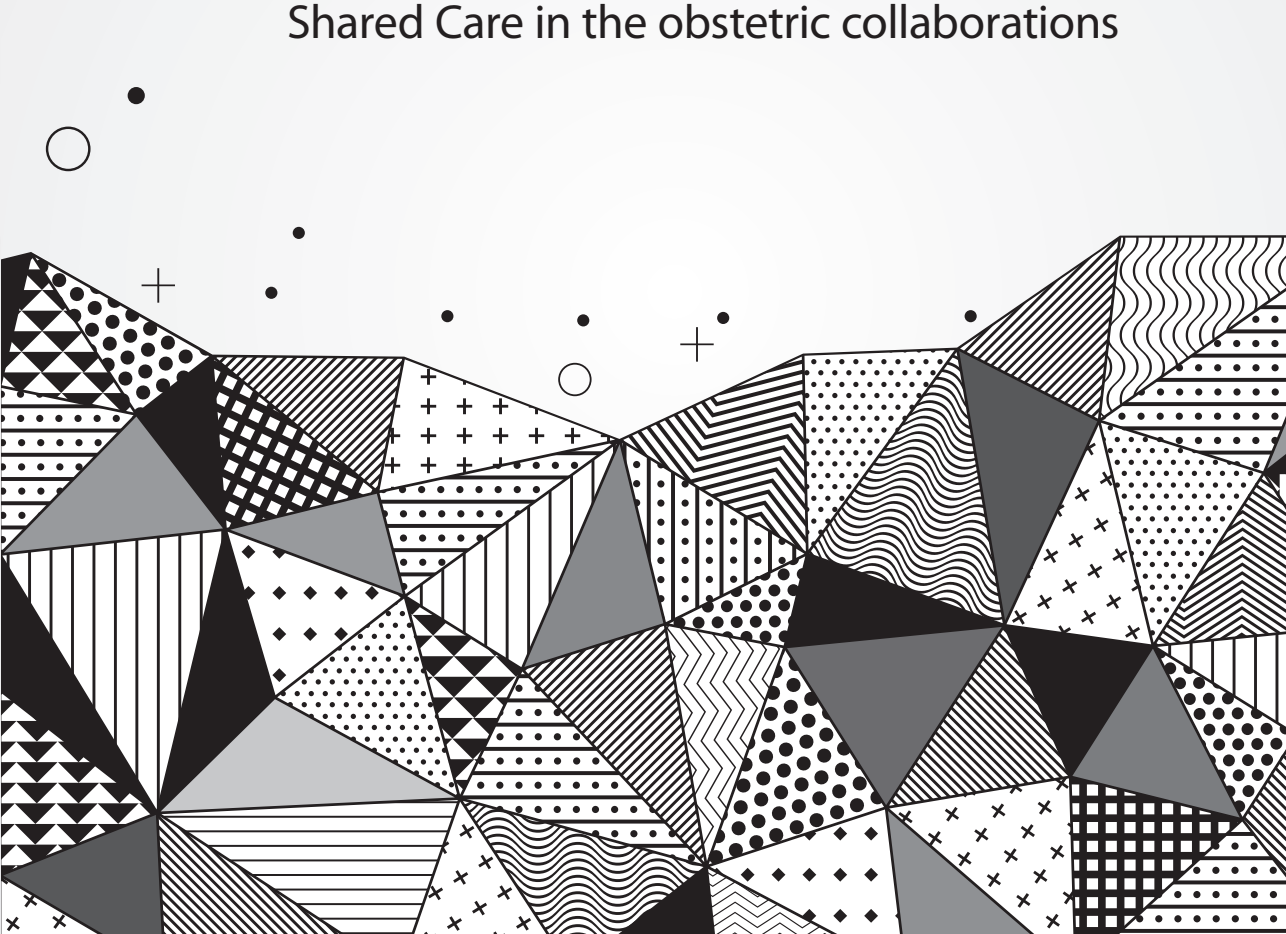
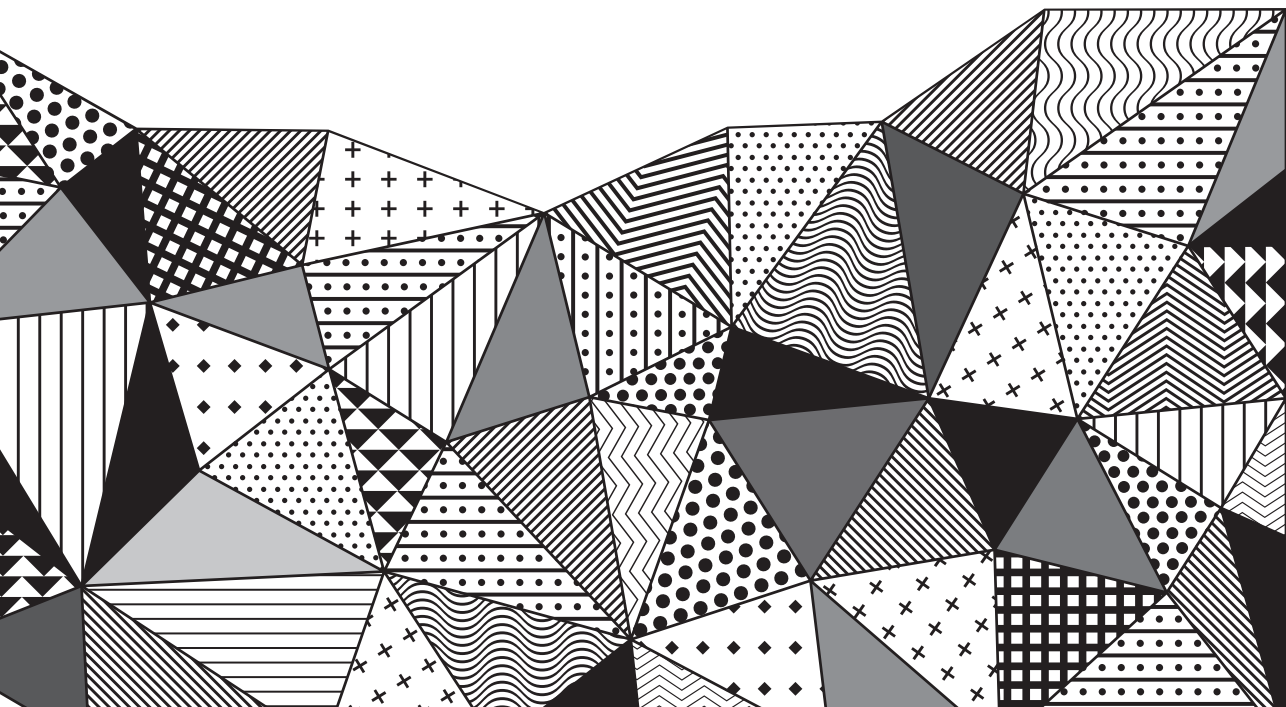
Part III

Shared Care in the obstetric collaborations





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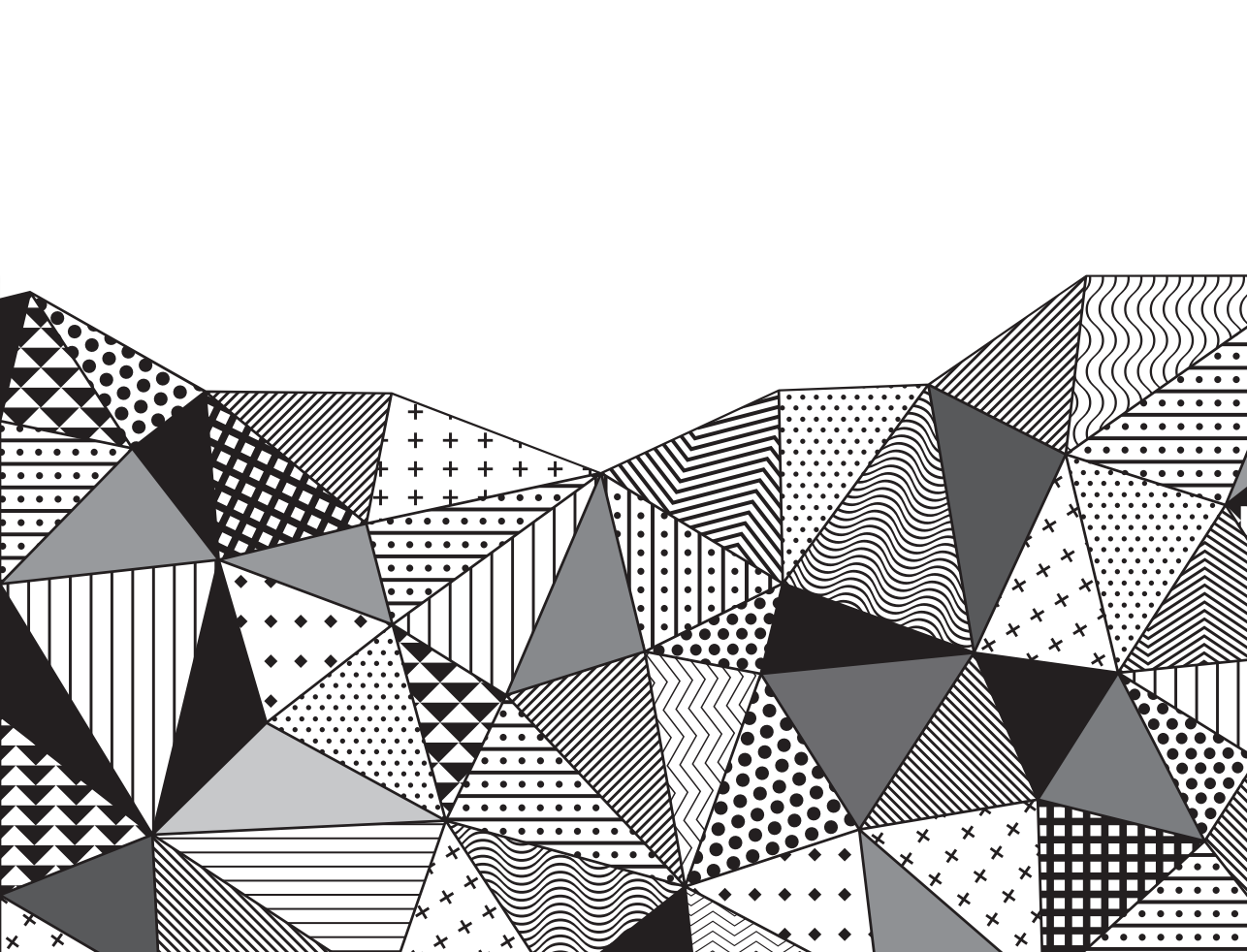
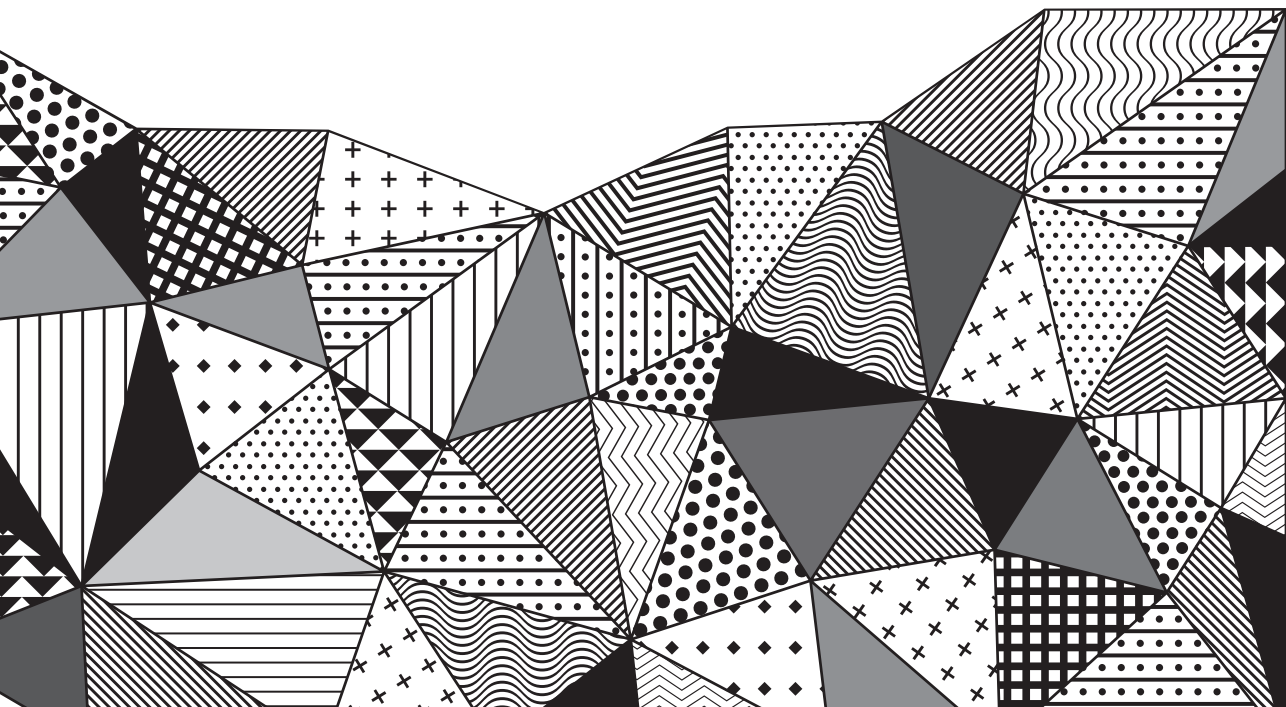
Chapter 8

Developing a Shared Care model in Dutch obstetric care





Chapter 8.1

Bridging between professionals in perinatal care: towards Shared Care in the Netherlands

Posthumus AG, Schölmerich VLN, Waelput AJM, Vos AA, De Jong-Potjer LC, Bakker R, Bonsel GJ, Groenewegen P, Steegers EAP, Denktaş S

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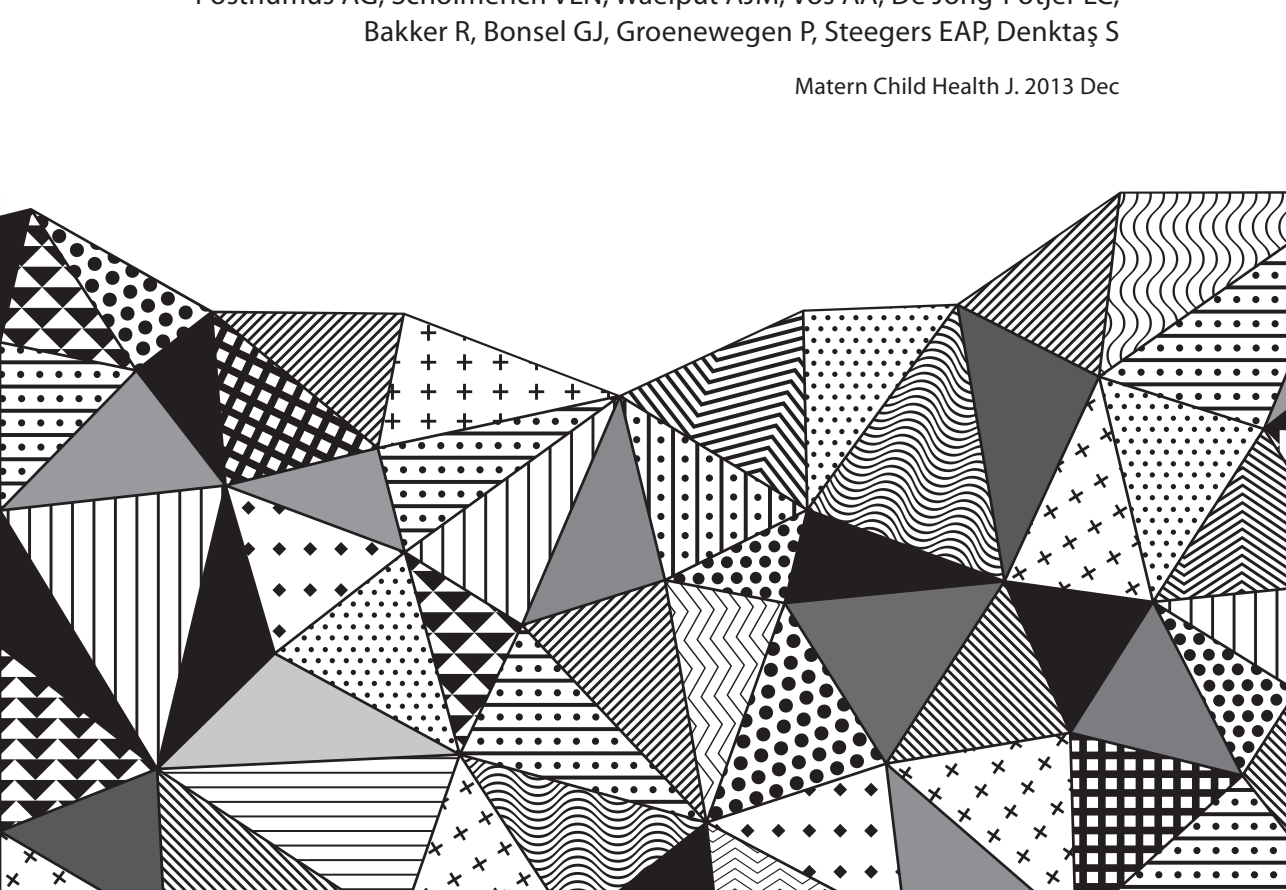

ABSTRACT

Purpose: Relatively high perinatal mortality rates in the Netherlands have required a critical assessment of the national obstetric system. Policy evaluations emphasized the need for organizational improvement, in particular closer collaboration between community midwives and obstetric caregivers in hospitals. The levelled care system that is currently in place, in which professionals in midwifery and obstetrics work autonomously, does not fully meet the needs of pregnant women, especially women with an accumulation of non-medical risk factors.

This article provides an overview of the advantages of greater interdisciplinary collaboration and the current policy developments in obstetric care in the Netherlands. In line with these developments we present a model for shared care embedded in local 'obstetric collaborations'. These collaborations are formed by obstetric caregivers of a single hospital and all surrounding community midwives.

Description: Through a broad literature search, practical elements from shared care approaches in other fields of medicine that would suit the Dutch obstetric system were selected. These elements, focusing on continuity of care, patient centeredness and interprofessional teamwork form a comprehensive model for a shared care approach.

Conclusion: By means of this overview paper and the presented model, we add direction to the current policy debate on the development of obstetrics in the Netherlands. This model will be used as a starting point for the pilot-implementation of a shared care approach in the obstetric collaborations', using feedback from the field to further improve it.

BACKGROUND

The midwife plays a key role as provider of obstetric care in the Netherlands. About 84% of pregnant women start with a first antenatal visit to the community midwife. At the start of the delivery about 50% of pregnant women are under responsibility of a midwife. [1]

The midwife and the obstetrician work autonomously and generally play a complementary role. Yet complementarity requires an intensive mutual relationship with a common point of departure in the management of pregnant women. The nature and quality of this collaboration has come under scrutiny as perinatal mortality rates in the Netherlands are higher than in the surrounding countries and are showing a slower rate of decline. [2] The latest confirmed statistics describe a fetal mortality rate (deaths from 22 weeks of gestation) of 6.4 and neonatal deaths (up to 7 days postpartum) of 2.7 per 1000 births. [1]

Explanations for these adverse outcomes have been put forward at the level of the mother, the unborn child, the organization of care, including the Dutch 3-tier system, and the area of living. [3] At the organization level, a nationwide study suggested a key role for low hospital performance at off business hours. [4] Neighbourhood inequalities seem to play an additional role, with higher risks for adverse outcomes for women living in deprived areas, in particular in the four largest cities in the Netherlands. In some of these neighbourhoods, perinatal mortality is beyond 30 per 1000 births. [5-6]

As a response to public concern, the Ministry of Health installed an Advisory Committee on 'Good care during pregnancy and child birth' in 2009. Based on stakeholders' opinions this committee presented a set of recommendations on the direction in which the Dutch obstetric field should evolve. [7] This report was followed shortly by a scientific report with a comprehensive analysis of national perinatal data, an overview of knowledge gaps and a proposition for a research agenda in the perinatal health field. [3]

Both reports underscored the need for organizational improvement, in particular closer collaboration between community midwives and obstetricians. This was also emphasized by the recent recommendations of the Foundation for Perinatal Audit in the Netherlands, after audit analyses of perinatal mortality at term. [8] Furthermore, both professional organizations for obstetricians and midwives endorse the necessity of an integrated obstetric care system.

The current situation

The Dutch obstetric system is unique in the world. It consists of three levels of care which function mainly autonomously. The primary level of care is provided by independently practicing community midwives who care for estimated low-risk pregnant women from the early prenatal until the postpartum period. Pregnancy, birth and the

puerperium are traditionally perceived as fundamentally physiological processes. [9] If pregnancy and childbirth occur without complications, women can choose to either deliver at home or in a hospital, both under the supervision of their community midwife. If complications (threaten to) occur, midwives refer women under their care to an obstetrician at the secondary care level. Tertiary care takes place in centres for perinatology with a neonatal intensive care unit and an obstetric 'high care' department. The latter is reserved for severely ill women, severe fetal pathology and (threatening) prematurity (<34 weeks of gestation). [10] Approximately 15%-18% of women have their first antenatal visit directly at a secondary or tertiary care hospital because of their high-risk medical or obstetric history. [3, 11] Referral is based on the 'List of Obstetric Indications' which is a risk selection list. [12] This list consists of medical conditions divided into risk categories. These different categories are shown in Figure 1. Depending on the severity, either a community midwife (category A) or an obstetrician (category C) is eligible to deliver care. Category B covers consultation and category D a hospital based midwife-led delivery.

The current classification system does not facilitate shared responsibility by both professionals. Moreover, it implies that thorough risk selection of pregnant women is always possible, resulting in a high-risk versus low-risk dichotomy with a 'demarcation-of-responsibilities' between community midwives and obstetricians. [13] However, several studies have shown that the occurrence of adverse perinatal outcomes often depends on the presence of a number of smaller risk factors rather than a single greater one that may be easier to detect. This is known as risk accumulation. [6, 14-15] The presence of this risk accumulation and the under-detection of conditions such as intrauterine growth restriction make it harder to state that a woman exclusively belongs in one level of care or the other. [14] This may indicate that the current system needs adjustment.

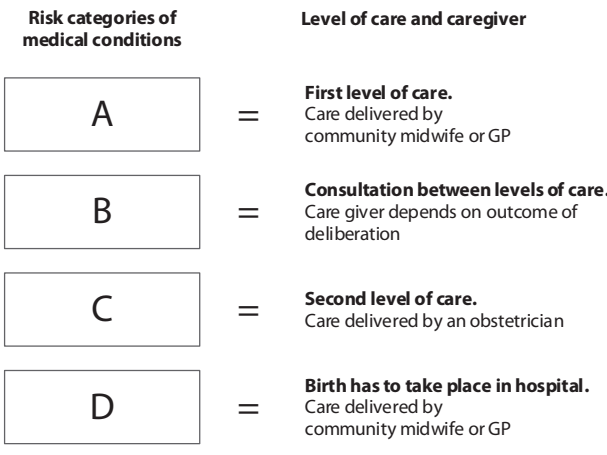

Figure 1. The List of Obstetric Indications.

Some of the problems experienced in the relationship between community midwives and obstetricians might reflect broader system issues such as negative financial incentives caused by the insurance policy, e.g. referring a patient to another professional for consultation may result in loss of income for the initial caregiver. More specific factors that seem to play a role but are not explicitly described in the literature include a lack of communication between midwives and obstetricians which can be an important problem when transferring patients during labour. The authors believe providers from different disciplines feel a lack of mutual respect and support for the contributions that they make in providing obstetric health care. This is supported by preliminary results from interviews we have conducted with obstetric caregivers. The resulting fragmentation of care between the different professionals makes the system vulnerable to the occurrence of substandard care.

Local obstetric collaborations (OC's) have been important starting points for new developments in obstetrics in the Netherlands. Starting in 1987, OC's were founded across the country, consisting of obstetricians of a single hospital and all surrounding community midwives referring to this hospital. OC's are meant to evoke better collaboration between primary and secondary obstetric care.

A recent investigation by the Dutch Health Care Inspectorate found that OC's were in place in 91% of the 92 hospitals providing obstetric care. In these OC's, midwives and obstetricians regularly have meetings to deliberate about the care in their geographical area. Next to the OC's, all hospitals providing obstetric care have implemented local multidisciplinary perinatal mortality audits. [16] Collaboration during these audits and on guideline development stimulates the cooperation between obstetric caregivers on a policy level. [8, 17]

The Advisory Committee has expressed the aim of increasing collaboration between the obstetric levels for patient care. This aim has only been incorporated into the targets of a quarter of the OC's. Multidisciplinary collaboration for individual patients has so far only taken place on a small scale. Other recommendations by the Committee including local execution of multidisciplinary protocols developed on a national level and prevention of caregiver delay, are embraced by almost all OC's. The Committee also emphasized the importance of timely identification and assessment of medical but also of nonmedical risk factors, by all professionals involved in perinatal care. [7]

A precondition for this is a risk selection instrument focusing on both types of risks, including psychological, social, lifestyle, obstetric and non-obstetric care related risks. The Rotterdam Reproductive Risk Reduction (R4U) checklist could fulfil these criteria and is based on the concept of risk accumulation. [18] During the first antenatal visit (at the community midwife or obstetrician) risks can be assessed with the R4U and subsequently a (weighed) score can be calculated for the (combination of) risk factor(s) identified. If the total score of a pregnant woman is higher than a given cut-off point, she

can be prioritized for a 'shared care' approach within the OC. Shared care can be defined as interdisciplinary collaboration with a joint sense of responsibility for the individual patient and the ability to learn from each other's skills and knowledge. [19] Such an approach to care can help to improve the current system.

Aim of this paper

Even though a number of recommendations have been made, a clear-cut model that ensures tailored shared care for the individual pregnant woman in the Dutch obstetric health system is not available.

