CAPACITY POOLING WITHIN THE MIDWIFERY PROFESSION

What are the effects?

Babet Stroop

Industrial Engineering and Management
University of Twente

Supervisor KNOV
drs. S. Verweij

Supervisors University of Twente
Dr. ir. A.G. Maan-Leeftink
Prof. dr. ir. E.W. Hans

KNOV

UNIVERSITY OF TWENTE.

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Management summary

Problem definition

The current pressure on the midwifery care system requires us to look for more efficient ways to provide maternity care and thereby secure the midwifery profession for the future. Pooling midwifery capacity could be a way to strengthen and profile midwives in the region by taking a shared effect in providing care for a larger group of pregnant women. The goal of this study is to:

Assess the potential of capacity pooling within the midwifery profession.

Method

The theoretical contribution of this study is the development of a method that is able to assess the effects of capacity pooling within the midwifery profession while considering continuity of care provided within the Dutch midwife-led continuity of care model. We evaluate the current literature on the effects of capacity pooling within healthcare in general and acute obstetric care in specific. Next to this, we elaborate on the concept of continuity of care. We present a Discrete Event Simulation model of team midwifery, which we use to examine the current performance of team midwifery in a case study at cooperation VeRVe. Performance is measured using the following key performance indicators: utilization of midwives, continuity of care, access to care and the length of stay. We then explore the effects of capacity pooling based on multiple experiments evaluating both urgent consultation slots and pooling of midwifery shifts.

Results

Introducing an urgent consultation slot of fifteen minutes in the morning within the existing appointment schedule increases the average continuity of care provided within acute care requests with on average 7%. We observe an increase in continuity of care of on average 3% for an urgent consultation slot of fifteen minutes in the afternoon. Next to the evaluation of urgent consultation slots, we distinguish four capacity pooling levels (CPLs) as illustrated in Figure 1.

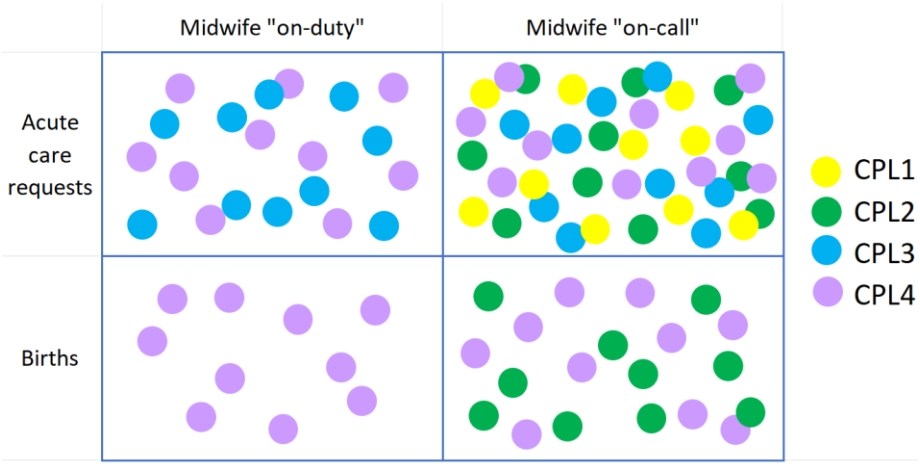

Figure 1 Capacity pooling levels (CPLs).

Results on capacity pooling for both the care provision for acute care requests and births show a 12.5% and 25% decrease in required midwifery capacity for CPL2 and CPL4 respectively. Capacity

pooling only for acute care requests requires one midwife with a utilization of 13% for CPL1 and two additional midwives with a utilization of 13% and 1% for CPL3. The percentage of acute care requests provided by a known midwife decreases with on average 8%, 8%, 44% and 44% for CPL1, CLP2, CPL3 and CPL4 respectively. The percentage of births attended by a known midwife decreases with on average 0%, 12%, 1%, 60% for CPL1, CPL2, CPL3 and CPL4 respectively.

Conclusion and discussion

The results of our study, which quantitatively evaluated both efficiency and continuity of care, provide midwives in the Netherlands with the ability to balance these measures against each other, empowering them to make an informed decision. We contributed to theory by developing a discrete event simulation model that is able to evaluate multiple levels of capacity pooling with the Dutch MLCC model based on the utilization of midwifery shifts, access to care, waiting time and continuity of care provided in both acute care requests and births. Lack of available data on the frequency and characteristics of urgent consultations within primary midwifery care highlights the need for further research in this area to study the effects of urgent consultations on the provision of midwifery care and to identify the variability caused by these processes. Registration of acute care requests within midwifery practices is therefore a prerequisite. Next to studying the characteristics of urgent consultations, it is important to analyze primary care provided by midwives in combination with secondary and tertiary obstetric care.

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Glossary

KNOV	Koninklijke Nederlandse Organisatie van Verloskundigen
MLCC	Midwife-led Continuity of Care
CC	Continuity of care allows time for the pregnant women and her midwife to clarify expectations, to get to know each other and to understand important values in the woman's life that reflect her choices during pregnancy.
On-duty	The first midwife available for urgent consultations
On-call	The second midwife available for urgent consultations
EOS	Economies of scale
LOS	Length of stay
CVlow	Low variability for regular consultation duration
CVhigh	High variability for regular consultation duration
VeRVe	Verbond van Rijnmondse Verloskundigen
VPTC	Verloskundig Prenataal Triage Centrum
VPTC1	Capacity pooling on-call midwives providing care for acute care requests.
VPTC2	Capacity pooling on-call midwives providing urgent consultations.
VPTC3	Capacity pooling on-duty & on-call midwives providing care for acute care requests.
VPTC4	Capacity pooling on-duty & on-call midwives providing urgent consultations.

1 Introduction

In this chapter, we introduce the research topic. We first provide background information on the midwifery care system for pregnant women in the Netherlands in Section 1.1 and the motivation of this research in Section 1.2. In Section 1.3 we explain the problem description after which we describe the problem approach in Section 1.4.

1.1 Midwifery care in the Netherlands

Pregnancy and childbirth are exceptionally important periods of life for women. The way women are treated, the relationships they build and everything that happens during pregnancy, birth and beyond are essential and can have profound consequences (Coxon & Jones, 2016). Therefore, midwives are providing care based on individual woman's needs, values, and preferences, which may be affected by emotional, social, obstetric, medical, or family issues that pregnant women are experiencing. Midwives need to cope with this complexity and anticipate on the gaps between healthcare services to provide the care women need. Internationally, Dutch maternity care is a source of inspiration to improve or restore midwife-led care and decrease medicalization, in particularly because of the high level of home births (De Vries, 2004). The Royal Dutch Organization of Midwives (KNOV) is an organization for and by midwives in the Netherlands. The KNOV strives for the best maternity care for mothers, partners, and children, by supporting midwives, connecting them, and looking after their interests (Verloskundigen, Missie, Visie & Beleid, sd). Currently, maternity care within