We fill this gap by presenting an overview paper that: 1) highlights the advantages of greater collaboration between community midwives and obstetricians in the Netherlands, 2) describes a model of shared care in which the expertise of caregivers is endorsed and a range of practitioner behaviours, practices, and policies which can contribute to collaborative obstetric health care are provided, and 3) describes the pilot implementation of shared obstetric care in clinical practice.

Towards a shared care model: first a theoretical framework

We propose a reappraisal of the care provided by community midwives and obstetricians. Based on the arguments outlined above, starting points are improved tailored care for the individual woman and the involvement of the expertise of both community midwives and obstetricians.

We searched for descriptions of different forms of collaboration between obstetric professionals in other countries, such as Canada, Australia, New Zealand and the United Kingdom. [20-25] There were a number of different approaches: shared care provided by midwives and obstetricians for low and/or high risk cases, a form of case management or community antenatal care combined with intrapartum care delivered by hospital-based professionals. However, as the Dutch obstetric system is different from the systems abroad, there is no precedent for a model of shared care that can be fully implemented in the Dutch context. [11, 26]

We then performed a broad literature search on shared care and its synonyms in all fields of medicine. These synonyms are numerous. Examples are 'integrated care', 'joint care', 'combined care' and 'collaborative care'. These terms indicate differences in the intensity of collaboration between health care professionals.

By reviewing studies that explicitly describe models of care, elements of these models were identified that satisfied the following requirements: 1) compatible with the recommendations of the Advisory Committee, 2) contribute to the development and sustainability of shared care and 3) can be applied to the Dutch health care system.

For purposes of clarity we organized these elements into three categories: continuity of care, patient centeredness and interprofessional collaboration. The categories of the

proposed shared care model are summarized in Table 1 and a visualization of the model is given in Figure 2.

Table 1. Overview with the specific categories and elements of the new model for Shared Care.

Category	Elements
Continuity of care [27]	– Case manager oversees the care from booking visit to postnatal period [7, 31] – Templates for standardised care pathways [47] – Interdisciplinary electronic patient notes [7, 32] – Short waiting times for referral to other health care professionals [30] – Scheduled frequent meetings to discuss care plan [7, 30]
Patient centeredness [38]	– Frequent and thorough communication with the pregnant woman [31] – Self-management of the woman is fostered [32] – Cultural (and socio-economic) background of the woman is taken into account [30] – Care provider is close to the community of the pregnant woman [30] – Efforts are made to combine appointments to different care providers – Home visit by one of the care providers to each pregnant woman [7] – Interdisciplinary individual care plan for the pregnant woman [7, 37]
Interprofessional collaboration [39]	– Shared sense of responsibility for the individual pregnant woman [7, 36] – Clear definition of roles of different health care professionals [32] – Joint set of aims and ambitions for collaboration [32] – Stimulation of trust among the care providers [7, 32] – Strong leadership in the implementation of shared care [40] – Trainings on team work and sessions for interprofessional education [7, 41] – Continuous evaluation and feedback on the Shared Care approach [32] – Opportunity for experimentation and pilot-projects [32]

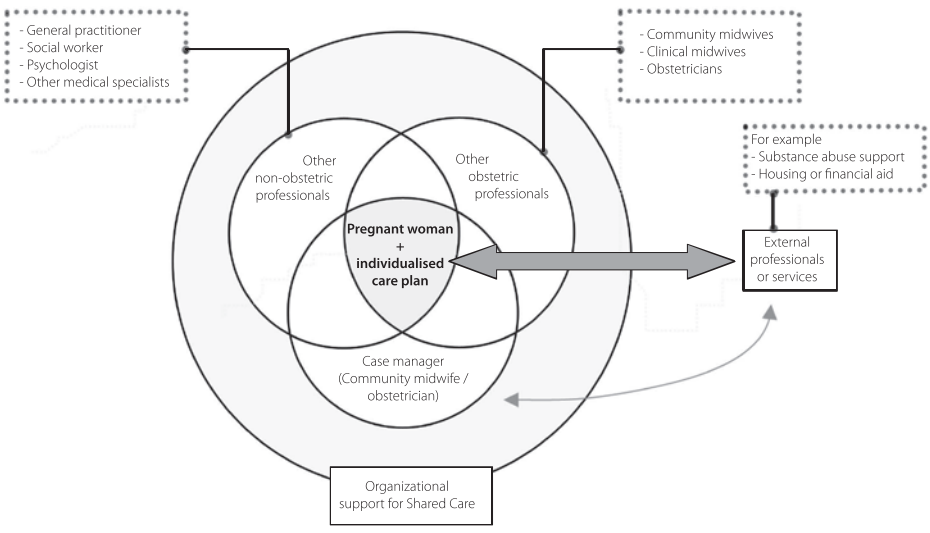

Figure 2. Visualisation of the Shared Care model.

Continuity of care

The first element of our shared care model is 'continuity of care'. This concept is defined by Haggerty *et al.* as: "the degree to which a series of discrete healthcare events is experienced as coherent and connected and consistent with the patient's medical needs and personal context." Three types of continuity can be distinguished: relational continuity (e.g. a limited number of different care providers directly involved with the patient), informational continuity (e.g. patient information known to an individual care provider) and management continuity (e.g. care protocols). [27] Our model foresees that case management can help to improve the latter two forms of continuity. [28]

The case manager - either a community midwife or an obstetrician, depending on the risk profile – should guide a woman through pregnancy from the first antenatal visit to the postpartum period coordinating the necessary care. [7, 29-31] He or she is the primary caregiver and the primary point of contact for the pregnant woman and for all other caregivers involved.

To further enable continuity of information, a number of facilitating factors should be addressed, such as uniformity in shared information and electronic patient notes that are accessible to all involved health care professionals. [32-35] On a small scale experiments with shared electronic notes already take place in the Netherlands. Ideally, the notes alert caregivers to scheduled tasks for an individual patient or the availability of new results. Furthermore web based applications allow for the sharing of non-patient information such as shared protocols, schedules and care plan templates. [36]

If a pregnant woman scores above the cut-off point of a given risk-assessment tool, such as the abovementioned R4U, a customized care plan based on the care plan template is made by the case manager and discussed within the OC. [37] The care plan includes predesigned care pathways. [12, 32] A care pathway focuses on a specific need or risk of the pregnant woman. Often the pathways address non-medical issues that form an (indirect) risk for the pregnant woman, such as domestic violence or being un-

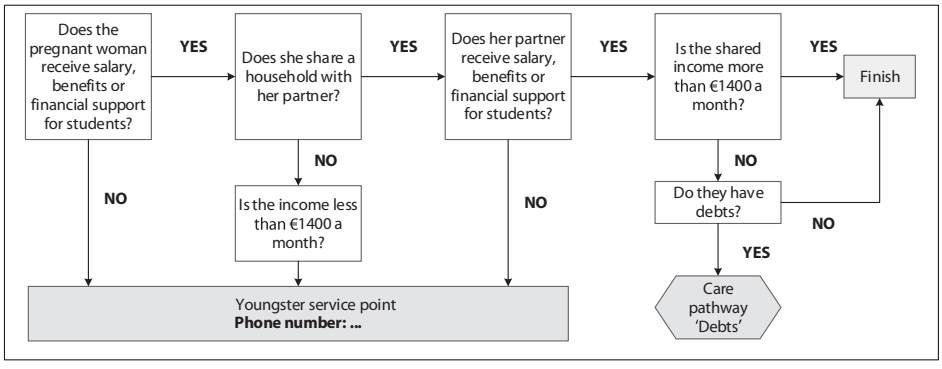

Figure 3. Care pathway 'Income and pregnant women (age 18-23 years)'.

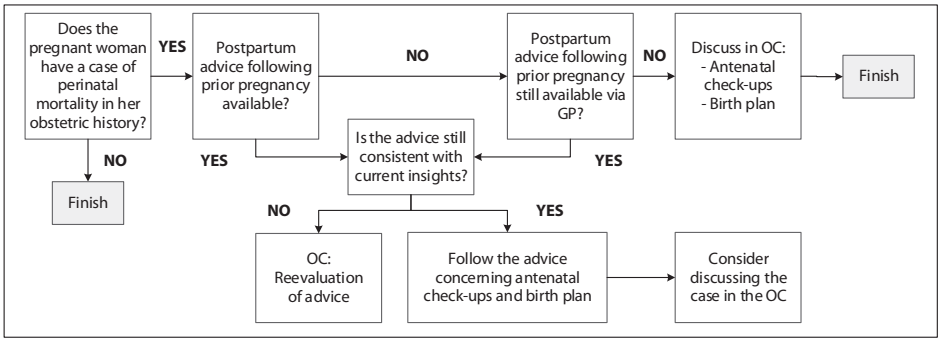

Figure 4. Care pathway 'Perinatal mortality in obstetric history'.

insured. Moreover, the pathways consist of steps that need to be taken by the caregiver (including relevant referral procedures). The predesigned pathways should therefore be adapted to the local settings. Examples of a non-medical and medical care pathway are given in Figure 3 and 4. We hypothesize that women with an accumulation of different risk factors will benefit from the care pathway approach.

Patient centeredness

The Institute of Medicine defines patient centred care as "providing care that is respectful of and responsive to individual patient preferences, needs, and values, and ensuring that patient values guide all clinical decisions". [38] This definition shows strong parallels to one of the aims of the Advisory Committee, namely a comprehensive approach to patient care. Currently, obstetric caregivers are mostly trained for and focused on the clinical aspects of pregnancy. When they identify complicated non-medical factors such as financial and psychological issues, they do not have the right tools and training to support the woman, or referral options might be unknown or unavailable. In a shared care approach caregivers such as general practitioners, social workers and psychologists can help to meet those needs and reduce the related risks.

In order to acquire a more complete picture of the (non-medical) background of the pregnant woman, a home visit before 34 weeks of gestation is made by one of the obstetric caregivers. [7] If present, psychosocial issues can be assessed and prenatal information can be given (this assessment is carried out again after the woman has given birth). Furthermore, the inventory of the domestic situation is used to determine whether home birth is a safe option for the pregnant woman, unborn child and the caregiver.

In this shared care model, the self-management and empowerment of the pregnant woman should be encouraged, enabling her to make informed choices and to know what to expect during pregnancy and delivery and when to contact her caregivers. Ef-

forts should be made to limit barriers (e.g. language) for this. A program in Rotterdam illustrates how this can be done. Here, perinatal health peer educators have been trained to support women from different socio-economic and cultural backgrounds. As stated before, obstetric care can only meet the needs of the individual woman when socio-economic, cultural and religious backgrounds are taken into account. [30]

Interprofessional collaboration

Interprofessional collaboration is understood to be the process in which different professional groups work together to make a positive impact on the provision of health care. [39] The proposed model aims to create a shared sense of responsibility amongst caregivers for individual pregnant women prioritized for a shared care approach. [36] This can be stimulated by a number of different measures which will also help to increase mutual respect and trust between caregivers: First, a joint set of aims and ambitions. [32] Second, clearly defined roles and activities of different caregivers. [32] These should be complementary and should allow caregivers to be responsive to the changing needs of patients, their families, and other caregivers, as well as to resource availability. [29, 32-33] A third measure is the deliberation amongst professionals on an individual patient level. A community midwife and an obstetrician are always involved in the design and evaluation of the care plan of pregnant women selected for the shared care approach, even though only one of these caregivers holds final responsibility. Depending on the specifics of the case, other healthcare professionals can be consulted, such as a general practitioner or a social worker. Other options include one-to-one meetings to reflect on difficult cases or shared rounds.

If a caregiver observes patient issues that may be of relevance to other providers involved, this is communicated in the meetings and, if necessary, at an earlier stage to the case manager. [36] For example, a general practitioner might notice in her consultations that the pregnant woman shows signs of depression and communicates this to the involved obstetric caregivers. Collaboration could also be facilitated by locating all caregivers in close proximity of each other. [30, 40] In order to improve necessary teamwork skills, teamwork trainings can be introduced. [41] A fourth measure to improve collaboration could be interprofessional education. [29, 41-42] The abovementioned shared rounds and case deliberation can also contribute to improved interprofessional education. A fifth measure could be frequently scheduled face-to-face meetings by members of the OC. Here, care for new and ongoing cases can be discussed and evaluated. [29-31, 43] A structured approach for these meetings is necessary, using a daily board consisting of a chairman (either one individual for a longer period of time or a rotating chairman) and a secretary to schedule the interdisciplinary meetings and to ensure that agreed tasks are carried out. [32, 36] In addition, the board can direct the ongoing monitoring, evaluation and adjustment of the shared care approach as a whole.

The sixth measure we propose is creating opportunities for innovation and experimentation. [32] For example, pregnant women who in the current system are only treated by an obstetrician, would – according to this model – primarily be seen by a community midwife with some specific additional antenatal appointments with an obstetrician. An example is given in Box 1. Through such innovations the traditional barriers between the levels in the Dutch obstetric system can be overcome in order to become a truly shared care system.

Box 1: A case

Mrs. T is a 29 year old G2P1. In her first pregnancy intrauterine growth restriction occurred. Her son was born at 38+3 weeks of gestation with a birth weight of 2350 grams (< 2.3 percentile). She was told that therefore in her next pregnancy her antenatal care should be given by an obstetrician in the hospital. Her midwife and obstetrician are members of the same OC. In the OC they have started an experiment for women with an intrauterine growth restriction in the prior pregnancy. They receive their care primarily from their midwife but are seen four times by an obstetrician for extra ultrasound fetal biometry measurements to check on fetal growth. If all is well Mrs. T can give birth under supervision of her midwife. She feels content with this option.

DISCUSSION

Adverse perinatal outcomes in the Netherlands have necessitated an orientation towards a shared care approach to adjust the current obstetric system. Based on our overview of the literature, it seems that shared care should lead to improved pregnancy outcomes and better use of the time and skills of community midwives, obstetricians and other caregivers.

We collected elements from shared care models outside the field to create a model that may suit the Dutch obstetric system. Because the model is based on an exploration of the literature there may still be elements that we have overlooked that could be a valuable addition. The elements we have included were categorized as pertaining to patient centeredness, continuity of care and interprofessional collaboration. Further investigation of these concepts could also lead to an inclusion of additional elements to the model in the future.

Excluding a number of the elements we encountered in the literature was inevitable as a choice needed to be made on which elements were suitable for the Dutch obstetric system. Most were not applicable because of being very specific for other fields of medicine. An example is the fluctuation of care intensity over time in long-time follow up for oncology patients. [44]

Lastly, we are aware of the potential discrepancies between this theoretical model and clinical practice. However, the model we present is a starting point and feedback from the field will help to improve it.

Getting started

The pilot-implementation of the model commences at the end of this year, taking place in OC's in the city of Rotterdam. In this city some important steps towards shared care have already been taken in the framework of the perinatal health program 'Ready for a Baby'. In this program, health researchers joined hands with municipal policy makers in order to develop a comprehensive program to improve perinatal health in the city. [18] One of the tools that we propose to use for the shared care model, the risk screening instrument R4U, is adopted from the 'Ready for a Baby' program.

Semi-structured interviews with obstetric caregivers in the Rotterdam region have been completed and will be used to obtain a clearer picture of the current challenges in collaboration and caregivers' opinions about shared care. Perceived success and failure factors of the shared care approach, changes in effectiveness of interprofessional collaboration, number of interdisciplinary referrals and patient satisfaction will be evaluated after the pilot-implementation of the model. This information will be used to further improve the model and the intervention.

The study in the Rotterdam region will focus on the implementation process and organizational perspectives of the development of shared care. The national program 'Healthy Pregnancy 4 All', which encompasses the same intervention, will focus on perinatal outcomes. [45]

Shared care in obstetrics does exist in other forms abroad, but to our knowledge there is no literature available on the development and implementation of a model that meets the needs of the obstetric health system in the Netherlands. We believe that this study and the outcomes of the implementation in the field are therefore also of interest to (obstetric) health care systems abroad that show parallels to ours. In addition, it is relevant to other countries considering the implementation of a perinatal approach similar to the current Dutch system.

Possible barriers

There are a number of barriers to be expected when implementing this model. These barriers will be explored in the pilot implementation. How extensive the change is that needs to be made to adopt the shared care model greatly depends on the current situation within the various OC's.

The shared care model will necessitate a different mind-set for all involved health care professionals. The current system clearly divides the roles between primary and secondary obstetric care. Both professional groups are used to working fairly autonomously, yet many health caregivers realize that a change is necessary. This is shown by the fact that all hospitals and most of the community midwifery practices in Rotterdam have agreed to implement the R4U as a tool for a shared care approach.

Lack of time may be another challenge. If a woman has a number of different risk factors more time will be needed for the caregivers to arrange all necessary care pathways for her. Furthermore the OC's currently tend to meet on a (bi)monthly basis. To collaborate on an individual patient level, meeting more frequently is necessary. The physical separation of midwifery practices and hospitals may therefore form another barrier in the long run because caregivers will need to travel to attend face-to-face meetings. If the caseload is not too high, sending a single representative per midwifery practice and medical specialty may be a solution.

We also realize that a number of the required changes will necessitate additional financial means which may not be available in all participating OC's. The reimbursement in new models of collaborative care is currently an important topic of discussion in the Netherlands. Recently the Dutch Healthcare authority published a report on the funding of integrated obstetric care, concluding that interprofessional collaboration needs to be established first before funding for integrated care will be provided. [46] If this model proves to be successful, the outcomes could be used in deliberations with insurance companies to obtain an alternative reimbursement model. For now we will need to find provisional solutions through dialogues with the OC's, the hospital boards, health insurance companies and regional support structures.

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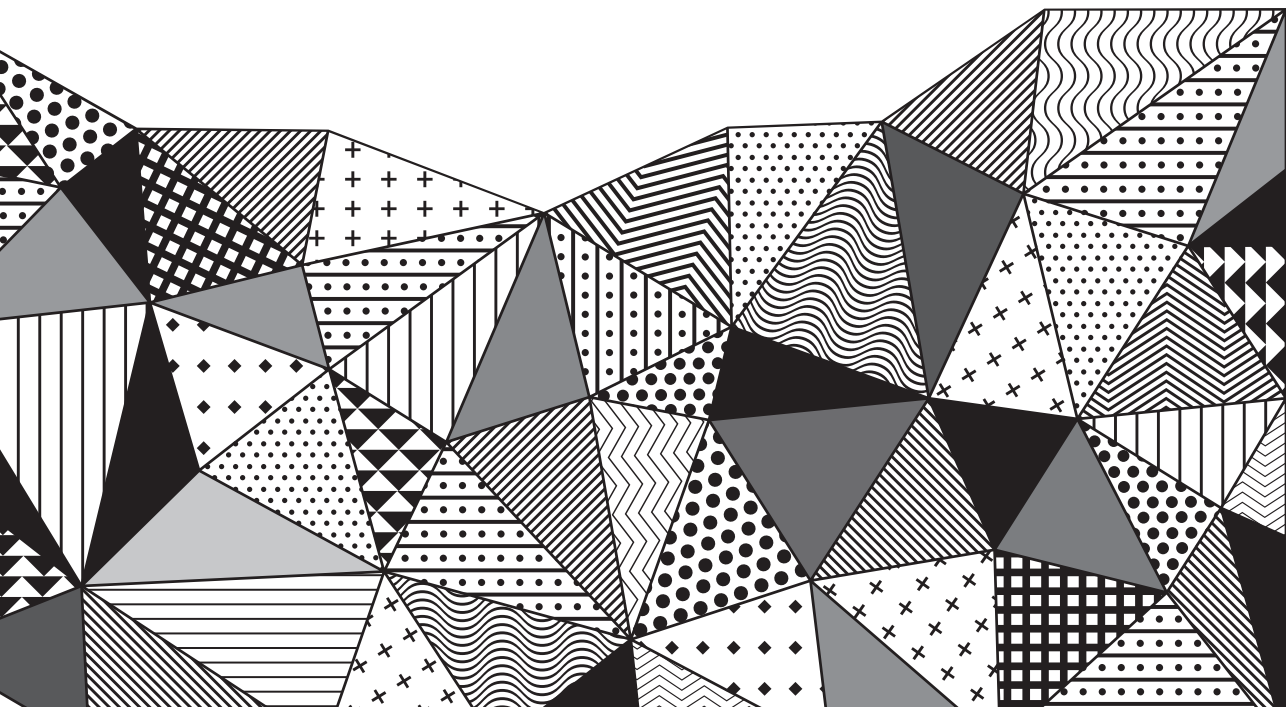

Chapter 8.2

Improving interprofessional coordination in Dutch midwifery and obstetrics: a qualitative study

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ABSTRACT

Background: Coordination between the autonomous professional groups in midwifery and obstetrics is a key debate in the Netherlands. At the same time, it remains unclear what the current coordination challenges are.

Methods: To examine coordination challenges that might present a barrier to delivering optimal care, we conducted a qualitative field study focusing on midwifery and obstetric professional's perception of coordination and on their routines. We undertook 40 interviews with 13 community midwives, 8 hospital-based midwives and 19 obstetricians (including two resident obstetricians), and conducted non-participatory observations at the worksite of these professional groups.

Results: We identified challenges in terms of fragmented organizational structures, different perspectives on antenatal health and inadequate interprofessional communication. These challenges limited professionals' coordinating capacity and thereby decreased their ability to provide optimal care. We also found that pregnant women needed to compensate for suboptimal coordination between community midwives and secondary caregivers by taking on an active role in facilitating communication between these professionals.

Conclusions: The communicative role that pregnant women play within coordination processes underlines the urgency to improve coordination. We recommend increasing multidisciplinary meetings and training, revising the financial reimbursement system, implementing a shared maternity notes system and decreasing the expertise gap between providers and clients. In the literature, communication by clients in support of coordination has been largely ignored. We suggest that studies include client communication as part of the coordination process.

BACKGROUND

Dutch midwifery and obstetrics distinguishes three levels of care: primary, secondary and tertiary care. Community midwives situated in neighbourhood practices provide primary care, while obstetric caregivers in hospitals provide secondary and tertiary care. Community midwives and obstetricians in secondary and tertiary care are autonomous professionals. Nevertheless, they need to coordinate activities to support women during their pregnancy and labour/birth such as sharing information related to pregnant women. This is especially necessary when pregnant women transfer from one level of care to the other. As professionals in the three levels of care are autonomous and yet *inter*dependent on each other in order to deliver optimal care, the Dutch midwifery and obstetric system is imbued with inherent coordination challenges. In this study, we use Faraj & Xiao's definition of coordination: "(..) coordination is about the integration of organizational work under conditions of task interdependence and uncertainty". [1]

The current public debate in the Netherlands, along with two key public reports, emphasizes the need for improved coordination in midwifery and obstetrics, especially between primary and secondary care. [2,3] However, coordination has not yet been systematically studied in this sector. We aim to fill this gap by conducting a field study on coordination challenges within primary and secondary care in the region of Rotterdam, the second largest city of the Netherlands. By interviewing and observing caregivers, we investigated which factors are frequently mentioned as barriers to successful coordination. This study focuses on the antenatal phase of care as care of women during labour/birth and the postnatal phases could manifest different coordination challenges. In line with our above mentioned definition of coordination, we adopted a practice-based method in order to explore coordination "as it occurs in practice" during everyday working routines. [1]

The challenge of coordination is not unique to Dutch midwifery and obstetrics and is also present in other health care sectors in the Netherlands and abroad, where professionals are highly specialized. Specialization allows professions to develop their own expertise, but also makes it more difficult to then integrate their various contributions in order to deliver optimal care. [4] Although recently changes have been made to medical education, many professionals were still educated to believe that the quality of their provided care depends on their individual knowledge and hard work and not on coordination with others. [5] As such, it is not surprising that health care is viewed as particularly burdened by the coordination challenge. [6]

There are two major perspectives on how coordination can be achieved. The organizational design-perspective is the traditional perspective, which argues that it is possible to achieve optimal coordination with the right *organizational structures* in place, such as rules and protocols. [7] More recent studies point out that this assumes a static and

predictable environment of an organization. [1] Emphasizing that many organizations work in dynamic environments and are faced with time constraints and uncertainty, Faraj and Xiao argue for a coordination-practice perspective. [1] These studies point to the importance of *interprofessional communication* (in addition to organizational structures) to deal with an unpredictable environment. [8] In line with this perspective, Gittell has developed the 'Relational Coordination Theory', highlighting that coordination is a fundamentally *relational* process. [9]

The Dutch midwifery and obstetric care system

Community midwives care for women estimated to be at 'low-risk' for obstetric and medical complications from the early antenatal until the postpartum period. If women remain low risk throughout pregnancy, women have the option of birthing at home, at a birthing centre (community midwife-led centre in proximity of hospital) or in a hospital, in all cases under the supervision of their community midwife. In 2012, 84.7% of pregnant women started antenatal care with a visit to a community midwife. At the onset of labour, 51.6% of women were still under the care of their community midwife. [10] As such, community midwives play a key role in the provision of maternal health care in the Netherlands.

Should complications (threaten to) occur, community midwives refer women to secondary care in a hospital setting. [11] If necessary, obstetricians refer women with very high maternal or fetal risk to tertiary perinatal care, which is located in eight academic hospitals and two additional non-academic hospitals with obstetric high care and neonatal intensive care units. In 2012, 15.3% of women entered antenatal care in secondary or tertiary care due to their high-risk medical and/or obstetric history. [10] Secondary and tertiary care is provided by obstetricians, resident obstetricians and in most hospitals also by hospital-based midwives (midwives specifically trained to work in a clinical setting). [12]

Coordination and performance outcomes

Several studies in health care have found a relationship between coordination and performance outcomes in the area of efficiency (e.g. length of hospitalized stay, costs) and effectiveness (e.g. patient satisfaction, clinical outcomes). [9,13] It would be particularly relevant to improve coordination in the Dutch midwifery and obstetrics as perinatal mortality rates are still relatively high compared to other European countries, and also unequally distributed across neighbourhoods. [14,15] In 2010, the extended perinatal mortality rate (deaths from 22 weeks of gestation up to 28 days postpartum) was 9.0 per 1000 births. [16] In socio-economically deprived neighbourhoods of the four largest cities, perinatal mortality can be over 30 per 1000 births. [14,15]

METHODS

Gathering data

We conducted a field study consisting of interviews and observations in order to investigate coordination within midwifery and obstetrics in the region of Rotterdam. The data collection took place in the summer of 2012.

The decision to opt for a qualitative design was based on two arguments. First, the qualitative approach allows to inductively explore the current factors that make it challenging to achieve coordination in Dutch midwifery and obstetrics. Second, asking "how" questions rather than "how many" allowed us to gain a richer and deeper understanding of our field site. Whilst the results of this study cannot be generalized to a larger or different population, they do indicate how coordination can be improved in Rotterdam.

Selection:

The selection of informants was done by purposive sampling. This means that we chose respondents based on specific characteristics to ensure the inclusion of a wide range of perspectives. We included community midwives, hospital-based midwives, obstetricians and resident obstetricians. All obstetric departments of all hospitals and all midwifery practices in the region of Rotterdam were contacted and invited to participate. We spoke to at least one hospital-based midwife and two obstetricians from each of the seven hospitals in the region of Rotterdam (excluding one hospital which does not employ hospital-based midwives). We interviewed community midwives from 13 out of the 33 midwifery practices in the region of Rotterdam. When scheduling interviews with community midwives, we attempted to interview caregivers located in diverse neighbourhoods, ranging from urban to more rural, and high-income to deprived neighbourhoods.

Interviews:

We conducted 40 interviews with 13 community midwives, 8 hospital-based midwives and 19 obstetricians (including two resident obstetricians). We interviewed caregivers from a tertiary hospital, which also acts as a secondary care hospital and as such works together with community midwives (to protect anonymity this hospital is referred to as belonging to secondary care from this point onwards). The first and second author (a social scientist and a non-practicing medical doctor, respectively) conducted most of the interviews, with additional support from two social scientists. The interviews were semi-structured and consisted of broad and open questions (see additional file 1 in the appendix). We asked questions regarding coordination experiences, the perceived consequences of misaligned coordination, and how caregivers dealt with coordination challenges.

Observations:

To complement the interviews and further enhance the quality of the data, the first author conducted non-participatory observations. Each of the four types of professionals was shadowed during a typical workday, which included interaction with pregnant women. In the hospital settings, this included the outpatient clinic and consults between (resident) obstetricians and community midwives. A community midwife was shadowed during regular consulting hours. These observations took place at three different hospitals and one midwifery practice. The observed care providers were all individuals whom we had interviewed beforehand. During and at the end of the day, they were willing to answer questions that arose during the observations. Next to this, three multidisciplinary meetings to discuss the organization of care as well as a perinatal audit meeting discussing substandard care led by midwifery and obstetric professionals were observed. The four studied types of caregivers were present at all of these meetings.

Role of researchers and consent:

The first and second authors are affiliated to a tertiary medical centre. As such, the researchers worked in the same department as a few of the respondents. The researchers did not know the large majority of the other respondents outside of the department. All of the interviews were audio recorded and the contents as well as the field-notes were fully transcribed without any identifying characteristics of the respondents. Consent was obtained from all observed and interviewed caregivers. We do not reveal any confidential or potentially identifying data of care providers and pregnant women. During the observations, it was the responsibility of the shadowed care providers to clarify the presence of the researcher and ask pregnant women for consent. In this study we do not include any data from pregnant women who did not provide consent. This study was exempt from an ethical approval in the Netherlands as it did not require respondents to take any specific actions (such as taking blood tests). For more information, please see the Dutch CCMO (Dutch Central Committee on Research Involving Human Subjects) website: http://www.ccmo.nl/nl/uw-onderzoek-wmo-plichtig-of-niet.nl

Analysis

The analysis of the interview transcripts and observation field-notes was conducted to identify coordination challenges. We used directed content analysis in order to create codes for the analysis. This means that key concepts derived from existing literature are used to form pre-set codes. Directed content analysis was chosen as it is suitable when trying to support existing theoretical frameworks, or when applied to a novel context. [17] We used key concepts of the organizational-design perspective to identify codes for organizational structures. Examples of these pre-set codes are 'obstetric protocols' and 'midwifery guidelines'. [8] Sketching the organizational structures can help to un-

derstand the context within which coordination practices occur. Drawing on research from the coordination-practice perspective, we used Gittell's relational coordination theory to derive codes for interprofessional communication, such as 'mutual respect' or 'frequency of contact'. [8, 9]

During the coding process of the first eight interviews, we also used emergent codes in order to facilitate a possible extension of the existing literature. The customized coding list (containing pre-set and emergent codes) was used to analyse the remaining interviews and field-notes. All analyses were done using ATLAS.ti 7. To increase the trustworthiness of our interpretation of the data, we reviewed the pre-set and emerging concepts with midwifery and obstetrics providers during both the fieldwork and the analysis phase. The fourth author, a non-practicing community midwife and a colleague of the first author, a gynaecologist, also provided valuable feedback as experts from the field regarding whether the codes adequately represented the empirical data. All of the quotes used were translated into English by an English native speaker, and then translated back into Dutch by a Dutch native speaker to check for consistency. The analysis performed on the data collected allowed us to identify patterns of coordination in midwifery and obstetrics in the Netherlands. We paid attention to both the respondents' perception of coordination, and the actual coordination routines as we saw them unfold.

RESULTS

We found that all caregivers interviewed mentioned a variety of factors they currently employ to facilitate coordination. Most frequently cited were multidisciplinary meetings in 'collaborations in midwifery and obstetrics' (*verloskundige samenwerkingsverbanden*), which allow for deliberation between community midwives and obstetrical caregivers regarding the organization of care and the care for specific pregnant women .In order to indicate areas for improvement, we focus on commonly cited and observed unmet coordination challenges. Figure 4 (see 'discussion') provides an overview of the most commonly identified problems. For an overview of the number of respondents who mentioned these specific problems, see additional file 2 in the appendix.

The results indicate that the current system of midwifery and obstetric care makes it challenging for community midwives and secondary obstetric caregivers to achieve coordination. As an obstetrician explained: "These two systems [of care], they don't understand each other". Coordination problems mostly emerged during referral from one level of care to another level. According to national data, these referrals occur frequently in the Netherlands: in 2012, approximately 32.9% of women who started care at the primary level switched to the secondary or tertiary level of care before the onset of labour.

The current ***organizational structures*** seem to separate community midwives and secondary caregivers and often do not encourage joint deliberation. For one, the current obstetric guidelines classify women into one level of care. They do not arrange for shared care, where a pregnant woman could be, for instance, seen by both a community midwife and an obstetrician. The obstetric guidelines do leave room for deliberation between the levels of care, but this is primarily employed to decide which level of care a pregnant woman belongs to.

Next to these guidelines, there is also a clear physical separation between community midwives and secondary caregivers, as community midwifery practices are mostly located in neighbourhoods, away from hospitals. As such, formal and informal contact between primary and secondary caregivers typically does not take place on a daily basis during the antenatal phase of care. Moreover, community midwifery practices and hospitals use different and non-compatible maternity notes (also referred to as antenatal notes or patient files) systems. The process that most hospitals and community midwifery practices use for exchanging information relating to pregnant women involves several steps (see text box 1).

Text box 1

Community midwives print out a summary of their maternity notes and ask the pregnant woman to hand this to the secondary caregiver. This document is then scanned and added to the hospital maternity notes. Should a pregnant woman move back to the community midwife, secondary care-providers update the responsible community midwife via telephone, fax, email or post, by providing a summary of their maternity notes.

Moreover, community midwifery practices and most secondary hospitals are financially autonomous, which means that their income partially depends on the number of women in their care, and the type of care provided. Caregivers explained that this could lead to an incentive not to refer women to other caregivers. Without exception, all caregivers stated that this created an unwanted situation of competition and discouraged collaboration.

Different ***perspectives*** on antenatal health also seem to separate community midwives and secondary caregivers. An insightful illustration of this is that community midwives refer to pregnant women as 'clients' and secondary caregivers use the term 'patients'. Community midwives emphasized that pregnancies are a fundamentally physiological process. As an obstetrician observed (text box 2), this made some community midwives reluctant to collaborate with secondary care. Some secondary caregivers also reported that they felt that they did not speak the same 'language' as community midwives and therefore did not always understand each other. On the basis of our interviews and observations, we found that obstetric caregivers tend to use more 'medical' terms to convey the same meaning. Several obstetricians explained that frequent contact with

Text box 2

"I think that [community midwives] are definitely in support of working with secondary care, but for now the perceived threat that pregnant women will be medicalized is way too big, this clashes with their ideas of a physiological birth." (Obstetrician)

community midwives in multidisciplinary meetings ('obstetric collaborations') helped to overcome the feelings of frustration resulting from different perspectives on antenatal health.

The current state of ***interprofessional communication*** also hinders the achievement of coordination in Dutch midwifery and obstetrics. For one, we found that *shared knowledge* between primary and secondary care-providers was partially missing. All community midwives reported being somewhat familiar with what secondary obstetric caregivers do. Hospital-based midwives who used to be community midwives were highly knowledgeable about both 'worlds'. However, many (resident) obstetricians stated that they were largely unaware of what community midwives actually do, including how they screen for risks. This also became apparent during our observations. In addition, almost all caregivers stated that there was *inaccurate communication* during referrals and consults, where essential information related to pregnant women was not referred correctly and/or completely, or not transferred at all.

All caregivers mentioned *mutual respect and trust* between community midwives and obstetricians. The issue of respect was particularly emphasized by community midwives, and commonly associated with a perceived hierarchy. Frequently mentioned issues were: obstetricians not taking the medical opinion of midwives seriously, a lack of trust between community midwives and obstetricians and a feeling of being in competition with each other. We also found that the abovementioned elements - fragmented organizational structures, different perspectives on antenatal health and problematic interprofessional communication - are intertwined. This is illustrated by the following situation (see text box 3), where not seeing how other professions work due to infrequent face-to-face contact was intertwined with a lack of shared knowledge of each other's policies and consequently not trusting the other professional.

Textbox 3

A community midwife reported that when she transferred a client to a specific hospital, the secondary caregivers always re-ordered the laboratory blood measurements, even when she had sent them the results of blood tests she had recently ordered herself. She felt that this was a sign of lack of trust in community midwives, and that she did not want to work with the hospital anymore. However, interviews with obstetricians from this very hospital revealed that it was hospital policy to always re-order blood measurements from any external care unit. The community midwife was not aware of this hospital policy.

Pregnant women as communicators

We found that pregnant women at times needed to compensate for suboptimal coordination between community midwives and secondary caregivers. As already indicated above, one major area of suboptimal coordination is the transmission of information related to pregnant women between midwives and secondary care professionals. Pregnant women who were referred between primary and secondary care sometimes forgot to take a hardcopy of their maternity notes with them. When this happened, professionals did not have immediate access to these notes due to the lack of a shared digital maternity notes system in Dutch obstetrics and midwifery. Even when the maternity notes were transferred correctly between primary and secondary care, the contained information was not always accurate. During our observations and based on the interviews, we found that professionals frequently dealt with these coordination problems by asking pregnant women to provide information about the care received at the other care level, and sometimes the results of relevant tests. These questions went beyond the standard intake questions that are routinely asked after referral. During our observations, and based on the perception of the interviewed professionals, some women had difficulty answering these questions – especially regarding the specific results of tests that had been done.

Based on our interviews, women not only transmitted information, but also needed to correct or add information in the process of referral from one level of care to the other. For example, a woman had had a previous child with a metabolic disease. This information was known to the community midwife, but not conveyed to the obstetrician who later on became responsible for the care of the woman. The obstetrician only discovered the history of metabolic disease because the pregnant woman had mentioned it.

DISCUSSION

Our research indicates that community midwives and secondary obstetric professionals at times work in fragmented worlds. This fragmentation can be understood from an organizational-design perspective, as we identified problematic organizational structures, such a lack of a shared maternity notes system and misaligned financial incentives. Additionally, in line with the more recent studies taking a coordination-practice angle, the results show that there were also a number of coordination practices that made coordination difficult. Important were different perspectives on antenatal health and suboptimal interprofessional communication. Thus organizational structures and coordination practices hindered caregivers in achieving optimal coordination. These challenges also exist outside of Dutch midwifery and obstetrics, and have been shown to have adverse effects on organizational efficiency and effectiveness. [1, 8, 18]

An unexpected finding of this study is the communicative role of pregnant women in support of interprofessional coordination. Pregnant women played a role in transferring and correcting information between community midwives and secondary caregivers. This is an outcome that none of the caregivers in our study aimed for, but seems to be the result of a number of currently suboptimal coordination practices, as outlined in this article.

As pregnant women support coordination between community midwives and secondary caregivers, they may be experiencing tensions similar to 'boundary spanners'. [19] Pregnant women who are able to effectively communicate might help facilitate coordination between separate organizations. However, we expect that women who are less educated and/or not fluent in Dutch have more difficulties fulfilling this communicative function. Therefore, these women might be particularly disadvantaged. This may contribute to the existing perinatal health disparities associated with socio-economic status in the Netherlands (see introduction).

Having pregnant women take on a communicative role in situations where they might not fully be able to do so is not only problematic in the setting of Dutch midwifery and obstetrics, but in the entire health care sector. Health care professionals are highly specialized, and clients are typically without expert knowledge. In the case of Dutch midwifery and obstetrics, this imbalance in expertise makes it very challenging for pregnant women to understand and accurately engage with the information received from caregivers and navigate through oftentimes complex and fragmented systems of care.

The communicative role of clients/patients is a central theme in the field of 'patient participation', which is expected (but thus far rarely proven to) increase quality of care, care outcomes and ultimately, patient empowerment. [20-22] However, it does not seem that the findings of our study are examples of patient participation. At the lower end of the patient empowerment scale, participation is seen as informing pregnant women so that they are able to join in discussions about their condition. At the higher end of this scale, participation is conceptualized as enabling clients/patients to join in the decision-making process. [21] The findings in our study did not include joint decision-making. Pregnant women did not *receive* information for the purpose of greater participation, but actually they were *transmitting* information in situations where there was presumably an expertise gap between them and the professional.

Next to studies on patient participation, studies on coordination focus on the *effect* of coordination on clients, such as on patient satisfaction or clinical outcomes. [9, 13] For instance, Gittell's model of relational coordination is increasingly used to assess coordination practices, but it does not include a possible communicative role of the client. [9] As such, the coordination literature currently treats clients as merely recipients, rather than as supporters or even as co-producers of coordination. This study indicates that research on coordination should incorporate the experiences of clients. The term

'stake-holder coordination' would be more apt in incorporating the role of clients in coordination processes than the currently used term 'interprofessional coordination'.

Practical implications

We found that pregnant women are at times required to take on a communicative role to facilitate coordination. This might be an additional indication for the need - already felt by the professionals - to improve coordination in Dutch midwifery and obstetrics. Fortunately, a large number of initiatives are currently in place to improve coordination in Dutch midwifery and obstetrics. Based on the results of this study, we recommend a number of measures that could help improve interprofessional coordination and thereby minimize the necessity for pregnant women to take on a communicative role in support of coordination, as outlined in figure 4.

We recommend more frequently scheduled face-to-face meetings with both midwives and hospital-based caregivers in order to discuss and improve coordination practices as well as the care pathways for women that would benefit from shared care, i.e. the involvement of more than one level of care. [23] Such meetings are already in place in some areas and could increase interprofessional communication, such as mutual trust and shared knowledge. [18] This could concurrently be achieved by implementing training in interprofessional teamwork and education. [24, 25] In terms of education, we recommend that the training of resident obstetricians include time spent at community midwifery practices. Moreover, we support the current movements in the Netherlands towards a shared maternity notes system for all levels of care, as is in use in part of the UK. [3, 26]

A concurrent strategy would be to improve the communicative capacity of pregnant women so they are better equipped to support interprofessional coordination, if they need to. This could be done by exploring ways of making provider-information more accessible to pregnant women, facilitating more dialogue between pregnant women and providers, and increasing health literacy. Although effectiveness studies remain scarce [20], some potentially interesting interventions exist, such as www.mijnzorgnet.nl $_{B}$ a website that allows clients, their social network and providers to share and discuss health-related information. However, it should be noted that increasing the communicative capacity must only be seen as a potential complimentary strategy. Pregnant women cannot be expected to master the technical knowledge in order to fully navigate the midwifery and obstetrics system and the prevailing medical expertise.

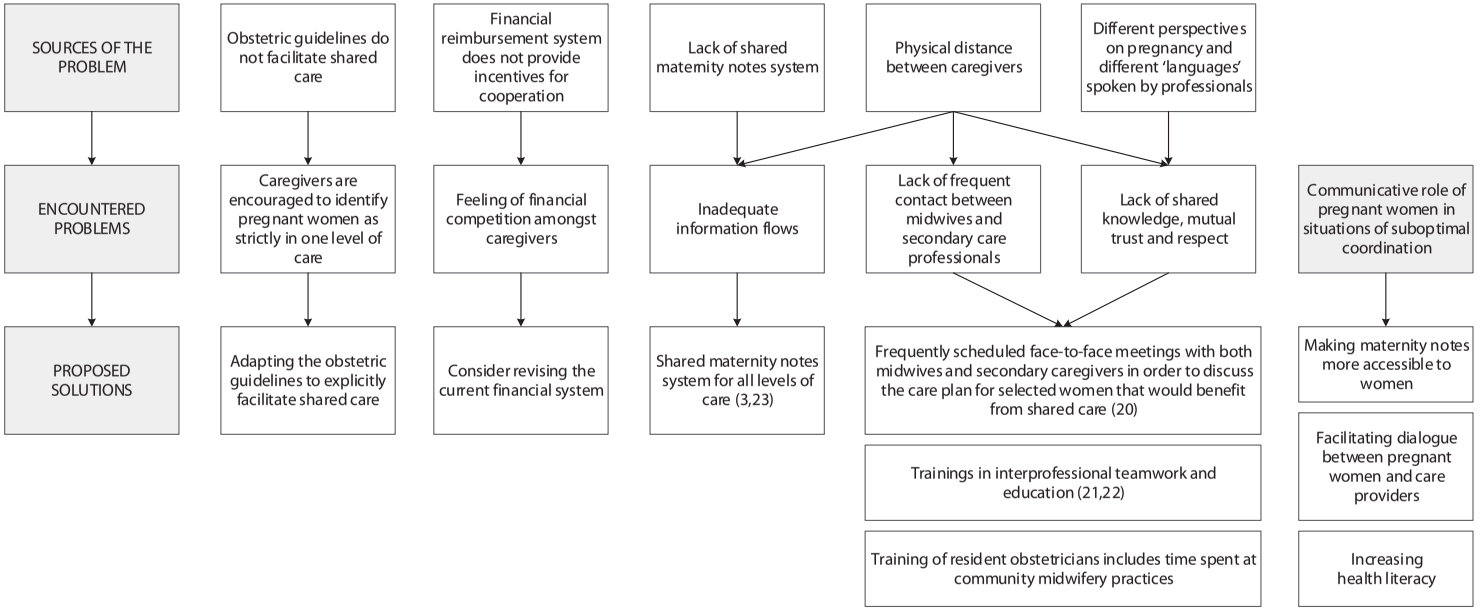

Figure 1. Sources of the coordination problems, encountered problems and possible solutions. This figure summarizes the identified sources of a given problem and the encountered problems, based on the findings of this study. Moreover, it indicates possible solutions suggested by the authors. It should be noted that the currently encountered problems (middle row in the figure) are seen as contributing to the problem of 'communicative role of pregnant women in situations of suboptimal coordination (far right in the figure). The arrows indicating this have not been added in order to reduce figure complexity.

Limitations & future research

While we conducted a relatively large number of interviews, we only spent several days doing observations of obstetric practices, which is brief compared to traditional standards. The scope of this study was the region of Rotterdam. This was done in order to provide a detailed picture of local coordination challenges. Whilst the results cannot be generalized, we believe that they do indicate possible areas in need for improvement in midwifery and obstetrics in the entire Rotterdam region and in other regions in the Netherlands. This is because almost all of these regions have autonomous yet interdependent primary and secondary care systems; and the organizational structures that complicate coordination in Rotterdam such as lack of a shared maternity notes and physical distance can also be found elsewhere in the country. [3]

We recommend extending the scope of coordination studies to include a broader range of coordinating stakeholders. This could be done by studying the coordinating roles of other professionals, such as nurses, general practitioners and managers. Moreover, it would be interesting to conduct interviews and more observation moments with pregnant women themselves in order to better understand the role they play within coordination processes. Lastly, it would be interesting to conduct studies on the role of clients in the coordination process in other health care sectors.

CONCLUSION

This study indicated coordination challenges within Dutch midwifery and obstetrics in the realm of organizational structures, perspectives on antenatal health, and interprofessional communication. An unexpected finding of this study is that some pregnant women played an active role in communicating in situations of suboptimal interprofessional coordination. We argue that these findings underline the urgency to improve coordination. We recommend increasing multidisciplinary meetings and training, revising the financial reimbursement system, implementing a shared maternity notes system and decreasing the expertise gap between providers and clients. Moreover, monitoring the manner in which clients actively communicate due to imbalances in the coordination of care should garner more attention in future research.

Endnotes

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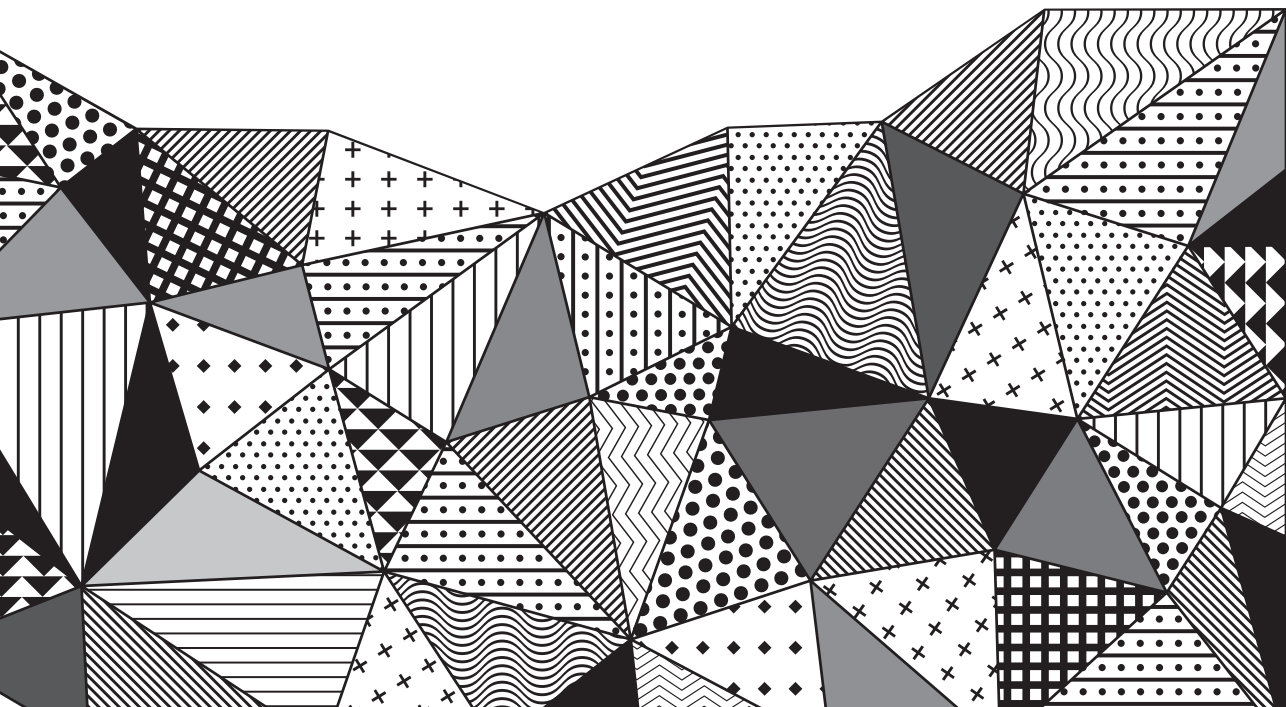
APPENDIX

See the open access version of this article to access Additional file 1 and 2:
http://www.biomedcentral.com/1471-2393/14/145

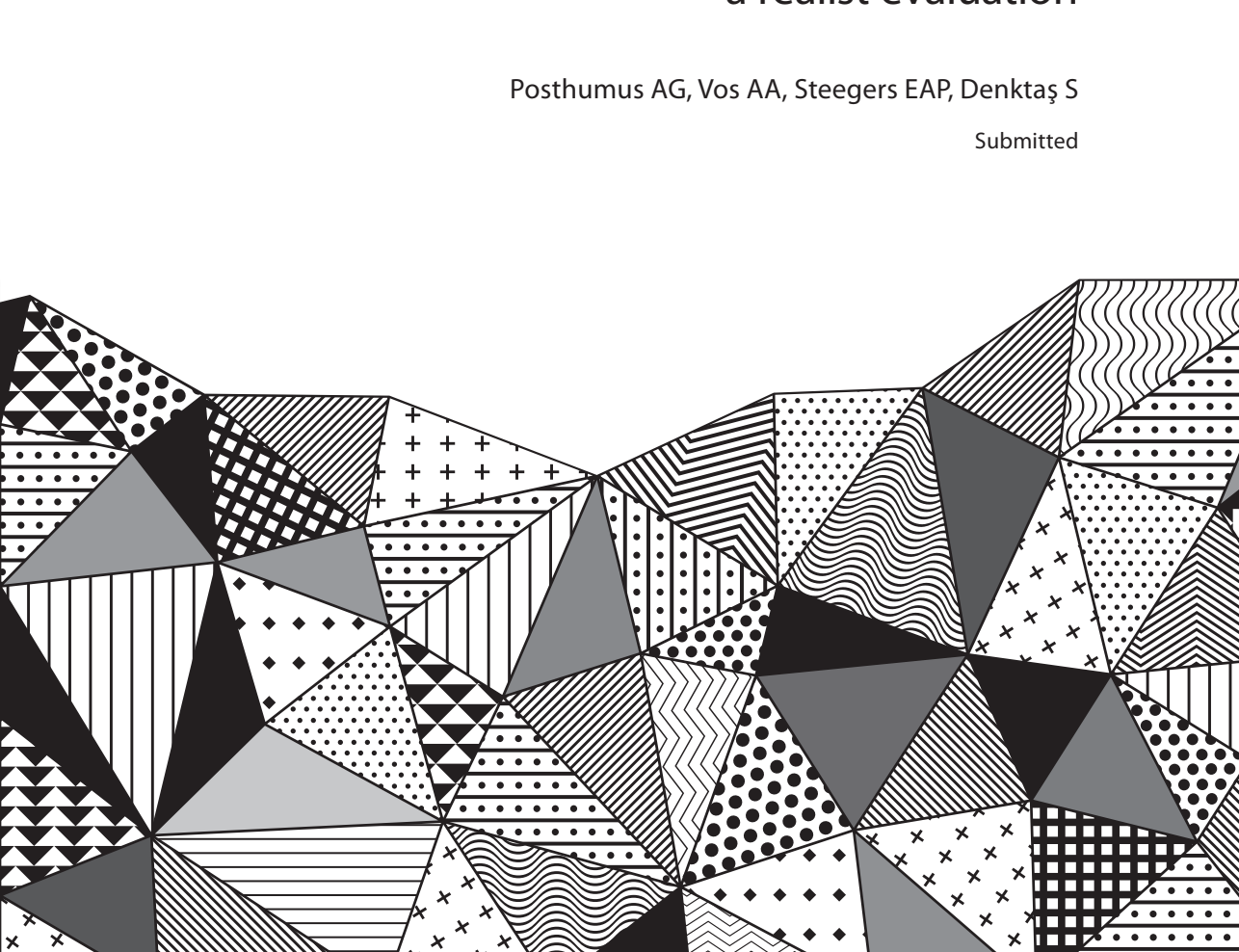


Chapter 8.3

Shared Care in obstetric care in Rotterdam: a realist evaluation

Posthumus AG, Vos AA, Steegers EAP, Denktaş S

Submitted



ABSTRACT

Background: Perinatal mortality rates are relatively high in the Netherlands and differ substantially within the country. More specifically odds of fetal and neonatal mortality are significantly higher in deprived neighbourhoods than in more affluent areas. These inequalities are caused by an accumulation of individual level medical and non-medical risk factors. To reduce the absolute number of adverse perinatal outcomes and the relative inequalities, several changes in obstetric care were required. These included improved risk detection and risk reduction, and improved collaboration between obstetric caregivers. To achieve these goals in the city of Rotterdam, a new risk detection tool, the Rotterdam Reproductive Risk Reduction scorecard, was implemented in both midwifery practices and obstetric departments in hospitals in the area. The implementation of this tool and the associated shared actions for risk reduction (care pathways) were evaluated in order to deduct lessons from it for future interventions.

Methods: The implementation was evaluated using the framework of the realist research cycle. This approach attempts to find an answer to the question 'what works for whom in what circumstances and in what respects, and how?' An initial theory on how the programme worked was developed based on interviews with stakeholders (n=10). The programme theory was tested using both quantitative and qualitative data. Based on caregivers' experiences (n=28) with the intervention, contexts and mechanisms that led to both expected and unexpected results of the intervention were explored. The initial programme theory was then refined, leading to so-called refined context-mechanism-outcome-configurations for this intervention.

Results: The geographical location of the study site (urban / rural) was the most relevant context in this intervention. The geographical location was associated with the risk load in the patient population. In urban areas, caregivers were confronted with increased numbers of high risk women. In contrast, the opposite was the case in rural areas. The awareness of the infrequent occurrence of risks (mechanism) led to demotivation of caregivers in these areas (outcome). Additionally, the pro-active detection and reduction of risks was expected to be time-saving (mechanism), the contrary was the case. Higher engagement (outcome) occurred at study sites where increased collaboration between midwives and obstetricians already occurred (mechanism). Media and policy attention for adverse outcomes and risk detection also had beneficial effects. Lastly, the perception on pregnancy of caregivers mattered. Some feared that additional risk detection would lead to a further departure from the concept of pregnancy as a physiological process (mechanism).

Conclusion: In the implementation of a complex intervention to improve risk detection, risk reduction and collaboration in obstetric care, the geographical location as a proxy for patient population was the most important context, shaping the engagement of

caregivers. This, and the other contexts and mechanisms in this study, form an important point of departure in the future implementation of comparable interventions, within and outside obstetric care.

INTRODUCTION

Background

Birth outcomes in the city of Rotterdam were suboptimal in comparison to other parts of the Netherlands. [1] Moreover there were unacceptable differences in birth outcomes within the city, with some neighbourhoods having sixteen fold increased perinatal mortality rates compared to other neighbourhoods. [2] These disparities could largely be attributed to individual risk differences in pregnant women. [3] Contrary to prior dominant beliefs on the sole importance of medical risk factors, Timmermans and colleagues demonstrated the additional importance of psychosocial (non-medical) risk factors in adverse birth outcomes.[3] From this followed that in order to reduce inequalities in birth outcomes, there was also a need to assess and then reduce non-medical risk factors, such as psychosocial risk factors, in pregnant women. This was also acknowledged in national reports on the improvement of birth outcomes nationwide. [4, 5]

Additionally these reports underscored the importance of collaboration between the different caregivers. The Dutch obstetric care system is divided into three distinct tiers. The first consists of autonomously working community midwives, the second and third of obstetricians in hospitals. Low risk pregnant women receive care exclusively from a community midwife. When risks (threaten to) occur during pregnancy, labour or puerperium the woman is referred to an obstetrician in the second tier of care. The third tier is reserved for severely ill women and threatened pregnancies. [6] The distinction between low and high risk is made based on the 'Obstetric Indication List', which states per risk factor whether care should be provided by a community midwife or an obstetrician. [7] Because there is a strong demarcation of responsibilities between these professionals, there is relatively little sense of urgency for extensive collaboration. A prior study on coordination between the tiers of care, showed that other sources of this problem include a lack of shared guidelines, physical distance between the different caregivers, a different perspective on pregnancy and differences in 'language' spoken by professionals. [8] Additionally, because all tiers of care were primarily focussed on medical risk detection and not on non-medical risk detection, there was also little collaboration with other partners in the public health field.

In order to improve birth outcomes in the city of Rotterdam 'the Ready for a Baby' programme was developed by policy makers and health care professionals in 2008. [9] This programme consisted of a number of experiments embedded in different parts of

the obstetric chain of care. One of these projects focused on the development of an instrument for medical and non-medical risk detection early in pregnancy that could be used by both community midwives and gynaecologists: the Rotterdam Reproductive Risk Reduction (R4U) scorecard. [10] To implement this R4U scorecard in routine practice in the Rotterdam area, the Shared Care pilot program was launched in 2011, embedded in the Ready for a Baby program. This program aimed to simultaneously introduce uniform medical and non-medical risk detection for all pregnant women and to improve collaboration amongst obstetric care professionals and between obstetric care professionals and caregiver in other public health domains. Additionally, these outcomes were expected to contribute to the overarching goal of reducing adverse perinatal outcomes. This was however not the primary focus of our pilot programme.

Shared Care pilot programme

The complete Shared Care pilot program consisted of three interventions: 1) the R4U scorecard; 2) subsequent care pathways; and 3) multidisciplinary patient deliberations. The R4U scorecard is a tool to detect both medical and psychosocial risk factors associated with adverse birth outcomes. [10] More specifically these adverse outcomes are preterm birth (<37 weeks of gestation), small for gestational age (birthweight < 10^{th} percentile for the weeks of gestation), low Apgar score (score <7 at five minutes after birth) and congenital anomalies. The scorecard consists of 73 risk factors, categorized into six domains (social, life style, ethnic descent, care, general medical, obstetric), which are filled out with a 'yes'/'no' by the caregivers during the pregnancy booking visit. During the programme period it was available on a secure website, for which participating caregivers received a password. The scorecard is based on the principle of risk accumulation: the presence of a combination of smaller less significant risks may also lead to an overall increased risk for adverse birth outcomes. Therefore the R4U scorecard includes a weighted score system, in which the individual woman's risk profile is translated into a sum score.

To reduce adverse outcomes, there was a need to act upon risks that are present. Therefore for each individual R4U-risk, a blueprint for a care pathway was developed. Care pathways aid caregivers in organizing concrete support for specific risk factors, e.g. a safe house for women who are confronted with domestic violence or a coach for women with mental disabilities. The blueprints were adjusted by a working group of local caregivers to the local situation within an Obstetric Collaboration (OC). OC's consist of both tiers of obstetric care: the obstetricians of a single hospital and all surrounding community midwives referring to this hospital. The OC's meet on a regular basis (1) to discuss policy, (2) to participate in audits of perinatal mortality cases and cases of severe morbidity and (3) at times meet to discuss individual patient cases. The care pathways were uniform for all obstetric caregivers within an OC. A care pathway could

be deployed for a patient if the caregivers felt it was suitable in this specific case and the pregnant woman consented in receiving the proposed help or referral as stated in the care pathway.

Finally, multidisciplinary patient deliberations were meant to bring together community midwives, obstetricians and if necessary other caregivers to discuss policy for high risk pregnant women. The woman's risk level could be determined by the sum score she had on the R4U scorecard. At the OC level a cut-off score could be determined, above which women were discussed.

All community midwives and obstetricians in the city of Rotterdam were invited to participate in the Shared Care program. They were approached via the OC's. If the obstetricians and a number of community midwifery practices were willing to participate, the program was implemented at these hospitals and practices. All practices and hospitals received an instruction on the use of the digital R4U scorecard by the principal investigator (AP). New caregivers at already-participating locations were either instructed by the investigator or by colleagues, depending on how confident the latter felt about their abilities. All caregivers were also invited to participate in the care pathway working groups, a selection of caregivers was willing to do so.

Realist evaluation

This Shared Care programme can be seen as a complex intervention. These interventions are often defined as "interventions that contain several interacting components". [11] This is the case for the Shared Care programme. Additionally the number of activities required by the caregivers delivering the intervention, the variability of the outcomes and the permitted tailoring of the programme make Shared Care a complex intervention.

Traditionally interventions are evaluated using a 'black box' method, in which the investigators are only interested in whether the intervention has an impact on outcomes. [12] However, extrapolation of these findings to other contexts is difficult because the specific contextual conditions and mechanisms that have led to the achievement of the result have not been investigated. [13] In the past years 'white box' methods or 'theory-driven' evaluation have therefore gained in importance. In these methods the focus is not only on implementation and effectiveness of an intervention, but also on the causal mechanisms and contextual factors that lead to change. [14] Theory-driven evaluation is guided by a conceptual framework, program theory. Program theory consists of the implicit and explicit assumptions of the stakeholders of a program on what actions need to be taken to solve a particular problem and why these actions will help to solve or reduce the problem. [14]

One form of theory-driven evaluation is realist evaluation. Realist evaluation does not ask 'what works?' but asks 'what works for whom in what circumstances and in what respects, and how?' This information is important to gain a better understanding of how

a programme works, how it can be improved and how it can be translated to other locations or situations. Realist evaluation sees programmes as embedded in social systems. The social relations and characteristics within and surrounding a programme need to be taken into account because these influence the workings of the programme. These may include the position of participants within an organization or the organizational culture. Also, programmes are active. This means that programmes are influenced by the interpretation of their subjects. The subjects' desire to participate or the lack of it, 'contaminates' the outcomes of the programme. Lastly, programmes are open systems. This means that external influences such as political change or media attention may lead to changes in the programme itself. [15]

Based on the above mentioned notions of what programmes are, the following 4 concepts have a central role in realist evaluation: 'mechanisms', 'contexts', 'outcome patterns' and 'context-mechanism-outcome pattern-configurations'. *Mechanisms* refer to the ways in which the components of a programme bring about change. [15] Often these processes are not directly visible. In realist evaluation, the potential underlying *mechanisms* of a programme (as defined by the researchers) are the hypotheses under investigation. *Contexts* are actors or factors that are not part of the intervention, but that do have an influence on the mechanisms of the programme. [16] These contexts include barriers and facilitators, and play an important part in explaining why programmes are successful in some conditions, but not in others. *Outcome patterns* refer to all intended and unintended results of the programme, following from the mechanisms in the different contexts. *Context-mechanism-outcome pattern-configurations (CMOC's)*

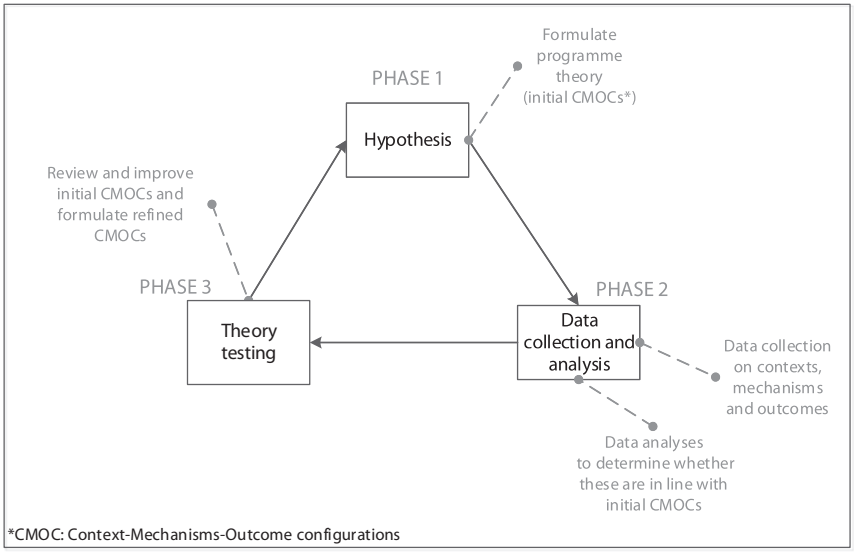


Figure 1. The realist evaluation cycle, derived from Pawson and Tilley.

bring together the individual components in models that explain which mechanisms are activated by an intervention, in whom and in what conditions and to which results these are expected to lead. These CMOC's can be subjected to investigation. In realist evaluation, programmes are evaluated using the realist research cycle which broadly consists of 3 phases (figure 1). The starting point is the programme theory or the initial CMOC's. This is derived from what is already known in the literature and from the stakeholders who developed the programme. In the second step these initial CMOC's are empirically tested, preferably using multiple data sources to enable triangulation. Based on the findings in the second step, the third step consists of improving the initial CMOC's, leading to the development of refined CMOC's. This realist research cycle can then be repeated over and over again, giving rise to a more concise programme theory each time.

In this study we investigated the Shared Care programme using the realist research cycle to gain a better understanding of the mechanisms and conditions that underlie the translation from the programme components (interventions) to the outcomes. This paper provides an account of the implementation of the programme, the variations found between the different participating sites and how these differences influenced the CMOC's under investigation. Based on these findings we then refined the initial programme theory.

METHODS

Study setting

The Shared Care programme was implemented in the Rotterdam area between January 2012 and December 2014. At the start of the programme all six OC's in the area participated. However two important organizational changes led to a regrouping of the prior six OC's into four OC's. The first event was the bankruptcy of one of the hospitals in 2013. The majority of the caregivers were then relocated to one of the three surrounding (participating) OC's. Additionally two OC's with a great overlap in midwifery practices merged at the beginning of 2014.

Study design

Phase 1 - Identifying the programme theory

Programme theory can be defined as "the stakeholder's assumptions underlying programmes, whether implicit or explicit". [14] These assumptions concern both the causal processes that are expected to occur to reach programme goals, and the actions that need to be taken to initiate desired changes. To identify the programme theory of the

Shared Care programme, 10 stakeholders who were directly or indirectly involved in the development of this programme were invited to participate in a semi-structured interview. We defined the stakeholders as being people who were directly influenced by the development of the program, or people who directly influenced the development of the program themselves. The stakeholders had different backgrounds and included municipal policy makers, a gynaecologist, a research midwife, an epidemiologist, programme directors, and senior investigators. In the interviews we asked the stakeholders about their views on the reasons for the development of the programme, the primary and secondary goals of the programme and how the R4U and care pathways were supposed to contribute to achieving these goals. Moreover we asked them for anticipated opportunities and barriers thought to be of influence on the outcomes (Appendix 1 – interview guide). All interviews were recorded and transcribed verbatim. Additional to the interviews, a documentary analysis was completed on reports and publications on the Shared Care programme and the municipal "Ready for a Baby" programme, which preceded the Shared Care programme.

Data from the semi-structured interviews and the documentary analysis, were then analysed by the principal investigator using NVivo qualitative data analysis Software Version 10 (QSR International Pty Ltd.). Themes were identified using conventional qualitative content analysis. A coding scheme on expected mechanisms, contexts and outcomes was developed inductively from the first 4 interview transcripts. From these analyses hypotheses were deducted on possible CMOCs. These were then discussed and revised with the research team (1 senior researcher, and 2 junior researchers). The resulting CMOC's were presented to five of the stakeholders for feedback. The CMOC's were then adjusted until they best fitted the data. Subsequently, the team deliberated on suitable data sources that would have to be collected to test the programme theory.

Phase 2 - Testing the programme theory

To test the programme theory both quantitative and qualitative data were collected. Through telephone questionnaires we obtained qualitative data on the views of caregivers participating in the programme. All participating hospitals (n=5) and midwifery practices (n = 17) were invited to choose one caregivers to participate in the questionnaire. If the designated caregivers was a member of the care pathway working group, another colleague from the same hospital or practice was also invited to participate in the questionnaire. This was done because working group members tend to be committed to the Shared Care programme and may not be representative for the average caregivers in the programme. The 2 midwifery practices that discontinued their participation in the programme were also invited for the telephone questionnaire to obtain balanced results in our evaluation.

The first part of the questionnaire [Appendix 2] consisted of open questions to elicit context, mechanisms and outcomes in practice:

– Experienced changes in daily practice due to the R4U and care pathways;
– Mechanisms by which these changes came about;
– Advantages and disadvantages of the R4U and care pathways;
– Barriers and facilitators in the implementation and use of the R4U and care pathways

.In the second part of the questionnaire the initial CMOC's were presented to the participants as statements. They were asked to comment on each of them. Lastly, information was asked on the experienced collaboration within the OC.

The quantitative data were collected to objectify the distinguishing characteristics of the OC's (contexts) and the degree of implementation of the programme. We derived the data from the filled out R4U scorecards, the logbooks from the care pathway working groups and the patient registries of the midwifery practices and hospitals. The quantitative data was analysed using IBM SPSS Statistics version 20.0 for descriptive statistics (IBM Corp., Armonk, NY, USA). The qualitative data was processed in NVivo qualitative data analysis Software Version 10 (QSR International Pty Ltd.). All data were investigated as a whole and then stratified by OC, so that both overarching contexts and associations in OC characteristics and underlying mechanisms could be explored.

Phase 3 - Refining the programme theory

The initial CMOCs were then compared with the phase 2 data to identify the similarities and differences. Using the same data, we defined organizational characteristics of the study sites (OC's) and explored whether sites could be grouped together in terms of these characteristics. Potential relations between the organizational characteristics, the similarities and differences between the phase 2 data and the initial CMOCs were then discussed by the research team. Based on these discussion the refined CMOC was crystallized.

Ethics and consent

Ethical approval was obtained from the Medical Ethics Committee of the Erasmus Medical Centre, Rotterdam (MEC-2013-045). Informed consent was obtained from all stakeholders, obstetric caregivers and pregnant women participating in the study.

The Shared Care project was supported by the Achmea Healthcare Foundation (website in Dutch: https://www.zilverenkruis.nl/Archief/partners/Paginas/Stichting-Achmea-Gezondheidszorg.aspx), grant number 102541.

The research team operated independently and there were no conflicts of interest.

RESULTS

Implementation of the pilot programme

Five hospitals and 17 midwifery practices participated in the pilot programme. We reached out to them via the OC's. Though participation was expected to be determined at the OC level, in practice this occurred at practice or hospital level. The intention was to implement the R4U scorecard, care pathways *and* meetings to discuss patients in all participating OC's. However caregivers were reluctant to implement all components of the program at the same time. Most were only willing to participate if components were introduced into practice one by one. At the end of the project the R4U was in place, the pathways developed but the patient deliberation meetings were not implemented at any of the sites. The use of the care pathways had commenced recently at the time of evaluation.

Phase 1 - Identifying the programme theory

We approached ten stakeholders, for the first phase of our realist evaluation cycle. All were willing to participate. Amongst them there was consensus that the two primary goals of the Shared Care project were: 1. improving the awareness and ability of obstetric caregivers to act on non-medical risks; 2. contributing to improved collaboration between these caregivers.

In order to reach these goals, a number of different expected contexts and mechanisms came to the fore which are summarized in figure 2. First, the demarcation between the first and second tier of care was mentioned, in part caused by different views on pregnancy and child birth. These views lead to differences in professional language used between the two tiers of care. The R4U was expected to enhance uniformity in language on non-medical risks and univocal communication, because all professionals use the same risk detection tool. In the current system, risk detection is primarily focussed on medical risks, and patients are less likely to be asked about non-medical issues. Therefore caregivers are unaware of the prevalence of these issues amongst their patients. By filling out the R4U for all patients, caregivers do ask these questions and the stakeholders expected this to lead to better professional insight in the risks within their patient population. Additionally, the R4U and care pathways were expected to reduce the time necessary to organize suitable help for social issues. Previously, non-medical risk factors would come to the professionals' attention in the course of pregnancy, labour or puerperium. Often help would have to be organised under time pressure or at inconvenient hours (e.g. at night). By screening all women for risks early in pregnancy, there is time to deliberate on a proper action plan and fewer last-minute or emergency social interventions are necessary. Therefore it was anticipated that overall, using the R4U would save time. Because the focus in obstetric care was primarily on medical risks,

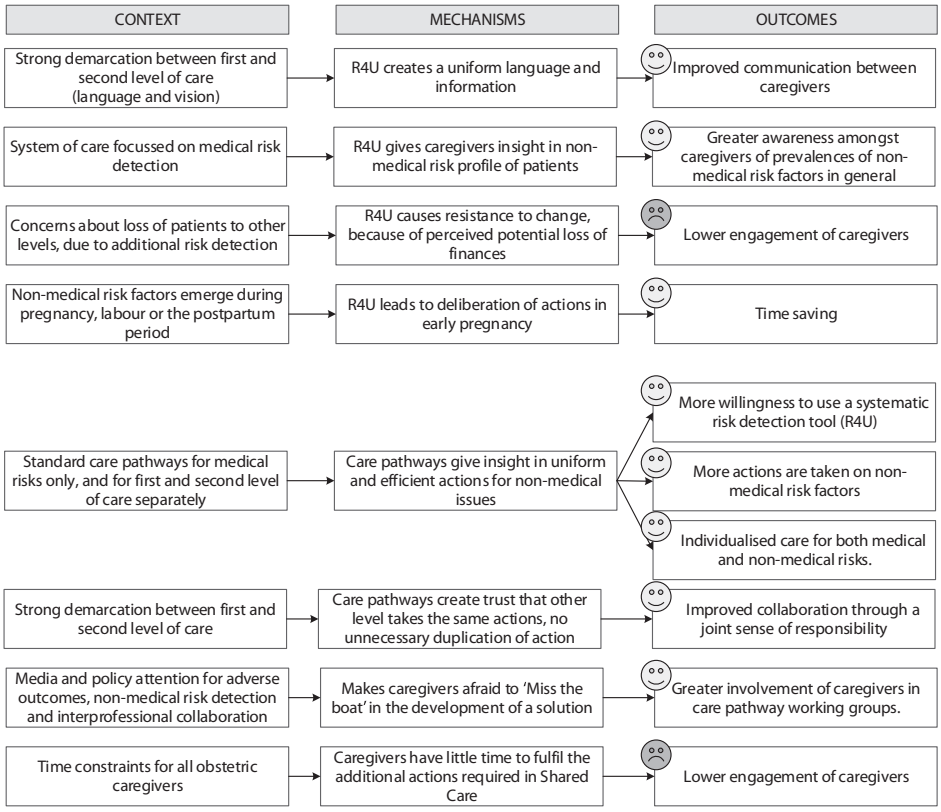


Figure 2. Initial Context-Mechanism-Outcome configurations for the Shared Care project.

professionals have little experience in dealing with most of the non-medical issues. The care pathways were designed to close this gap. It was envisaged that the availability of these care pathways would make professionals more willing to work with the R4U screening tool: based on the care pathways the professionals know what to do with the detected risks. It was also anticipated that more actions would be taken because of the availability of the care pathways. Lastly, the care pathways were expected to improve collaboration between the care tiers because they contain shared decisions on necessary actions. Collaboration was envisaged to be enhanced through an improved sense of trust that all professionals will take the same action and no unnecessary duplications of actions occur (e.g. running lab tests twice).

The stakeholders also gave their views on the barriers and opportunities they expected. The first expected barrier was time constraint. Time at the pregnancy booking visit is already limited and professionals were expected to feel discouraged to include the extra screening tool and care pathways without receiving extra time to do so. The second barrier was the expected perception of competition for patients between the tiers of

care. Extra risk detection could lead to more referrals, loss of patients and therefore loss of income. Caregivers may therefore feel less inclined to screen for these additional risks. On the other hand, an important potential incentive for caregivers to participate in the project was the media attention for both adverse perinatal outcomes and for the perceived lack of collaboration between the different groups of obstetric caregivers. This attention would lead to a greater understanding that changes are necessary and inevitable. It was believed that caregivers would prefer to be part of the change at an early stage, in order to have influence from the start.

Phase 3 - Refining the program theory

To distinguish contexts that were relevant in the way the intervention played out, we identified a number of different characteristics of the study sites (site A, B and C). The study sites are not a one-on-one reflection of the OC's. Site A is a combination of two OC's. These OC's do collaborate, but not extensively. There is an almost complete overlap between the midwifery practices and therefore their patient populations. This would lead to a duplication of results if the two OC's were to be presented separately. Table 1 shows quantitative characteristics and outcomes per study site. Most notably site C has

Table 1. Characteristics and outcomes of the three study sites (consisting of a total of 4 OC's).

	Site A[1]	Site B	Site C[2]
Geographical location	Mostly urban	Mostly urban	More rural
Integration of care tiers	Not integrated	Not integrated	Integrated
Socioeconomic status	Low and high	Low > high	High
Number of hospitals	2	2	1
Number of midwifery practices	7	6	4[1]
Participation in care pathway meetings	All practices	Delegation	Delegation
Number of R4U's filled out	1363	268	330
% of eligible women with filled out R4U	32.5[1]	9.1	23.5
Median[3] number of risk factors per patient (range)	4 (0-20)	6 (0-23)	4 (0-16)
Median[3] number of non-medical risk factors per patient (range)	1 (0-17)	2 (0-20)	1 (0-8)
Number of interviewees	13	8	7
% locations continuing R4U and care pathways in the future	82	73	88

[1]The hospital at this study site has a large regional function: only a small sub-selection of women was eligible for participation. Reliable denominator data is not available and therefore data of this hospital has been excluded for this calculation.

[2]At this OC the first and second tier of care are completely integrated. However 1 autonomous midwifery practice remained. Additionally, after the bankruptcy of another hospital, 3 extra midwifery practices became members of this OC.

[3]Because the data is skewed, we present the median number of risk factors per patient.

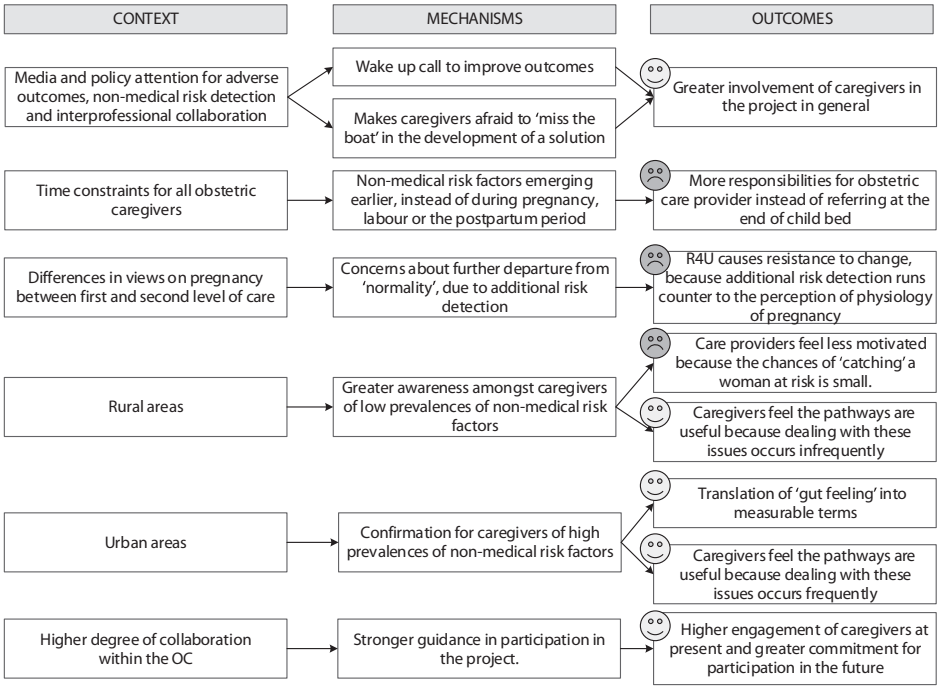


Figure 3. Refined Context-Mechanism-Outcome configurations for the Shared Care project.

a more rural patient population than site A and B. Additionally the percentage of women that did not fill out an R4U differs considerably per study site. Intention to continue the use of R4U and care pathways was high at all sites (73-88%).

In refining the program theory we distinguished between refined initial CMOC's and new CMOC's that emerged during the intervention. Additionally part of the CMOC's could be identified at all study sites whilst others were study site specific. The refined CMOC-configurations are summarized in figure 3.

Refining the initial CMO-configurations

The media attention on adverse perinatal outcomes was experienced as an important wake-up call, in terms of outcomes and the need to act, for others as the starting point for changes to come. All felt the importance of being involved. Two reasons were mentioned: 1) the need to improve perinatal outcomes, and the R4U and care pathways were a plausible way of doing so; 2) the momentum for Shared Care was growing. Those who were sceptical felt uncomfortable about not participating because the approach would be further developed without them.

In general, the R4U was seen as a useful tool to improve communication between the first and second tier of care at all three sites. However, most notably at site A and

B caregivers felt the R4U was a starting point, but improvement in communication still had a long way to go. Improving communication on one aspect of care, in this case non-medical risks, had not necessarily improved communication on other aspects. At site C, the R4U had only mildly enhanced communication, because communication between the tiers of care was already experienced as good.

Using the R4U had however helped to gain more insight in the presence of non-medical risk factors. This gain was larger for second tier caregivers than for autonomous working midwives. Many of the autonomous working midwives described having a more comprehensive approach, already taking social aspects of health into account. When using the R4U during their pregnancy booking visit, only a few additional questions had to be asked. A stance amongst part of the midwives was however that a focus on even more risk factors in pregnancy would lead to a further 'medicalization' of pregnancy, leading to further departure from normality.

Hypothetically additional risk detection could lead to more referral to the other tier of care and thus to financial loss. This had not withheld caregivers from participating in the project. Many did however understand why others might be cautious. The general tendency amongst both midwives and gynaecologists was that referral because of non-medical risk factors should not be the primary incentive. The starting-point has to be the pregnant woman and care should be delivered wherever it is best suited for her.

Using the R4U did not lead to a reduction in time spent on non-medical issues. It was felt that even though early risk detection did benefit the pregnant woman, in some cases it meant a lot of extra work for the caregiver. Without the R4U, risk factors might have gone completely unnoticed or would have been detected during puerperium and then communicated to third parties (i.e. child consultation clinic) for further follow-up. Because of detection during early pregnancy it became the obstetric caregivers' problem. Some respondents felt that the extra time investment was indeed a barrier and that financial reimbursement for this extra investment was necessary. Others felt the opposite, feeling that if the extra time invested in their patients led to better care, it was their duty to do so. Caregivers who already had an extensive intake at the pregnancy booking visit, felt that the R4U did not alter the amount of time spent.

The presence of care pathways to address the risk factors in the R4U, was expected to lead to a greater willingness to use the R4U. In practice, caregivers felt the R4U was more valuable when combined with the care pathways, but using the care pathways did not necessarily entail using the R4U first to detect the relevant risk factors. Some considered it an option to quit using the R4U in the future and to consult the care pathways when confronted with a risk factor. There was however general consensus that the presence of care pathways leads to more actions being taken. Whether the care pathways contributed to 'individualised care' was also topic of debate. The care pathways addressed individual risk factors, not individual patients. Therefore they were seen as protocols.

Some felt they had to be adhered to strictly, while others used them as a reference guide. Those who felt the need to adhere to the pathways strictly, found it disappointing that other caregivers chose not to do so. On the other hand, caregivers who wished to use the pathways as a reference guide felt threatened in their autonomy if the steps in the pathways became obligatory. Most interviewees felt that if all interpret and use them in the same way, the care pathways would help to improve trust.

Emerging CMO-configuration

The geographical location of the OC's proved to be an important context for the way in which the intervention played out. Two OC's were located in a more urban area (site A and B) and one in a rural area (site C). The rural area was characterised by a relatively high socioeconomic status and fewer adverse outcomes. In the urban area socioeconomic status was lower and the prevalence of adverse outcomes was higher. Site A provides services to both affluent and more deprived urban neighbourhoods, whereas site B covered mostly deprived urban neighbourhoods. There was general consensus that the R4U did help to gain more insight in the prevalence of risk factors in the patient population. However at site C it was demotivating because it confirmed beliefs that social issues had a low prevalence in the population. In R4U scorecards filled out by caregivers working in the deprived areas, the average number of risk factors was higher. This was in line with everyday experience of caregivers in these areas. Some remarked that this average may even be an underestimation because women estimated as being high risk were sometimes unwilling or unable to participate in the R4U.

DISCUSSION

In the face of relatively high adverse perinatal outcome rates and the need to improve collaboration between obstetric caregivers, the Shared Care pilot project was implemented in the larger Rotterdam area. The primary goals of the project were to improve the awareness and ability of obstetric caregivers to act on non-medical risks associated with adverse outcomes and to improve collaboration between these caregivers. A number of contexts and mechanisms were important in achieving these goals. Most notably we found that geographical location was an important context, because it coincided with the incidence of risk factors and caregivers' awareness of this through the R4U. It allowed to translate gut feeling on risks into measurable numbers and created a sense of urgency to act. The care pathways were thought to be a useful tool in this. One of the most important mechanisms was the further departure from the vision on pregnancy as a physiological process due to additional risk detection. This made caregivers more reluctant to participate.

Lessons for policy and practice

Geographical location of the study site thus served as a proxy for the prevalence of urban and deprivation issues. The higher risk load in the urban study sites is in line with prior publications which demonstrate a higher burden of both risk factors and consequently adverse outcomes. [3] The urban-rural divide in adverse outcomes caused by differences in deprivation is also widely described in other fields of medicine. [17] In the high-burden areas caregivers felt more motivated to use the R4U and care pathways then in the low-burden areas, because it provided guidance to problems they face on a daily basis. Caregivers are more likely to adept a strategy or change, if it meets their concrete needs. [18] Additionally the 'return on investment' is much higher for those working in more deprived areas: the number of women needing an R4U to identify one woman at risk, is much lower in the urban areas. Subsequently discerning in patient population per site is important because caregivers' needs differ accordingly. In low risk areas there is a need to emphasize the importance of risk detection for the individual patient in spite of a low overall incidence. Moreover, other methods for risk detection may be sought. For example, R4U questionnaires may be sent by mail to the women, checked by the caregiver and only discussed in case of remarkable findings.

In high burden areas, caregivers are more familiar with for example financial issues and housing problems and may feel less hesitant to ask their patients about it. However, objections were expressed by obstetric caregivers having to ask about these non-medical questions because it is more of a social work matter (i.e. organizing access to food support programs). Further exploration of the demarcations of responsibilities desired by these caregivers helps to identify gaps in care that may be bridged by other professionals.

The fact that the risk factors in the R4U are beyond the scope of current risk detection in obstetric care was experienced as a further departure from the attitude of pregnancy and childbirth as a physiology phenomenon, by some first tier midwives. Due to additional risk detection even fewer women would get to 'just be pregnant'. This is also illustrative for the differences in views on pregnancy between caregivers. In the first tier of care pregnancy is seen as a fundamentally physiological process, whereas in the second and third tier of care it is a more medical process. [8] Pregnant women in the second tier of care are estimated to be at high risk, thus this approach is understandable. The diverging views between the caregivers are one of the challenges between the tiers of care. Others include a lack of shared guidelines, physical distance between the different caregivers, and differences in 'language' spoken by professionals as described by Schölmerich *et al.* [8]

To overcome these barriers in the Netherlands, ways are sought to merge the tiers of care into one integrated approach in which a woman does not solely receive care from *or* a midwife *or* a gynaecologist but from both caregivers. The R4U and care pathways

would fit equally well into such an approach because the issues they tackle occur irrespective of type of caregiver.

Generally, in the implementation of new approaches or interventions adequate communication is important. Grol *et al.* describe that to influence behaviour and attitudes through effective communication, factors of both the receiver and sender of information should be taken into account. Perceived reliability and trustworthiness of the latter is thought to be important. [19] Even though the ambition of the Shared Care project was to improve collaboration between the care tiers, the fact that the project group was part of a third tier of care institution, was in itself a reason for caution amongst participants from other care tiers. In contrast with the initial CMOC, the fear of losing patients to other tiers of care was not an issue.

In all tiers of care the media attention for the adverse perinatal outcomes had been an important trigger for change. Interestingly, it was both a positive and negative incentive for those who participated. Some saw benefits and were intrinsically motivated, whilst others mostly wanted to avoid harm and therefore got involved. Because media attention occurred on a large scale, mandatory actions were to be expected. If in due time policy makers or health care insurance companies were to make Shared Care obligatory, non-participating caregivers would have had no influence on the course the development of the project took.

The degree of integration of the OC also played a role. In the tightly knit OC it was much more self-evident that all caregivers would participate than in the other OC's, where it was more of a choice at the practice level. However, a decentralized approach in decision-making leading to widespread support for an intervention may be more fruitful in sustainable implementation. [19] Fortunately the intention to continue participation was high at all study sites.

Limitations of realist evaluation

For the evaluation of our project we chose to use a realist evaluation approach. Because this approach offers answers to the question 'what works for whom in what circumstances and in what respects, and how?' It offers guidance to both policy makers and future project groups involved in implementing sustainable shared care. If applied in a cyclical manner external validity is greater than in traditional trials. [20]

There are also a number of limitations to the use of this method for evaluation. First, the development of the initial CMOC's is challenging when few prior studies have been published on the subject of study, as is the case with our study. As suggested by Chen *et al.* we therefore interviewed stakeholders to obtain their views on how the intervention was expected to work.

Second, it is difficult to exhaustively identify all relevant mechanisms and contexts, since many contexts and mechanisms may play a part and interact in generating

outcomes. Therefore the CMO-configurations under investigation are likely to be a simplification of reality. In our attempt to identify relevant CMO-configurations we have chosen a conservative approach by reporting only those CMO-configurations that we identified in multiple sites. Third, in this method of evaluation there is no room for the feedback-loop in which negative and positive outcomes in turn influence mechanisms during the intervention, as described by Byng *et al.* [21] If undesired outcomes occur (i.e. more time spent per patient), this will affect the willingness of caregivers in high burden areas to use the tool (mechanism). Fourth, in complex interventions such as this project it is almost impossible to attribute causality to specific determinants. This is because an interplay of multiple determinants lead to the outcome. Therefore ideally an evaluation approach like this one is combined with a traditional randomized experiment. This is currently being analysed in the national Healthy Pregnancy 4 All study. [22]

Limitations of our study

In our study the selection of interview candidates was done using purposive sampling. It is however difficult to be certain that a representative sample was obtained. Also, because the interviews for both the initial and refined CMO-configurations took place after the project was conducted, recall bias may have occurred. Concerning the stakeholders, relevant details on initial mechanism may have been forgotten or recalled differently because of the experiences during the project. The participants interviewed at the second stage of the study may have felt held back to give their honest recall of events and opinions, because the mechanisms and outcomes were not always positive. Moreover the primary investigator was also extensively involved in the implementation of the project. We explained to participants that the data would remain anonymous and that we were seeking to find both positive and negative feedback in order to truly learn from the intervention.

Overall implementation of the project proved to be difficult. Caregivers did understand the relevance of the project, but uptake was slow and time consuming. Because perinatal morbidity and mortality are important issues, the Shared Care project coincided with many other initiatives to improve outcomes. Efforts were made to collaborate and reduce overlap. But in spite of this, time pressure for caregivers was high and at times maintaining a clear overview of available projects and what these entailed, may have been difficult.

Even though it did not come to the fore in the interviews and questionnaires, the OC as the unit of implementation may not have been the most appropriate. It seemed a sensible starting point because both tiers of care are represented, but discussions and decisions concerning participation mostly took place at the practice level. Decision making at the OC level traditionally focusses on shared guidelines, the shift to other agreements and interventions is currently taking place.

CONCLUSION

Our study shows that geographical context as a proxy for patient populations was key in the implementation of an intervention to improve the awareness and ability of obstetric caregivers to act on non-medical risks associated with adverse outcomes and to improve collaboration between these caregivers. Additionally the differing perceptions on pregnancy of caregivers involved played a part. In the current debate on how Dutch perinatal care should be shaped, both aspects will need to be taken into account. Perinatal care must be customized to meet the needs and risks of individual women and in order to do so of different patient populations. Additionally an integrated approach to perinatal care should accommodate the different views on pregnancy, leading to tailored care to the individual covering both medical- and non-medical domains that best serves all pregnant women.

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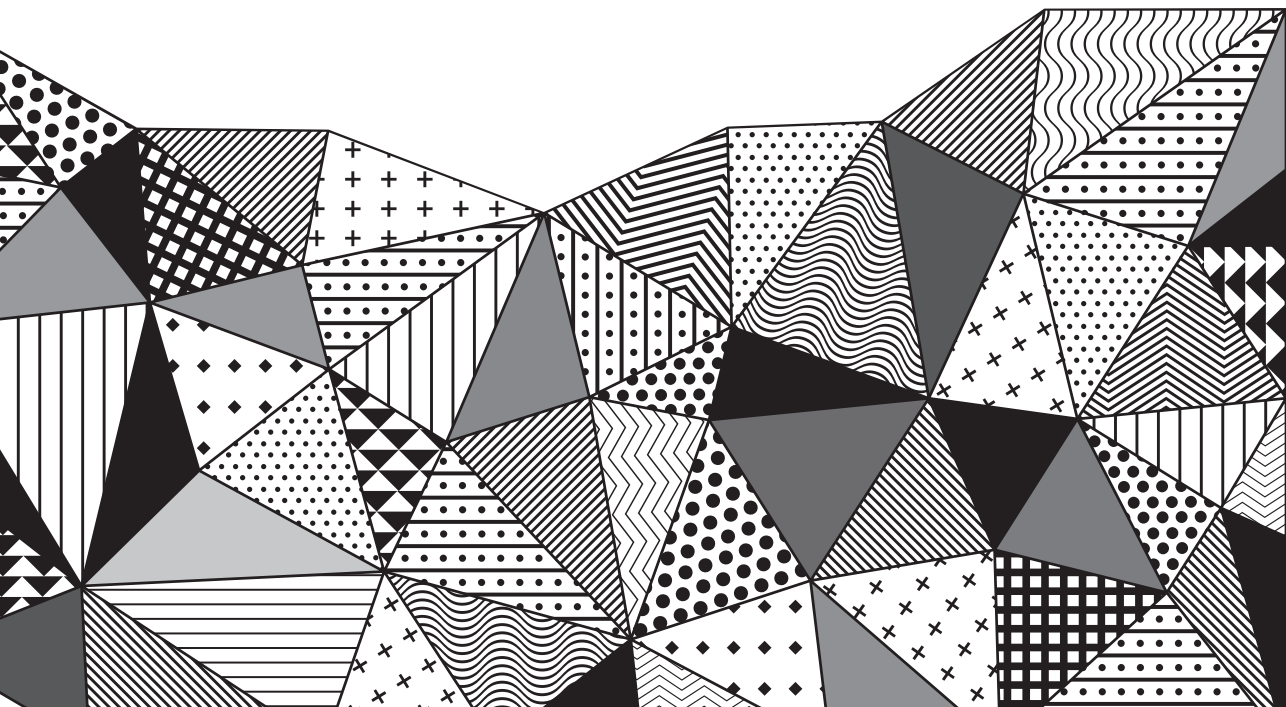
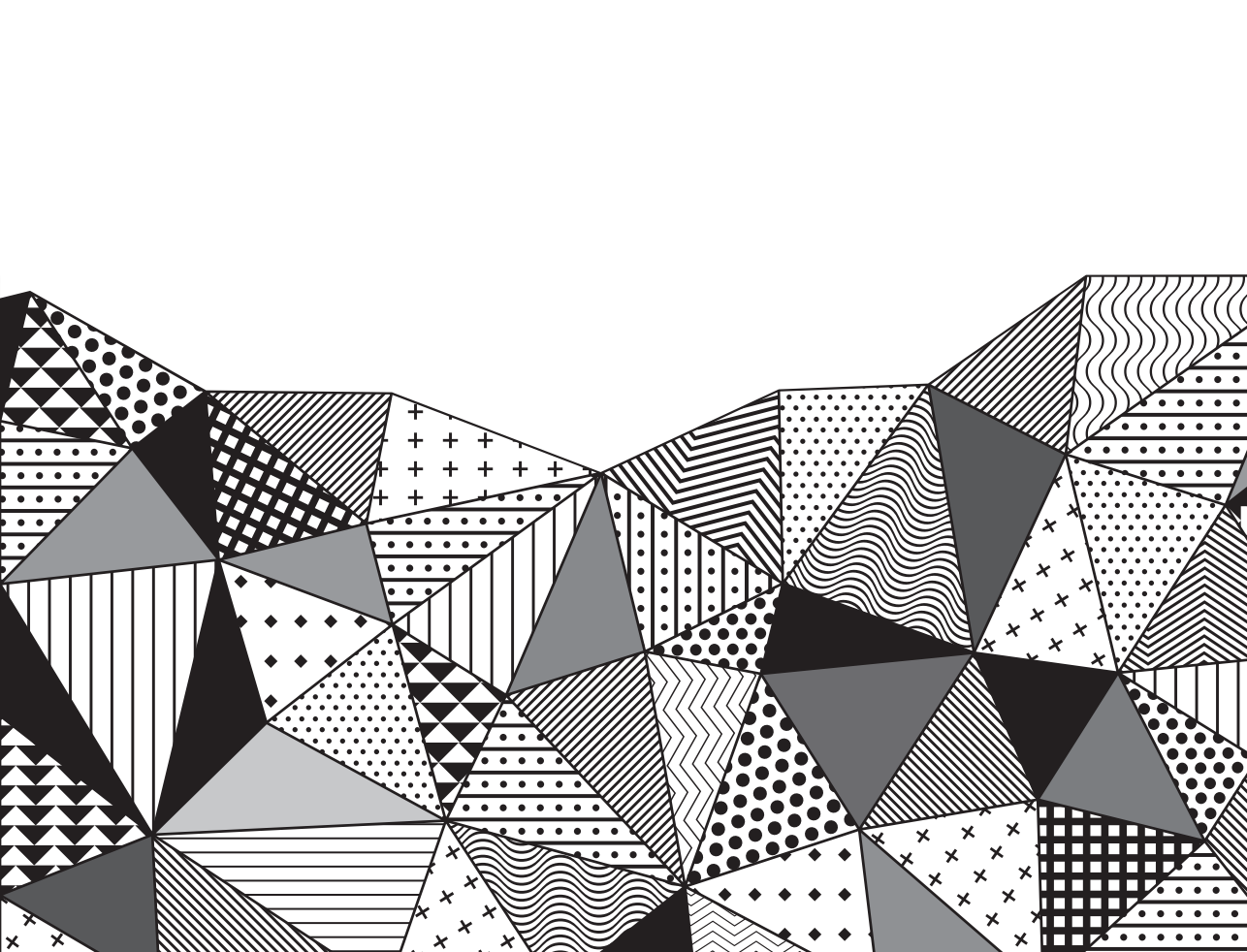


9

Chapter 9

General discussion and future perspectives



The reduction of health inequities should be the goal of every society. In the Netherlands, perinatal outcomes lagged behind in comparison to the surrounding countries. Additionally, large national inequalities (and potentially inequities) in perinatal outcomes were seen. To tackle these, a number of measures were proposed, including the development of improved risk detection and risk reduction and intensified collaboration between the different caregivers involved in care provision for pregnant women.

This thesis follows on from the demonstrated inequalities in outcomes and the proposed measures for improvement, focusing on both determinants and potential solutions for inequities in perinatal health in the Netherlands.

The main aims of this thesis were:

1. To establish the roles of personal and geographical factors relevant for the presence and perseverance of health inequalities, in the development of adverse perinatal outcomes, in particular the so called Big4 outcomes and perinatal mortality.
2. To investigate whether relevant differences exist in the provision, uptake and quality of perinatal care according to socioeconomic status and ethnicity in the Netherlands.
3. To investigate the feasibility and efficacy of a practice based Shared Care intervention in early pregnancy, aimed at 1) improving the detection and reduction of non-medical risks (which are known to contribute to perinatal inequalities) ; 2) improving collaboration between perinatal caregivers in risk management.

This chapter discusses the principal findings, the methodological considerations, future implications and provides the final conclusion of this thesis.

PRINCIPAL FINDINGS

Part 1: The roles of personal and geographical factors relevant for inequalities, in the development of adverse perinatal outcomes.

We found that both personal (e.g. ethnic background and socioeconomic status) and geographical factors (i.e. neighbourhood of residence) were relevant in the occurrence of preterm birth, being born small for gestational age and having a low Apgar score at five minutes after birth. These findings add evidence to an already large body of literature on non-medical determinants of adverse perinatal outcomes. [1-4] The principle of risk accumulation (the 'build up' of a number of smaller risk factors in an individual pregnant woman, leading to the occurrence of adverse outcomes [3]) played a part in all subgroups we investigated. The patterns of relevant risk factors did however differ according to socioeconomic status (SES) and ethnicity. We hypothesize that these differences are attributable to genetic make-up (in ethnicity) on the one hand and to cultural and behavioural differences (in both SES and ethnicity) on the other.

Moreover inequalities in birth outcomes were often in part determined by ethnic background and SES as risk factors and not only as strata for analyses: Women with a low SES and non-Western ethnic background were at higher risk for adverse outcomes. Ethnic minority background and SES are closely intertwined, showing a strong interacting effect when both are present. The effect of the combination of low SES and ethnic minority background is larger than the sum of the effects of the two separate determinants. Alongside this interplay of individual level determinants, the area of residence, and more specifically neighbourhood deprivation, plays an intriguing part in the cascade leading to adverse outcomes. [1, 5] SES at the individual level is not the same as SES at the neighbourhood level. In prior studies which corrected for individual level SES, a SES effect also remained at the neighbourhood level in relation to adverse perinatal outcomes. [6] This will be discussed in more detail later in this chapter.

Part 2: Differences in the provision, uptake and quality of perinatal care according to socioeconomic status and ethnicity in the Netherlands.

Living in a low SES neighbourhood and having a non-Western ethnic background were associated with lower probabilities of a number of different obstetric interventions. Also, after correction for maternal preference, ethnicity remained a significant determinant for differences in uptake of prenatal screening. Differences in health care reception rest on a number of causes, either on the patient side or the caregiver and health care system side. On the patient side reception may be lower because a patient makes an informed choice *not* to receive care (e.g. no prenatal screening based on religious conviction). Other, more negative causes are a lack of access to the health care system due to (anticipated) financial barriers, low levels of health literacy and / or language barriers. To overcome the latter informal interpreters are often used (i.e. friend and family of the patient), but this is challenging because these interpreters have no medical background and may feel uncomfortable translating private or upsetting information. [7] Additionally, a language barrier may mask the presence of low levels of health literacy, and overcoming a language barrier may at times not be enough. [8] Also, caregivers may not be sensitive to the needs and expectations of specific subgroups. [9, 10] Patient perceptions of diseases, the human body and health care may differ. [11] Prior studies have also demonstrated that the match or mismatch in ethnic background of caregiver and patients matter for the quality of care provided. [12]

Thus, in both part I and part II we identified inequalities in terms of perinatal outcomes and health care interventions. Part of these inequalities may be based on vertical equity (unequal treatment of unequals) which could be deemed ethically justifiable. However, not all demonstrated effects are thus explained. For example, in line with vertical equity we would have expected higher levels of interventions in low SES and non-Western women because they are at *higher* risk for adverse outcomes. This was not what we

found, in some cases the *contrary* was the case, with *lower* numbers of interventions. Part of these inequalities may therefore very well be "unnecessary and avoidable as well as unjust and unfair", contravening the principle of equality for all women. These are therefore health inequities according to the definition of the World Health Organization (WHO). [13] This makes them ethically unjustifiable.

The WHO has made universal health coverage within countries one of its primary targets. [14] In low income countries the differences are more outspoken than in high income countries. However reducing the remaining health coverage gap in high income countries also remains challenging. In general, preventive policies targeted at the population level, have less effect on those worst affected because these groups lack the competences and means to benefit. This is also known as the 'prevention paradox'. [15] The reduction of health inequities should therefore be achieved through a multi-faceted approach, reaching out at both the individual and group level. The latter also encompasses the neighbourhood of residence. Neighbourhoods affect health in a number of different ways. We distinguish at least two pathways which are both thought to interact in the occurrence of increased adverse outcomes in low SES (deprived) neighbourhoods. 1. The individual risk load of residents (i.e. women in deprived areas have accumulated more individual level risks, such as smoking and domestic violence) [3]; 2. 2. Increased exposure to neighbourhood level risk factors and stressors in deprived areas (i.e. exposure to smog, low sense of safety, lack of social capital). [16-18] Findings have been inconsistent on a possible third pathway, namely the influence of availability and quality of resources (i.e. schooling, health care facilities) in deprived neighbourhoods. [19]

In our study the level of ethnic minority density (which could be regarded as social capital in non-Western women) played a modest but significant part in the time of entry into antenatal care and had a protective effect for non-Western women. Prior studies have also demonstrated a relation with perinatal health outcomes. [17, 20] Social capital has been conceptualized to influence health in several different ways: firstly, by promoting the exchange of resources between residents, secondly by residents engaging in collective action to improve access to local services and amenities, thirdly through social control over healthy behaviour, and lastly by more efficient diffusion of health related information. Tapping into these systems to spread necessary information on perinatal health and health care, may be beneficial. However, deprived neighbourhoods tend to have lower levels of social capital. Additionally, social capital levels are not equal for Western and non-Western women. As Schölmerich *et al.* described it, often the *Western* women in these areas are the ones that experience lower levels of social capital, possibly explaining their relatively high risks of adverse birth outcomes within these neighbourhoods.

The above mentioned issues primarily concern determinants of adverse outcomes at the patient side. In focusing on the organizational side, we found that maternity unit

characteristics matter in the occurrence of neonatal mortality, but not intrapartum mortality. The importance of the explored organizational factors (number of obstetric staff and number of deliveries, 24*7 equality of service level and the travelling time of gynaecologists from home to the hospital when on call) in the odds of mortality was already emphasized by de Graaf *et al.* and Poeran *et al.* [21, 22]

In our analyses we made a distinction between children with and without major 'Big3'-disease in the importance of organizational characteristics. The *major* Big3-diseases were defined as: being born small for gestational age (< 2.3rd percentile), and / or preterm birth (<34 weeks of gestation) and / or the presence of major congenital anomalies (mortality rate or a NICU-admission rate of ≥ 20%. These diseases are associated with strongly increased odds of mortality. We found that children *without* major Big3 disease benefitted significantly more from optimal organizational characteristics than children *with* Big3 disease. This may in part be explained by the fact that caregivers are more alert and the organization of care more optimal when Big3-outcomes are expected. The outcomes emphasize the importance of an optimization of care by means of a multitrack approach to reduce mortality in both groups. A reduction in mortality of children *with* Big3 disease, would most ideally be reached through primary prevention of Big3 disease. Banning out Big3 disease completely is an unrealistic goal, but interventions to reduce the incidence can be put into place. One of the means by which such a reduction may be realized is through a broad introduction of general individual preconception care. By mapping out relevant risk factors for future parents and by providing support to reduce these, an optimization of the risk profile can be reached before conception. [23] Additionally standardized risk detection and reduction in antenatal care would be valuable to achieve the same in early pregnancy. The Rotterdam Reproductive Risk Reduction scorecard and the accompanying care pathways are a means to do so.

Part 3: The feasibility and efficacy of a practice based Shared Care intervention in early pregnancy aimed at 1) improving the detection and reduction of non-medical risks; 2) improving collaboration between perinatal caregivers in risk management.

Based on our findings in parts I and II of this thesis and the current literature, the importance of medical and non-medical risk factors is apparent. Theoretical knowledge on these risk factors is available, but adequate dissemination into obstetric practice is only possible if good interprofessional collaboration is in place. Adequate collaboration in The Netherlands is problematic for a number of different reasons. These include fragmented Dutch organizational structures, different perspectives on antenatal health between the different caregivers and inadequate interprofessional communication. At times these problems may necessitate pregnant women to coordinate their own care. This is specifically risky in Non-Western and low SES women, who are already at

increased risk for adverse outcomes, as they tend to have lower levels of health literacy and language proficiency. [24, 25]

To overcome these undesirable organizational issues a novel approach was developed, Shared Care. The points of departure in Shared Care are the delivery of continuity in care, patient centeredness and interprofessional teamwork. Additionally, crossing the boundaries between the medical and non-medical domains stood at the fore. During the implementation of the Shared Care project a debate on this new approach came into being. Some favoured a midwifery-led care approach, based on the Cochrane review that found both maternal and perinatal outcomes to be better in midwifery-led care than in other obstetric care approaches. [26] However, we believe that a one-on-one translation to the Dutch setting is not possible. The midwifery-led care approach assumes optimal risk detection and referral by the midwife and home births and high risk pregnancies were not taken into account. In the Netherlands, the current system of risk detection is not optimal. [27] Additionally, the traditional idea of a low risk / high risk dichotomy is untenable, because many women could be placed somewhere in between. The risk dichotomy is actually more of a risk 'sliding scale'. [28] In line with the Dutch Society of Obstetrics and Gynaecology we therefore believe that there is a need to move away from the tiered system that is currently in place. Midwifery and obstetric care should be integrated into one organization. Care and caregivers (the degree of involvement of midwives and / or gynaecologists) should then be tailored to meet the individual patients' needs, instead of being predominantly defined by the Obstetric Indication List only. [29] In this new integrated approach timely detection of both medical and non-medical risk factors should play a central role.

In the implementation of a new approach, numerous factors need to be taken into account. In the realization of the Shared Care project, the incidence of risk factors in the patient population mattered for the motivation of caregivers. This finding may be relevant in any intervention aiming at risk detection. If the risk load in a given population is high, the sense of urgency amongst caregivers to act, is likely to be greater. The intervention will then be experienced as more necessary. The reverse is also likely to be true in low risk populations. In our evaluation, we also found that some feared that additional risk detection would lead to a further medicalization of pregnancy. Such underlying beliefs are important to explore because they may greatly impact the willingness of caregivers to participate.

METHODOLOGICAL CONSIDERATIONS

This thesis consists of three parts, however the methodological consideration for part 1 and 2 are combined because they are both based on the same databases and contain comparable analyses.

Methodological considerations part I and II

Data sources

The Dutch Perinatal Registry contains approximately 97% of Dutch pregnancies since the year 2000 (www.perinatreg.nl). Community midwives, gynaecologists and neonatologists supply the information. The registry contains data from the time of entry into care up to and including the puerperium. External validation of the data is however limited. Additionally a number of relevant determinants are not registered. There is for example, no information on maternal lifestyle factors or on maternal SES and level of education.

The Peridos database contains data on the prenatal screening process in the Netherlands. The comprehensive registration from counselling to actual uptake of prenatal screening is quite unique. Peridos, however, does suffer from some of the same limitations as does the Perinatal Registry. External validation is yet to be carried out and the number of missings is quite substantial for many determinants because of few obligatory fields. Our project was the first to use data from the Peridos registry. Measures have been taken to improve data quality for research purposes, so this offers positive perspectives for future research.

Inherent to the use of these registries, is a limitation due to the retrospective nature of the data. Inferences can only be made in terms of associations, because the possibility of reverse causality can never be excluded completely. Additionally we have no information on what consequences improvements in identified risk factors would have on outcomes. Prospective randomized controlled trials focusing on the impact of risk reduction in terms of perinatal outcomes are preferable, but costly and time-consuming due to the rareness of events such as perinatal mortality. Retrospective studies such as ours do offer guidance in terms of relevant risk factors that merit further (prospective) investigation in studies such as the Healthy Pregnancy 4 All study. [30]

Analytical strategies

We will now elaborate on outcomes measures, determinants and analytical approaches that merit extra discussion. In a number of studies in this thesis Big3 or Big4 diseases were the outcomes of interest. Focusing on these diseases, instead of perinatal mortality was preferable for two reasons: 1. perinatal mortality is a rare event, thus necessitating very large study populations to investigate multiple risk factors. Studying morbidity

with increased risks of mortality, required smaller numbers; 2. More importantly, the Big3 / Big4 diseases are harmful in their own right. As Barker had already demonstrated in the 1990's, part of these diseases (being born small for gestational age and preterm births) are precursors of diseases in later life, e.g. diabetes mellitus and cardiovascular disease. [31] Of the cases included in our study we do unfortunately not have long term follow-up data.

A number of determinants in our analyses also merit extra discussion. SES was often analysed as a neighbourhood level variable. As a proxy for neighbourhood we used the four-digit postal code area. Averaging 4080 residents per neighbourhood in 2006, these areas are comparable to census tracts in the United States or Lower Layer Super Output Areas in the United Kingdom. Four-digit postal code area boundaries do however not always parallel neighbourhood boundaries and form no socially meaningful entities. Most neighbourhoods consist of more than one four-digit postal code area. Because the postal code areas are not a one-on-one reflection of neighbourhoods, the appointing of the postal code as the neighbourhood level variable in our multilevel analyses is not ideal. However, information such as SES was only available at the postal code level. We used this as a neighbourhood characteristic in most of our analyses. However, in a number of analyses we treated postal code SES as an individual determinant.

Almost all of our analyses contain ethnicity as a determinant. Ethnicity in itself is a complex entity and an exact definition is problematic. It could be described as "the group a person belongs to, or is perceived to belong to, because of culture, language, diet, religion, ancestry, and physical textures". [32] In our registries ethnicity was based on a variety of criteria, leading to potential misclassifications. For the purpose of our studies we chose to dichotomize ethnicity into Western / non-Western. This has both advantages and disadvantages. The drawbacks include the lumping together of culturally and genetically very different groups of women. Hypothesizing about the underlying mechanisms for demonstrated results must therefore be done with caution.

Additionally, the crude classification of ethnicity may contribute to a stereotyping of non-Western women. The dichotomizing does however allow us to investigate broad patterns: we could demonstrate that inequalities exist in the Netherlands, both in terms of outcomes and of care.

Moreover we had little information on individual level motivation for behaviour of both patients and caregivers. This concerns factors such as lifestyle (e.g. smoking), reasons for late entry into care, motivation for referral of patients and motivation for obstetric interventions. Only in our analyses of prenatal screening, we knew what the personal preferences of pregnant women were. By knowing this we could at least partly explore the influence of choice and more importantly, differences in uptake of care *not* related to choice. Other individual level information on behaviour, such as smoking, was never available to us in any of the analyses, so it could not be corrected for.

In our models we included small-for-gestational-age as a determinant for fetal growth. Ideally intrauterine growth and more particularly intrauterine growth restriction would have been included in the models. This is more accurate because non-SGA children may still be growth restricted (i.e. they had a greater growth potential which they did not fulfil). Vice versa some small-for-gestational-age children are actually genetically small and intrauterine growth reached was to their full potential. [33] However the databases at our disposal did not have information on intrauterine growth.

Concerning our analytical strategy, in most of our analyses we used a multilevel approach. For our studies multilevel models have advantages in comparison to regular multivariable regression models. Both individual level and neighbourhood level determinants could be included in a single model. Additionally these models correct for clustering of residents within neighbourhoods, leading to more appropriate, more conservative effect estimates. Additionally we stratified our study sample in a number of analyses. Stratification is a valuable method to explore potential differences in patterns of determinants. Because our sample sizes were large enough in most cases, we were able to stratify our populations *and* apply multivariate analyses. Stratification does have a caveat: caution must be taken, that cases with differing etiological pathways are not grouped together. As described above our grouping together of all non-Western women has its uses and disadvantages. Concerning our stratification for SES, it is reasonable to assume that the comparison between low and high SES is crude, but it does provide the greatest contrast. Where nuances between different ethnic minorities may still have clinical use, the differentiation between many subgroups of SES would have little clinical significance. We believe it suffices to demonstrate that differences in perinatal outcomes according to SES are present and that the low SES group thus deserves extra attention.

Methodological considerations part III

Uniqueness of the Dutch obstetric system

Because the Dutch obstetric system has no directly comparable equivalent in the world, adopting a Shared Care strategy one-on-one from another country was not a desirable nor a feasible option. Out of necessity we chose to explore components of shared care in obstetric care systems abroad and in other fields of medicine. The reverse is also true, because our situation and system are unique, generalizing our findings to other countries and settings may be problematic.

Analytical strategies

Up-front the sample size of the Shared Care project was expected to be small, due to the local municipal character of the project. This did not pose a problem because the quantitative issues concerning risk detection and reduction were included in the much larger

Healthy Pregnancy 4 All study. This cluster randomized controlled trial took place in 14 municipalities across the Netherlands and focused on the effectiveness of the Rotterdam Reproductive Risk Reduction (R4U) score card, care pathways and multidisciplinary collaboration in the reduction of adverse pregnancy outcomes (small for gestational age (birth weight < p10) and preterm birth (<37 weeks). [30] The qualitative focus of our study adds a more nuanced understanding of mechanisms and contexts that need to be taken into account in the implementation of a tool such as the R4U. It is reasonable to assume that our findings in the Rotterdam area, can be extrapolated to other urban areas in the Netherlands.

Impact

Measuring the impact – either quantitatively or qualitatively – of an intervention such as ours is challenging. It is not implemented in an isolated setting. Instead, the program is influenced by numerous factors such as the caregivers involved, patient advocate groups and political changes. [36] Obstetric care in the Netherlands has been a very dynamic field in the past years. Due to the relatively high levels of adverse outcomes, a vast number of policy measures, new projects and other initiatives took place. [34-36] Moreover, the increased attention on the matter, also in the media, has made both caregivers and patients more aware. All of these factors may dilute, strengthen or distort the impact of our intervention. The rich data gained through the qualitative approach of our evaluation allowed us to gain a deeper insight into these underlying mechanisms influencing our intervention. Providing proof that our intervention to improve risk detection and reduction works is difficult. Based on all prior evidence on the associations between the risk factors in the R4U and adverse outcomes, it is plausible to assume that a reduction of these factors will improve outcomes. Moreover, addressing many of these non-medical issues is relevant because they affect the living environment of the new-born (i.e. housing issues, maternal illicit drug use) and the future health of the whole family.

RECOMMENDATIONS FOR RESEARCH, POLICY AND PRACTICE

Recommendations part I and II

– At the patient level there is a need to improve health literacy of women in disadvantaged positions. For example by means of empowerment training, one enables women to ask the right questions to caregivers and to participate more actively in 'their' care. Additionally for women with a language barrier, it remains important to learn the Dutch (or English) language, thus reducing at least one of the barriers potentially leading to inequities in care. Reaching women in disadvantaged posi-

tions remains problematic. Reaching them through their social networks may be a solution. By organizing meetings in homes, community centres, churches, mosques, but also at schools, (adolescent) women can be reached at places they frequent.

- The awareness of current obstetric caregivers on the presence of inequities in perinatal outcomes should be improved. Workshops should be developed on the topic of size and causes of inequities, including differences in disease patterns, subconscious stereotyping and discrimination. Creating awareness is a first step towards reducing these undesirable differences.
- Additionally caregivers need to receive tools to help bridge inequities. In the first place these should target low health literacy skills in patients. Caregivers need to recognize illiteracy and language barriers. If the latter is present a professional interpreter should be consulted. Preferably interpreting is not done by an informal interpreter (i.e. a relative or friend of the patient). To stimulate the use of professional interpreters, these facilities must be easily accessible for caregivers at for example outpatient clinics and rounds. Additionally the financial costs must be covered. Also if a language barrier is absent it is still important to verify whether a patient has understood the information given to her (for example by having it repeated back to the caregiver). Lastly, verifying the perspective the patient has on the disease is important. E.g. does the patient perceive herself to be mortally ill and does she incorrectly believe that surgery is absolutely necessary, or does she rightly understand that her condition is not that serious and that watchful waiting is appropriate.
- We recommend the further development of comprehensive evidence-based tools to support caregivers working with women from high risk groups. Culturally competent tools (e.g. information films to improve informed decision making) and comprehensive care pathways for vulnerable pregnant women are amongst the options.
- At the organizational level equity in health care and responsiveness to patients' diversity in needs should be promoted. Preferably, the workforce within an organization is a reflection of society, also in terms of its diversity. All staff, doctors, midwives and nurses alike should be informed and trained on the presence and reduction of inequities in care. Also, professional interpreters should be available at all times (either physically or by telephone) for all caregivers.
- In hospitals the efforts to provide equal quality of care during day and night shifts should be continued. However, aiming for daytime obstetrics, when staffing levels of all specialties are most optimal, remains important. Furthermore, in the reduction of mortality due to major Big3-disease, prevention should be given a central role. Prevention should ideally occur through a two-track approach, consisting of preconception care for future parents *and* early antenatal risk detection and risk reduction (e.g. by means of the R4U) once they are pregnant.

- At a policy level, efforts should be made to embed diversity and inequity in health, in both regular medical, midwifery and nursing education. Both in the development of education material and tools to assist professionals, women from the community (and more specifically with a non-Western and low SES background) should be asked to participate actively, so that these measures meet their needs.
- Future research should focus in more detail on patient and caregiver behaviours in care reception and provision to gain a deeper understanding of why these inequities occur. In obstetrics causes above and beyond the currently known causes may play a role. Another topic on the research agenda should be the underlying mechanisms in the association between high ethnic minority density and relatively better use of care in non-Western women.

Recommendations part III

- There is a need to develop a clear cut, comprehensive definition of integrated care for obstetrics in the Netherlands, supported by all professional organizations involved. This should entail true integration in terms of financial means and the vision on pregnancy, not a redefinition of separate autonomous domains. In this integrated approach risk detection, of both medical and non-medical risk factors, should play a central role. In any case, caregivers should receive support in the implementation of a more integrated approach, in order to overcome interprofessional differences in amongst others perceptions and goals.
- More awareness should be created amongst professionals on the importance of non-medical risk factors and the accumulation of (smaller) risk factors. Firstly, because these also contribute to the occurrence of adverse perinatal outcomes. Secondly, because it demonstrates that the traditional perception of a low risk / high risk dichotomy within obstetric care is untenable.
- In the implementation of more extensive risk detection and risk reduction, the specific patient population should be taken into account. Populations with a lower incidence of risk factors potentially benefit from a more low key approach (e.g. written questionnaires) than high risk populations (face-to-face interviews).
- In the realization of all the above mentioned recommendations, it may be useful to seek collaboration with health insurance companies, because many of the interventions will require more time and innovation and thus more financial means.

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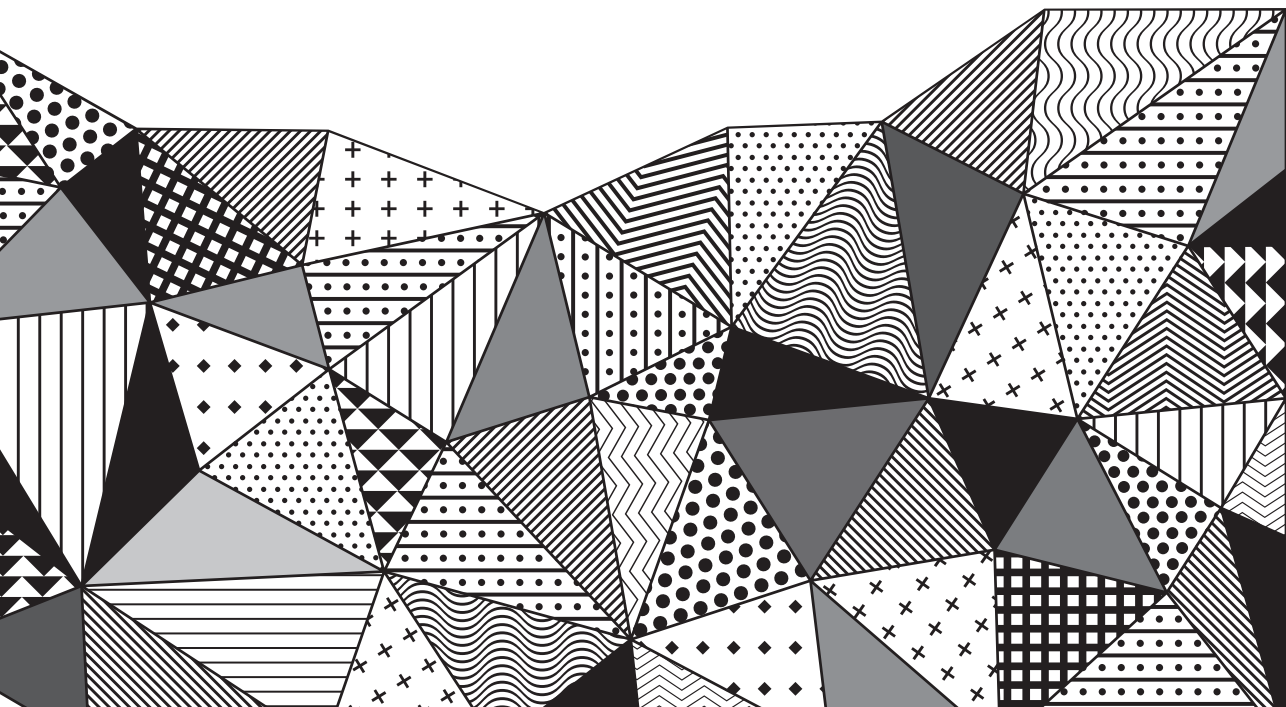

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Chapter 10

Summary

Samenvatting

ENGLISH SUMMARY

All women have the right to equal care and to the best possible health outcomes. This also holds for perinatal care. Because the perinatal outcomes lagged behind in the Netherlands in comparison to the surrounding countries, extensive research has been conducted on these outcomes and their determinants in the past decade. Additionally, large differences in terms of perinatal morbidity and mortality were found *within* the Netherlands, which possibly contribute to the suboptimal position of the Netherlands as a whole. Moreover, the odds of adverse outcomes were larger in the four largest cities of the Netherlands in comparison to the rest of the country, but there were also differences at the neighbourhood level. The odds of perinatal mortality were up to sixteen times higher in deprived neighbourhoods than in affluent neighbourhoods.

These differences in outcomes are associated with both individual level maternal risk factors (such as a non-Western ethnicity and a low socioeconomic status, and related risks) and risk factors at the neighbourhood level (such as insecurity and social cohesion). It is not merely a matter of exposure, individual sensitivity or unhealthy behaviour. Prior research has demonstrated that healthcare also plays a role: the odds of less adequate healthcare are larger in deprived groups, those who need it most receive the least adequate care. The causes of inequalities in perinatal healthcare and perinatal outcomes are thus both patient related and healthcare organization and professional related. This thesis focuses primarily on the professional and the healthcare organization. We believe it is plausible to assume that outcomes in perinatal healthcare can be improved by means of adequate and consequent detection, and reduction of both medical and non-medical risk factors. Additionally, intensified collaboration between caregivers involved seems to be of great importance because case management is complicated when a mix of risk factors is present. This is also important because fragile groups of patients are at risk to receive insufficient care. In this thesis we will first explore the inequalities in perinatal outcomes and perinatal healthcare. After this we will elaborate on the development of a 'Shared Care' model which focusses on intensified collaboration between obstetric caregivers based on shared risk detection and care pathways.

The research in this thesis has the following goals: 1) to establish the role of individual and geographical factors which are relevant for inequalities in the occurrence of adverse perinatal outcomes; 2) to determine the presence of relevant differences in healthcare provision, uptake and quality of perinatal care according to socioeconomic status and ethnicity; 3) to determine the feasibility and efficacy of a 'Shared Care' intervention in the first trimester of pregnancy, which focuses on the detection and reduction of non-medical risk factors and the improvement of collaboration between obstetric caregivers in the management of these risk factors.

Part 1 'Deprivation, ethnicity and perinatal outcomes' describes the associations between different medical and non-medical determinants – amongst others socioeconomic status and ethnicity – and the occurrence of perinatal morbidity and mortality. **Chapter 2** explores the associations between medical and non-medical risk factors as determined by means of the R4U (Rotterdam Reproductive Risk Reduction) scorecard, and the odds of preterm birth, being small for gestational age and a low Apgar score at five minutes after birth. The R4U is a questionnaire consisting of 70 different risk factors, which is filled out at the antenatal booking visit. Both medical and non-medical risk factors proved to be relevant in the occurrence of adverse perinatal outcomes. Moreover the pattern of significant risk factors differed according to socioeconomic status (low / high) and ethnicity (Western / non-Western). **Chapter 3** describes a systematic literature review and meta-analysis on the associations of living in a deprived neighbourhood and the risk of preterm birth, being small for gestational age and perinatal mortality. In comparison with women living in the 20% most affluent neighbourhoods, women living in the 20% most deprived neighbourhoods were at increased risk for all of these adverse outcomes.

Part 2 "Deprivation, ethnicity and perinatal care" concerns the relation between (amongst others) socioeconomic status and ethnicity on the one hand, and a number of different perinatal care interventions on the other hand, as possible explanations for the large perinatal inequalities in the Netherlands. Additionally this part of the thesis focuses on the influence of hospital organization characteristics on the occurrence of perinatal mortality.

Chapter 4 explores the potential presence of evidence for inequalities in perinatal healthcare according to ethnicity and socioeconomic status. It was anticipated that high risk women (with a non-Western ethnicity or a low socioeconomic status) would receive significantly more risk related care. The contrary was the case. After correction for other maternal factors and hospital density, low socioeconomic status and non-Western ethnicity were associated with significantly lower odds of most obstetric risk related interventions. This is suggestive of relative underservice for these fragile groups.

Chapter 5 maps out the role of a number of different neighbourhood characteristics in relation to the time of entry into antenatal care of pregnant women. This mechanism differs from the selective underservice (chapter 4), leading to inequalities in perinatal outcomes. Social capital (the social support system within a neighbourhood) is important for healthcare behaviour of people. Additionally the proportion of non-Western (compared to Western) women residing in an area could influence this behaviour.

On average women with a non-Western ethnic background enter antenatal care later, than Western women. However, in neighbourhoods with a higher proportion of non-Western women (high ethnic minority density), non-Western pregnant women on average entered antenatal care slightly earlier than in neighbourhoods with a lower

proportion of non-Western women. The proportion of ethnic minorities in a neighbourhood probably reflects the degree of social capital of non-Western women in this area. This form of social capital seems to have a relatively protective effect on the time of entry into care for non-Western women. A possible explanation for this finding is that the social cohesion amongst non-Western women in these neighbourhoods is greater, leading to a better diffusion of knowledge on the healthcare system.

In **Chapter 6** the focus is on inequalities in the uptake of prenatal screening according to socioeconomic status and ethnicity. It is known that non-Western women have a lower uptake of prenatal screening and this is often attributed to an informed choice not to participate. In our study we also found that 85.7% of non-Western women participated in the combined test and / or the fetal anomaly scan, compared with 89.7% of Western women. However, after adjustment for patient choice, ethnicity remained a significant determinant of lower uptake of prenatal screening. Additionally an interaction was present for non-Western ethnicity and low socioeconomic status. It follows from this that non-Western women with a low socioeconomic status have the lowest odds of participating in prenatal screening, adjusted for their personal choice concerning participation.

Chapter 7 describes the influence of organizational factors on the occurrence of intrapartum and neonatal mortality. A distinction was made between children *with* and *without* 'major Big3 disease. Major Big3 diseases comprise: small for gestational age under the 2.3rd percentile, preterm birth before 34 weeks of gestation, and/or a major congenital anomaly with a mortality rate or NICU-admission rate of more than 20%. The organisational characteristics we explored were: the scale size of the obstetric department (patients and caregivers), 24*7 equality of staff level, travelling time of gynaecologists to the hospital when on call, and elective caesarean section rates in breech pregnancies (as a proxy for pro-activeness of intervention strategies). An improvement of any of these factors was associated with a reduced chance of mortality specifically in children *without* major Big3 disease. For children *with* Big3 disease the associations were not significant. We believe an explanation for these findings is that the hospital organization will have adjusted itself in advance in part of these cases because the *major* Big3-disease had already been detected before labour; moreover, part of these *major* Big3-births occur in perinatal centres without a 24*7 equality of service level effect due to the organization of these highly specialized centres. For the *major* Big3-disease children additional measures are necessary to realize a further reduction of mortality, with an important role for preventive measures based on adequate risk detection and –reduction.

Part 3 "Shared Care within the Obstetric Collaborations"

Chapter 8.1 presents the starting point we developed for Shared Care within the Dutch Obstetric Collaborations. Based on a literature study on obstetric systems in

other countries and forms of collaboration within other fields of medicine, we selected elements which are relevant within the Dutch situation. The selected elements can be divided into the following themes: patient centeredness, interprofessional teamwork and continuity of care. These themes were then taken into account in the Shared Care intervention. In this intervention uniform risk detection was applied in both the first and second tier of obstetric care, based on the R4U scorecard. Both medical *and* non-medical risk factors were acted upon using care pathways, which were uniform for both tiers of care. By means of shared risk detection and –reduction a contribution was made to intensified collaboration between the different caregivers.

Chapter 8.2 describes the existing visions on current collaboration within obstetric care, based on interviews with different obstetric caregivers. Organizational structures were fragmented, visions on antenatal health differed and there was inadequate communication between professionals. These issues form obstacles in the necessary synergy and thus interfere with optimal care, and probably form an extra risk for fragile pregnant women. Moreover, these issues sometimes necessitate pregnant women to coordinate their own care in order to fill in the gaps in communication between caregivers. For women with a low socioeconomic status and non-Western ethnicity this may be particularly difficult.

Chapter 8.3 describes the process evaluation of the Shared Care intervention based on the 'realist evaluation' cycle. In this method of evaluation the context in which an intervention is implemented plays a central part. Combinations of contexts and mechanisms lead to either desired or undesired results. By identifying different relevant contexts and mechanisms, lessons are learnt for the implementation of comparable interventions in the future. A number of different factors influenced the motivation of caregivers to participate in the Shared Care intervention. Notably, the incidence of risk factors in the population in which the intervention took place was important. A higher incidence made it easier for people to see the use of participating. Additionally the differences in visions on obstetric care played an important role. Part of the caregivers feared that extra risk detection would lead to a further departure from the view on pregnancy as a physiological process. This was thought to be undesirable.

Chapter 9 discusses the main findings and conclusions of this thesis. This thesis demonstrates that there are important inequalities in both perinatal morbidity and mortality and the provision of obstetric care. The professional organisation plays an important part in this. To bridge these inequalities further support of both patients and professionals will be necessary, in terms of workshops and professional interpreters. To improve perinatal outcomes across the board and to reduce inequalities in outcomes, there is a need to fully integrate the Dutch obstetric care system. Shared Care based on shared risk detection and –reduction may deliver a meaningful contribution to this development.

NEDERLANDSE SAMENVATTING

Alle vrouwen hebben recht op dezelfde zorg en op zo optimaal mogelijke gezondheidsuitkomsten. Dit geldt ook binnen de perinatale zorg. In Nederland is het afgelopen decennium uitgebreid onderzoek gedaan naar perinatale gezondheidsuitkomsten, en hun determinanten, omdat uitkomsten veel minder optimaal waren dan die in de ons omringende landen. Tevens werd vastgesteld dat er grote verschillen in perinatale mortaliteit en morbiditeit waren *binnen* Nederland, die mogelijk een rol spelen bij de lage positie van Nederland. De kans op suboptimale uitkomsten bleek onder andere groter in de vier grote steden dan in de gebieden daar buiten, maar ook op wijkniveau waren er verschillen. De kansen op perinatale mortaliteit waren in achterstandswijken tot zestien keer hoger dan in welvarende wijken. Deze verschillen in uitkomsten hangen samen met zowel individuele maternale risicofactoren (zoals een niet-Westerse etniciteit en een lage sociaaleconomische status, en daarmee verbonden risico's) als risicofactoren op wijkniveau (zoals onveiligheid en sociale cohesie). Het is niet alleen een kwestie van blootstelling, individuele gevoeligheid of ongezond gedrag. Uit eerder onderzoek is bekend dat ook de zorg een rol speelt: de kans op minder adequate zorg is groter bij achterstandsgroepen, diegenen die het het meeste nodig hebben krijgen de minst adequate zorg. De oorzaken voor ongelijkheden in zorg en zorguitkomsten liggen dus zowel bij de patiënt als bij de zorgorganisatie en de professionals. Dit proefschrift richt zich vooral op de professional en diens zorgorganisatie. Wij vinden het aannemelijk dat de uitkomsten in de geboortezorg kunnen verbeteren door adequate en consequente signalering, en reductie van zowel medische als niet-medische risicofactoren. Ook lijkt intensievere samenwerking tussen de betrokken zorgverleners van groot belang, omdat casemanagement complex is bij een mix aan factoren, en het gevaar bestaat van onvoldoende zorg bij kwetsbare groepen. In deze thesis gaan we eerst dieper in op ongelijkheden in perinatale uitkomsten en perinatale zorg. Daarna kijken we naar de ontwikkeling van een 'Shared Care' model waarin intensievere samenwerking tussen verloskundig zorgverleners aan de hand van gezamenlijke risicosignalering en zorgpaden centraal staat.

Het onderzoek in deze thesis heeft de volgende hoofddoelen: 1) het vaststellen van de rol van individuele en geografische factoren die relevant zijn voor ongelijkheden, in het ontstaan van nadelige perinatale uitkomsten; 2) het vaststellen van eventuele relevante verschillen in de zorgverlening, zorgontvangst en kwaliteit van perinatale zorg naar sociaaleconomische status en etniciteit; 3) het vaststellen van de haalbaarheid en doeltreffendheid van een 'Shared Care' interventie in het eerste trimester van de zwangerschap, met als doel het verbeteren van de detectie en reductie van niet-medische risicofactoren en het verbeteren van de samenwerking tussen verloskundig zorgverleners in de aanpak van deze risicofactoren.

Deel 1 "Achterstand, etniciteit en perinatale uitkomsten" beschrijft de associaties van verschillende medische en niet-medische determinanten -waaronder sociaaleconomische status en etniciteit- en het optreden van perinatale morbiditeit en mortaliteit. **Hoofdstuk 2** onderzoekt de associaties tussen medische en niet-medische risicofactoren zoals vastgesteld met de R4U (Rotterdam Reproductive Risk Reduction) scorekaart, en de kans op vroeggeboorte, dysmaturiteit en een lage Apgarscore vijf minuten na de geboorte. De R4U is een vragenlijst die bestaat uit 70 verschillende risicofactoren die uitgevraagd worden bij de eerste antenatale controle. Zowel medische als niet-medische risicofactoren bleken relevant voor het optreden van nadelige perinatale uitkomsten. Daarnaast bleek dat het patroon van significante risicofactoren verschilde op basis van sociaaleconomische status (laag / hoog) en etniciteit (Westers / niet-Westers). **Hoofdstuk 3** beschrijft een systematisch literatuuronderzoek en meta-analyse van de associatie tussen het wonen in achterstandswijken, en het risico op vroeggeboorte, dysmaturiteit en perinatale sterfte. Vergeleken met vrouwen die in de 20% welvarendste buurten woonden, hadden vrouwen in de 20% armste buurten een verhoogde kans op al deze nadelige uitkomsten.

Deel 2 "Achterstand, etniciteit en perinatale zorg" bespreekt de relatie tussen (onder andere) sociaaleconomische status en etniciteit enerzijds, en verschillen in perinatale zorginterventies anderzijds, als mogelijke verklaring voor de grote perinatale ongelijkheden in Nederland. Verder wordt er gekeken naar de invloed van ziekenhuisorganisatie -kenmerken op de kans op perinatale mortaliteit, als zodanig.

Hoofdstuk 4 onderzoekt of er aanwijzingen zijn voor ongelijke perinatale gezondheidszorg in relatie tot etniciteit en sociaaleconomische positie. De verwachting was dat hoog-risico vrouwen (met een niet-Westerse etniciteit of een lage sociaaleconomische status) aanzienlijk meer risico-gerelateerde zorg zouden ontvangen. Het omgekeerde bleek waar. Lage sociaaleconomische status en een niet-Westerse etniciteit waren na correctie voor andere maternale factoren en de dichtheid van ziekenhuizen, geassocieerd met een soms aanzienlijk lagere kans op de meeste obstetrische risico-gerelateerde interventies. Dit duidt op de mogelijkheid van relatieve onder-zorg voor deze kwetsbare groepen.

Hoofdstuk 5 brengt de rol van verschillende buurtkenmerken in relatie tot het al dan niet op tijd in verloskundige zorg komen van zwangere vrouwen in kaart. Dat is een ander mechanisme dan selectieve onder-zorg (hoofdstuk 4) waarlangs perinatale ongelijkheid in uitkomsten tot stand kan komen. Sociaal kapitaal (het sociale steunsysteem binnen een buurt) is van belang voor het zorggedrag van mensen. Ook het aandeel niet-Westerse (ten opzichte van Westerse) vrouwen woonachtig in een buurt zou daarop van invloed kunnen zijn. Vrouwen met een niet-Westerse etniciteit komen gemiddeld later in zorg dan niet-Westerse vrouwen. Echter, in buurten met een hoger aandeel niet-Westerse vrouwen (hogere densiteit van etnische minderheden), kwamen niet-Westerse

vrouwen gemiddeld iets minder laat in zorg dan in buurten met een laag aandeel niet-Westerse vrouwen. Het aandeel etnische minderheden in een buurt is waarschijnlijk een weerspiegeling van het sociaal kapitaal van niet-Westerse vrouwen. Deze vorm van sociaal kapitaal lijkt een relatief beschermende werking voor het moment van in zorg komen van niet-Westerse vrouwen te hebben. Een mogelijke verklaring hiervoor is dat de sociale cohesie onder niet-Westerse vrouwen in deze wijken groter is en dat daardoor kennis over het zorgsysteem beter wordt gedeeld.

In **hoofdstuk 6** ligt de focus op de ongelijkheden in deelname aan prenatale screening op basis van sociaaleconomische status en etniciteit. Het is bekend dat niet-Westerse vrouwen minder vaak deelnemen aan prenatale screening en vaak wordt dit geweten aan de keuze om niet mee te doen. Ook in deze studie vonden wij dat 85.7% van de niet-Westerse vrouwen de combinatietest en / of het structureel echoscopisch onderzoek ondergingen, ten opzichte van 89.7% van de Westerse vrouwen. Na correctie voor de wens van de patiënt, bleef etniciteit echter een significante determinant voor een lagere deelname aan prenatale screening. Tevens werd er een interactie gevonden voor niet-Westerse etniciteit en sociaaleconomische status. Daaruit volgt dat niet-Westerse vrouwen met een lage sociaaleconomische status de minste kans hadden op deelname aan prenatale screening, gecorrigeerd voor hun persoonlijke voorkeur om deel te nemen.

Hoofdstuk 7 beschrijft de invloed van organisatiefactoren op het optreden van durante partu en neonatale sterfte. Daarin werd onderscheid gemaakt tussen kinderen *met* en *zonder* 'major Big3'-aandoeningen. Onder major Big-aandoeningen worden verstaan: dysmaturiteit onder de 2.3^{e} percentiel, vroeggeboorte voor de 34e zwangerschapsweek en / of een congenitale afwijking met een sterftekans of opnamekans op de neonatale intensive care unit (NICU) van meer dan 20%. De bestudeerde organisatiekenmerken waren: het volume van de afdeling verloskunde (patiënten en zorgverleners), 24*7uur gelijkheid van zorg, de reistijd van dienstdoende gynaecologen en het percentage electieve sectio's caesarea (als maat voor de pro-activiteit van het interventiebeleid). Een verbetering van elk van deze factoren bleek significant geassocieerd met een verminderde kans op sterfte in juist de *niet*-major Big-kinderen. Voor Big3-kinderen waren de associaties niet significant. Wij verklaren deze bevinding doordat de organisaties zich in een deel van de gevallen waarschijnlijk aangepast zal hebben omdat van het kind bekend was dat het een *major* Big3-aandoening zou hebben; ook vindt een deel van deze *major* Big3-geboortes plaats in een perinatologisch centrum waar 24*7 effecten niet worden waargenomen door de organisatie aldaar. Voor de *major* Big3-kinderen zijn aanvullende maatregelen nodig om een verdere reductie van mortaliteit mogelijk te maken, waarbij een belangrijke rol is weggelegd voor preventie door middel van adequate risicodetectie en -reductie.

Deel 3 "Shared Care binnen de Verloskundige Samenwerkingsverbanden"

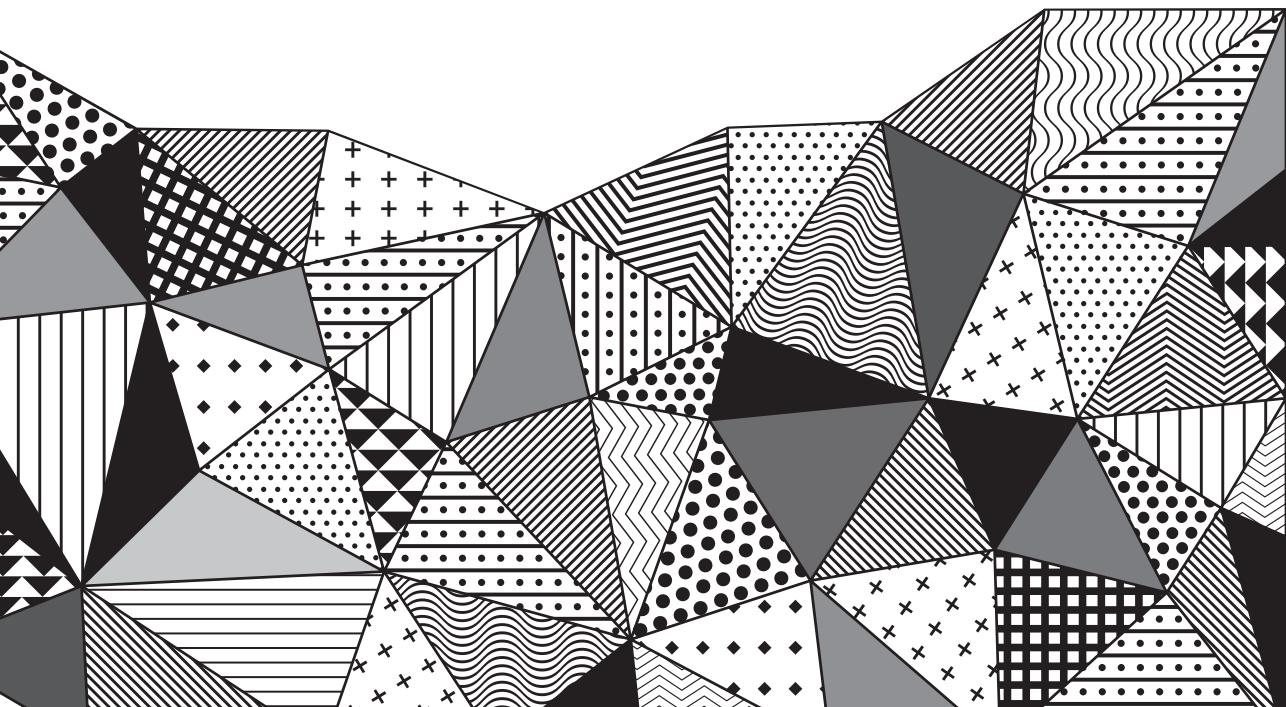
Hoofdstuk 8.1 presenteert het door ons ontwikkelde uitgangspunt voor Shared Care binnen de Nederlandse Verloskundige Samenwerkingsverbanden (VSV). Op basis van een literatuurstudie naar verloskundige systemen in het buitenland en naar samenwerkingsverbanden binnen andere vakgebieden, hebben wij elementen geselecteerd die relevant zijn binnen de Nederlandse situatie. De gevonden elementen zijn onder te verdelen in de volgende hoofdthema's: een centrale rol voor de patiënt, interprofessionele samenwerking en continuïteit van zorg. Deze thema's werden meegenomen in de Shared Care interventie. In deze interventie werd uniforme risicosignalering in eerste en tweede lijn toegepast aan de hand van de R4U scorekaart. Er werd ingegrepen op medische *en* niet-medische risicofactoren aan de hand van zorgpaden, die voor eerste en tweede lijn gelijk waren. Door middel van gezamenlijke risicosignalering en -reductie werd er bijgedragen aan intensievere samenwerking tussen de verschillende zorgverleners.

Hoofdstuk 8.2 beschrijft aan de hand van interviews met verschillende verloskundige zorgverleners de bestaande visies op de huidige samenwerking binnen de verloskundige keten. De organisatiestructuren bleken gefragmenteerd, verschillen in visie op antenatale gezondheid bleken aanwezig en er was sprake van inadequate communicatie tussen de professionals. Deze problemen staan synergie en daarmee optimale zorg in de weg, en vormen waarschijnlijk een extra risico bij kwetsbare zwangere vrouwen. Tevens blijken door deze problemen zwangere vrouwen soms genoodzaakt te zijn om zelf een actieve rol in de zorg op zich te nemen om de hiaten in de communicatie tussen de zorgverleners op te vangen, wat juist voor zwangere vrouwen met een lage SES of van niet-Westerse afkomst moeilijk kan zijn. **Hoofdstuk 8.3** beschrijft de procesevaluatie van de Shared Care interventie aan de hand van de 'realist evaluation' cyclus. Bij deze evaluatiemethode speelt de context waarbinnen een interventie geïmplementeerd wordt een centrale rol. Combinaties van contexten en mechanismen leiden tot al dan niet gewenste uitkomsten. Door verschillende relevante contexten en mechanismen te identificeren, worden lessen getrokken voor de toekomstige implementatie van vergelijkbare interventies. Verschillende factoren waren van invloed op de motivatie van zorgverleners om bij te dragen aan de Shared Care interventie. Met name de incidentie van risicofactoren in de populatie waar de Shared Care interventie plaatsvond was van belang. Een hogere incidentie maakte dat men de zin van deelname meer zag. Tevens speelde het verschil in visie op de verloskundige zorg een belangrijke rol. Bij een deel van de zorgverleners bestond de angst dat extra risicosignalering zou leiden tot een verdere verwijdering van de visie op zwangerschap als een fysiologisch proces. Dit werd als onwenselijk ervaren.

Hoofdstuk 9 bediscussieert de hoofdbevindingen en conclusies van dit proefschrift. Dit proefschrift toont aan dat er belangrijke ongelijkheden zijn met betrekking tot zowel

perinatale morbiditeit en mortaliteit als met betrekking tot de geleverde obstetrische zorg. De professionele organisatie speelt hierin een grote rol. Om deze te overbruggen zal er verdere ondersteuning van zowel patiënten als professionals plaats moeten vinden, in de vorm van onder andere scholingen en tolken.

Om de perinatale uitkomsten over de hele linie te verbeteren en een vermindering van ongelijkheden in uitkomsten te realiseren, is er de noodzaak om het Nederlandse verloskundige systeem te ontschotten. Shared Care aan de hand van gedeelde risicosignalering en -reductie kan daar een zinvolle bijdrage aan leveren.



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Chapter 11

Contributing authors
List of publications
PhD portfolio
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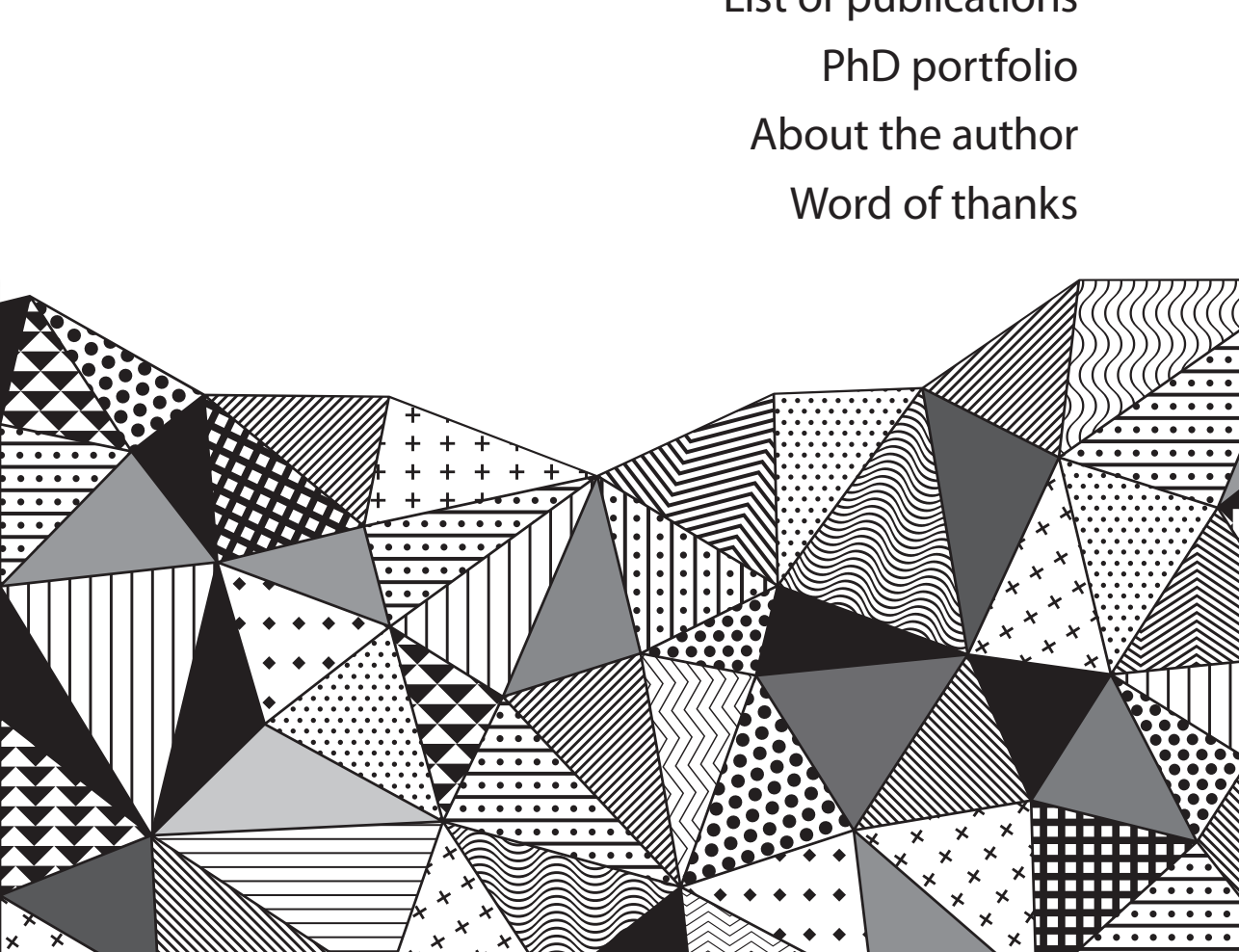
Word of thanks



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LIST OF PUBLICATIONS

Manuscripts related to this thesis:

An antenatal prediction model for adverse birth outcomes in an urban population: The contribution of medical and non-medical risks
Posthumus AG*, Birnie E*, van Veen MJ, Steegers EA, Bonsel GJ
Midwifery. 2015 Nov 10. pii: S0266-6138(15)00289-2. doi: 10.1016/j.midw.2015.11.006
*Shared first authorship

Deprived neighbourhoods and adverse perinatal outcomes: a systematic review and meta-analysis
Vos AA, Posthumus AG, Bonsel GJ, Steegers EA, Denktaş S
Acta Obstet Gynecol Scand. 2014 Aug;93(8):727-40.

Geographical, ethnic and socioeconomic differences in utilization of obstetric care in the Netherlands
Posthumus AG, Borsboom GJ, Poeran JV, Steegers EAP, Bonsel GJ
PLoS One. 2016 Jun 23;11(6):e0156621.

The association of ethnic minority density with late entry into antenatal care in the Netherlands
Posthumus AG, Schölmerich VLN, Steegers EAP, Kawachi I, Denktaş S
PLoS One. 2015 Apr 9;10(4):e0122720.

Inequalities in uptake of prenatal screening according to ethnicity and socio-economic status in the four largest cities of the Netherlands
Posthumus AG, Peters IA, Borsboom GJ, Knapen MK, Bonsel GJ
Submitted

Influence of maternal, child, process and organizational characteristics on intra-partum and neonatal mortality
Posthumus AG*, Bonsel*, Borsboom GJ, de Graaf J, Steegers EAP.
Submitted
*Shared first authorship

Bridging between professionals in perinatal care: towards shared care in the Netherlands
Posthumus AG, Schölmerich VLN, Waelput AJM, Vos AA, De Jong-Potjer L, Bakker R, Bonsel GJ, Groenewegen P, Steegers EAP, Denktaş S
Matern Child Health J. 2013 Dec;17(10):1981-9.

Improving interprofessional coordination in Dutch midwifery and obstetrics: a qualitative study
Schölmerich VLN, Posthumus AG, Ghorashi, Waelput AJM, Groenewegen P, Denktaş S
BMC Pregnancy Childbirth. 2014 Apr 15;14:145.

Shared care in obstetric care in Rotterdam: a realist evaluation.
Posthumus AG, Vos AA, Steegers EAP, Denktaş S
Submitted

Other scientific publications:

Effectiveness of score card-based antenatal risk selection, care pathways, and interdisciplinary consultation (the Healthy Pregnancy 4 All study)
Vos AA, van Voorst SF, Posthumus AG, Waelput AJM, Denktaş S, Steegers EAP
Submitted

Effect of audiovisual education about prenatal screening on informed decision making of pregnant women in the Netherlands
Peters IA, Posthumus AG , Reijerink JCIY, Steegers EAP, Knapen MK, Denktaş S
Submitted

Adverse drug reaction-related admissions in paediatrics: a prospective single-centre study
Posthumus AG , Alingh CW, van Grootheest K, Hanff L, Witjes B, 't Jong GW, de Hoog M
BMJ Open. 2012 Aug 24;2(4). pii: e000934. doi: 10.1136/bmjopen-2012-000934.

PhD PORTFOLIO

Name PhD candidate: Anke Gezina Posthumus
Erasmus MC Department: Obstetrics and Gynaecology
PhD period: 2011 - 2015
Promotors: Prof. dr. E.A.P. Steegers
Prof. dr. G.J. Bonsel
Prof. dr. S. Denkaş

1. PhD Training	Year	Workload (ECTS)
General courses		
NIHES 'Biostatistics for clinicians'	2012	1
NIHES 'Regression analysis for clinicians'	2012	1.9
CARMA course 'Scales development'	2012	0.2
Statistics in healthcare research using SPSS	2012	0.2
NIHES 'Principles of Epidemiologic Data-analysis'	2013	0.7
Biomedical English writing and communication	2014	2
Systematic literature searches in PubMed	2014	0.5
In-depth courses		
Basic course perinatal audit	2011	0.2
In depth course perinatal audit	2011	0.2
Course on chronological report for perinatal audit meetings	2011	0.2
Tutor training, dealing with group dynamics	2012	0.2
Presentations at (Inter)national conferences		
60th Annual meeting of the Society for Gynecologic Investigation, Orlando, USA: poster presentation	2013	1
6th European Conference of Public Health, annual conference, Brussels, Belgium: modified poster presentation	2013	1
34th Annual meeting of the Society for Fetal and Maternal Medicine, New Orleans, USA: poster presentation	2014	1
61th Annual meeting of the Society for Gynecologic Investigation, Florence, Italy: poster presentation	2014	1
DOHaD satellite meeting, Rotterdam, The Netherlands: poster presentation	2011	1
Sophia Research Days, Rotterdam, The Netherlands: oral presentation	2014	1.5
Regional consortium meeting, Rotterdam Presentation on 'scientific evidence for maternity care'	2014	0.5

Attended (inter)national conferences

National symposium Perinatal audit – 'First explorations', Lunteren	2011	0.4
National symposium Perinatal audit – 'Perinatal audit: on course', Nieuwegein	2014	0.4
2nd European Congress on Preconception Care and Health, Rotterdam	2012	0.4

Seminars, workshops, research meetings

Attending weekly and quarterly research meetings of the Department of Obstetrics and Gynaecology (and Urology) with 3 oral presentations	2011-2014	5
Attending the annual meetings of the Collaboration of Rotterdam Regional Gynaecologists' Teaching Hospitals (in Dutch: RGOC) 'Wladimiroff Symposium	2011-2014	0.6
Attending the symposium on behalf of the 2.5 year anniversary of the 'Sophia Birth Centre', Rotterdam, the Netherlands	2012	0.2
Attending the Final symposium of 'Ready for a Child (in Dutch: Afsluitend symposium Klaar voor een Kind)', Rotterdam, the Netherlands	2013	0.2

Other

Support and contact person for perinatal audit meetings in 15 hospitals in the Southwestern region of the Netherlands (>120 meetings)	2011-2014	38
Preparing and attending the regional perinatal audit meeting, Rotterdam	2011-2014	2
Attending the national perinatal audit meetings, Utrecht	2011-2014	3.5
Organizer, contact person and chair of 2 working groups on the development and implementation of local care pathways for medical and non-medical risk factors in collaboration with midwives, gynaecologists and social workers.	2013-2014	4

2. Teaching	Year	Workload (ECTS)
Lecturing		
Lecture on 'Ethnic origin, social disadvantage and poverty, NIHES	2012	1
Lecture on 'The Dutch Obstetric System' for medical Students: minor 'Circle of Life'	2012	1
Lecture on 'Perinatal audit' for Clinical Midwives Master's candidates (Rotterdam)	2012 & 2014	2
Lecture on 'Qualitative research methodology' for Clinical Midwives Master's candidates (Rotterdam)	2014	1
Lecture on 'The theory of planned behaviour' for bachelor students, Erasmus University College (Rotterdam)	2014	1
Tutoring		
Tutoring first-year Medical students in the first four months of their studies, also preparing them for an academic environment	2014	1
Tutoring midwives, research nurses, and gynaecologist in the practical use of a new antenatal risk assessment instrument (R4U) score card in the greater Rotterdam area	2012 - 2014	2

Supervising Master's theses

Tutoring Inge Masman (master thesis), **Title'***Signalering en interventies voor niet-medische risicofactoren voor invoering van de R4U en zorgpaden'*	2013	2

3. Other	Year	Workload (ECTS)
Board member of the association for PhD students of Erasmus MC, Promeras	2012-2013	1
President of the association for PhD students of Erasmus MC, Promeras	2012-2014	1.5
Organizing the PhD day, Erasmus MC, Rotterdam	2013,2014	1.5
Board member of the PhD committee, Erasmus MC, Rotterdam	2013-2014	1

ABOUT THE AUTHOR

Anke Posthumus was born on the 25th of august 1986 in Roosendaal. Her initial year of high school was spent at Patana high school in Bangkok, Thailand. After a stay abroad of four years in total with her parents and sister, she returned to Roosendaal and obtained her high school degree at the Jan Tinbergen College (Athenaeum) in 2004. Thereafter, she was accepted as a medical student at the Erasmus Medical Centre in Rotterdam. From the start she was fully committed to becoming a doctor. During her studies, Anke has not limited herself to the regular curricula but has always sought to apply her newly attained knowledge. She has travelled to Peru for a clinical internship in a small hospital in Huancayo and travelled to Washington for a research project in the Children's National medical Centre. Throughout her studies and practical experience, her enthusiasm for a specialization in obstetrics and gynaecology has grown. It excites here to be able to work in this specific field of medicine. In September 2011, my sister started her PhD research, which has resulted in this thesis. Anke now much enjoys her work as a resident in training in Obstetrics and Gynaecology at the Albert Schweitzer hospital in Dordrecht.

Fleur M. Posthumus, sister

DANKWOORD

Hier ligt het dan, mijn proefschrift is af. Het is een leerzame, mooie tijd geweest met veel hoogtepunten en op zijn tijd een uitdaging. Ik zou het zo weer doen. Maar ik heb het uiteraard niet alleen gedaan. Graag wil ik een groot aantal mensen bedanken.

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Het waren leerzame, leuke jaren!

Mijn tweede promotor, **prof. dr. Gouke Bonsel**, beste Gouke, bedankt voor de prettige en leerzame samenwerking, je feilloze gevoel voor en enthousiasme over epidemiologie, de ad hoc colleges over alle mogelijke onderwerpen van statistiek tot klassieke muziek, de uitgebreide leeslijst die je me in de loop van de tijd hebt aangeraden (waarvan een deel nog op de to-do staat, het was niet bij te benen), de demonstratie van multivariate analyses in Excel (ja, het kan) en het vertrouwen dat je in me had. Ik heb ontzettend veel van je geleerd.

Mijn derde promotor, **prof. dr. Semiha Denktaş**, beste Semiha, ik had me geen betere dagelijks begeleider kunnen wensen. Zowel op onderzoeksgebied als in algemene zin ben je een inspirerend mens, met een gezonde dosis humor. Jouw doorzettingsvermogen en daadkracht zijn bewonderenswaardig. Je weet de verbinding te leggen tussen onderzoek en beleid waardoor we die mensen kunnen bereiken waar het uiteindelijk om draait. 'Won't take no for an answer', fantastisch. Ik hoop je nog regelmatig te blijven zien.

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Naast mijn onderzoek was ik voor de Perinatale Audit lid van het Regioteam Zuidwest Nederland, samen met **dr. B.J. (Bert) Smit** en **dr. M.F.C.M. (Maarten) Knapen**. Beste Bert en Maarten, onze samenwerking begon helemaal aan het begin van mijn onderzoekstijd. Wat heb ik veel van jullie geleerd. De frequente (en soms lange) autoritten naar ziekenhuizen op alle mogelijke plaatsen in onze regio leidden tot interessante gesprekken en nieuwe inzichten. Jullie adviezen, zowel met betrekking tot de audit, mijn onderzoek als van alles daarbuiten, heb ik erg gewaardeerd. **Eline**, wat ontzettend fijn dat jij mij hebt opgevolgd als lid van het regioteam Zuidwest Nederland, een betere opvolger had ik me niet kunnen wensen.

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Beste **Adja**, na elke vraag was ik altijd verzekerd van een bedachtzaam antwoord, meestal in combinatie met een naam van deze of gene die zich in een rapport over de kwestie had uitgelaten. Jij werd nergens gesignaleerd zonder iPad, en je aanstekelijke lach was niet te missen. Ontzettend leuk dat we collega's waren, zowel binnen de onderzoeksgroep als binnen de perinatale audit.

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Lieve **Steef**, weet je nog: 'be patient, we are going to be doctors?' Dat zijn we inmiddels, and the story goes on. Bedankt voor jouw steun, in al het belangrijke en in alle futiliteiten in mijn leven.

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Mijn fantastische **'medico-meiden', Eef, Caar, Carien, Juul** en (nog een keer) **Steef**. Wat hebben we het altijd fijn samen. Zet ons bij elkaar en de dokters in ons gaan los. Maar bovenal kunnen we samen van het leven genieten. **Eef**, de verdiende donderdagavond wijntjes, om weer even ge-update te zijn en stoom af te blazen. **Carien**, om 'the latest' vanuit BMG-perspectief te horen en je bereidheid je weer eens mee te laten slepen in ondernemingen die in eerste instantie alleen in mijn ogen een goed idee zijn (het liefst over landsgrenzen;)).

Lieve **'Snorries'**, **Juud, As** en **Syl**, een bonter gezelschapje hadden ze niet in een huis kunnen stoppen, wat fijn om jullie nog steeds te zien. **Juud**, bedankt dat je altijd off-the-beaten-track wil, en zo niet, dan toch. Voor de grenzeloos goede gesprekken over het reële recht en onrecht in de wereld, en de invulling die wij aan ons eigen leven geven. **As**, voor je rationele kijk op diezelfde wereld en je doorzettingsvermogen. Jullie zijn power-chicks.

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Moon, Lau en **Mayo,** om de Brabantse gezelligheid er in te houden, wat fijn dat we elkaar nog steeds zien.

Mijn andere lieve geneeskunde-vriendinnetjes. **Leonie**, wat heerlijk om het vakoverstijgend wel en wee als promovendus (en alles daarbuiten) te kunnen delen. Dat houden we er in als AIOS;)! **Wendy**, kort geleden heb jij het voorbeeld gegeven. Goed voorbeeld doet goed volgen? Ik bewonder je doorzettingsvermogen en ben blij met onze eetdates. **Janelle**, waar een co-schap in Goes al niet goed voor is. We zien elkaar minder dan voorheen, maar het gaat om kwaliteit niet kwantiteit.

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Lieve **Sabine**, als kamergenootjes hebben we *no free lunch* gevonden, wel veel fun en goede gesprekken. Jouw bedachtzaamheid en rust waren een verademing als ik ergens niet uitkwam. Je vrolijkheid en gastvrijheid (en Radio Bermuda) maakten het af. Ook als onze onderzoeken al lang voltooid verleden tijd zijn, blijven wij elkaar zien.

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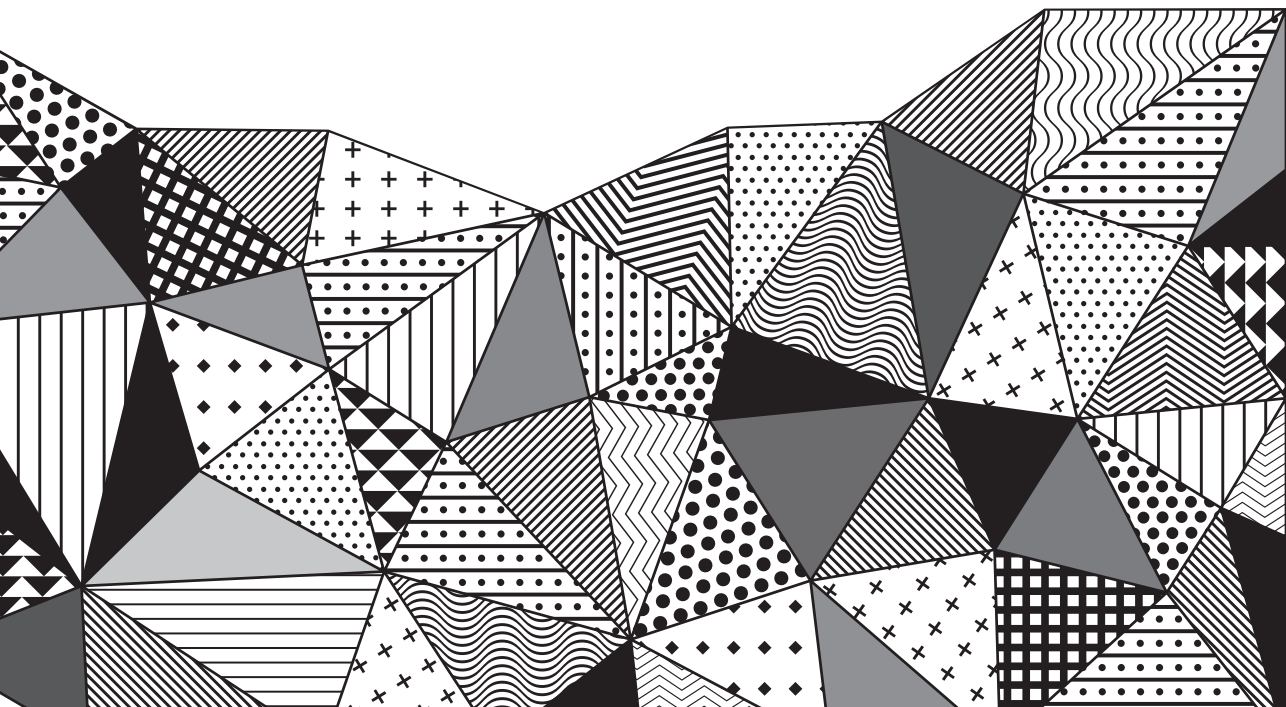
Lieve **Michiel**, wat ontzettend fijn dat jij hier vandaag bent. Wat hebben we al veel moois beleefd samen en wat gaan we nog veel moois samen doen.



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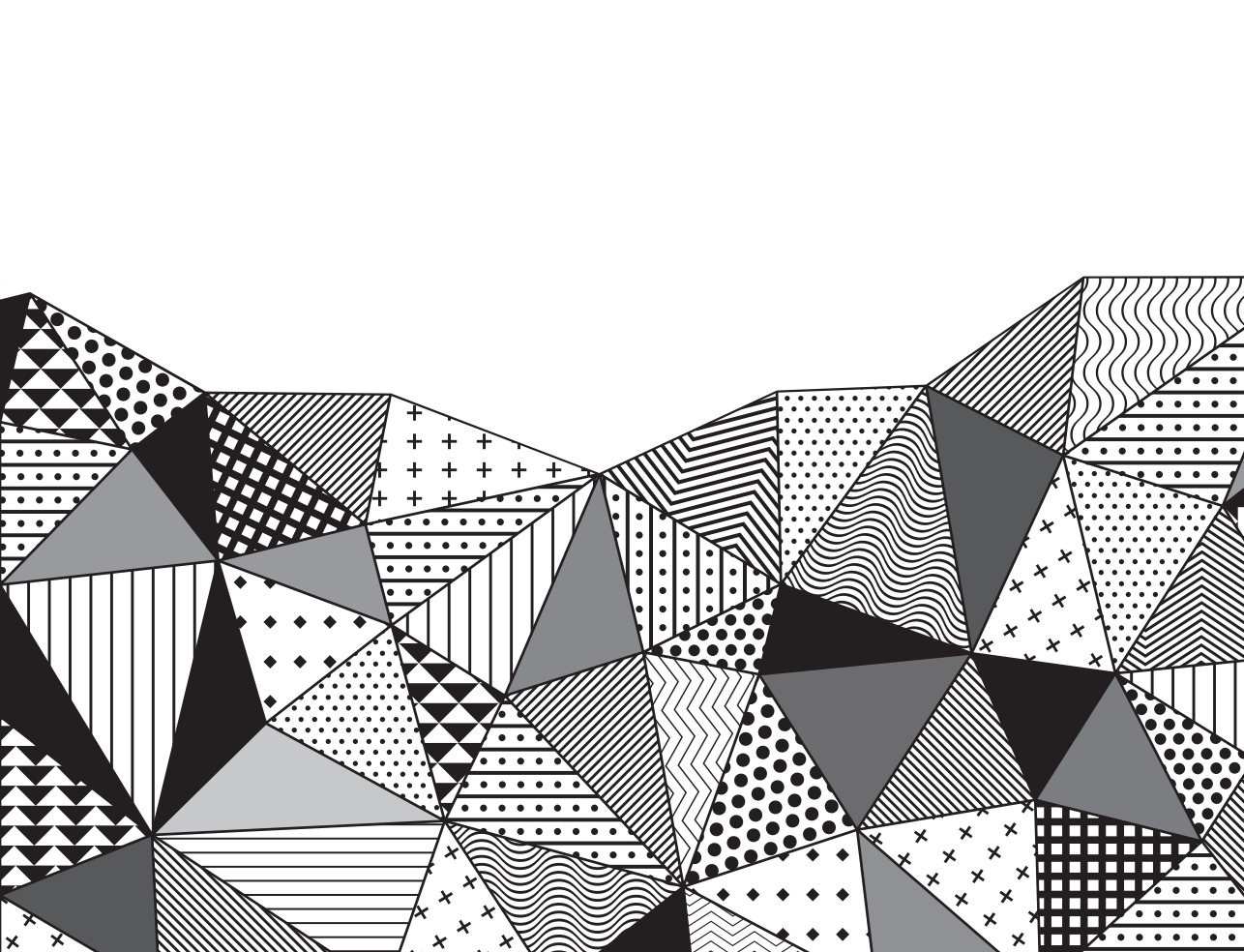
Chapter 12

Appendix



✂	Name			Study ID		G: P:	Date of Birth	
Name of practice		Zip Code			Date of booking visit		Due date	□ LMP □ US □ IVF

SOCIAL			action
Social situation	YES	NO	
Single mother			
Relationship problems > 3 months			
Experience of inadequate social support			
Domestic violence			
Previous referral to children's social services			
Work and income	YES	NO	
Unemployed (> 3 months)			
Standing labour			
Working hours > 32 and stressful			
Netto family income < 1000 euro			
Irredeemable Financial debts			
Partner unemployed			
Education	YES	NO	
Low education level (< 7 years) or illiterate			
Neighbourhood	YES	NO	
Housing problems			
Deprived neighbourhood*			
(*ZIP code classification present in script)			
ETHNICITY			
Ethnicity	YES	NO	
Surinamese - Hindo			
Surinamese - Creole			
Surinamese - Javanese			
Antillean / Aruban			
Cape Verdian			
Turkish			
Maroccan			
Non-Western other			
Language / communication	YES	NO	
Language barrier (limited Dutch or English)			
Exclusively communication by interpreter			
Mentally disabled			
REPRODUCTIVE FACTORS			
General	YES	NO	
Uninsured			
Family planning / age	YES	NO	
Unwanted pregnancy			
Unplanned, but wanted pregnancy			
Assisted reproduction (ICSI/IVF/IUI/oocyte donation)			
Teenage pregnancy (≤ 18 yeas)			
Advanced maternal age (≥ 40 jaar)			
Obstretical	YES	NO	
Start antenatal care 12 - 14 weeks			
Late start antenatal care > 14 weeks			
LIFESTYLE			
Intoxication	YES	NO	
Preconceptional smoking (past 6 months)			
Smoking during first trimester			
Smoking during second trimester			
Preconceptional alcohol use (past 6 months)			
Alcohol use during first trimester			
Alcohol use during second trimester			
Preconceptional illicit drug use (past 6 months)			
Illicit drug use during first trimester			
Illicit drug use during second trimester			
Nutrition	YES	NO	
Vegetarian, vegan or macrobiotic diet			
No daily vegetable intake			
No daily fruit intake			
Body weight	YES	NO	
BMI < 18			
BMI 30 - 35			
BMI > 35			

GENERAL HISTORY			action
Disorders	YES	NO	
Chronic maternal illness (as described in script)			
Annual consultation GP or physician			
Hemoglobinopathy			
Refuses blood transfusion (Jehovah's Witness)			
Medication	YES	NO	
Prescribed medication			
Over-the-counter drugs			
No preconceptional folic acid use			
Infectious diseases	YES	NO	
(Treated for) sexually transmitted disease last year			
Promiscuity			
At risk for Toxoplasmosis			
At risk for Rubella			
Psychiatry	YES	NO	
History of psychiatric admission / positive family history (1st degree)			
Current use of psychiatric medication			
Current psychiatric problems			
OBSTETRIC HISTORY			
History	YES	NO	
Nulliparous			
Recurrent miscarriage (2 or more)			
Interpregnancy interval < 6 months			
Preterm birth (< 37 weeks)			
Low Apgarscore < 7 after 5 minutes			
Small for gestational age (<p10)			
Previous child with major congenital anomalies			
Stillbirth (22 weeks - 7 days postpartum)			
Shoulder dystocia			
Instrumental delivery			
Caeserean section			
Gestational diabetes			
Manual placental removal / postpartum haemorrhage			
Placental abruption			
(Pre)eclampsia or HELLP syndrome			
Family	YES	NO	
Major congenital anomaly in first degree relative			
Other (as described obstetric indication list)			
Result booking bloods	POS	NEG	
Irregular antibodies			
Hepatitis B			
HIV			
Lues			

Preconception consult

□ Yes midwife date (mm/yy): □ Yes GP date (mm/yy): □ No

Plus factor

Result

Domain	Score
Social	
Ethnicity	
Care	
Life style	
General history	
Obstetrical history	
Lab results booking bloods	
CUMULATIVE score	

Time start consult (hh:mm)	
Time end consult (hh:mm)	

Partner present	YES	NO	NA

Additional notes

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Figure 1. Rotterdam Reproductive Risk Reduction Scorecard (R4U).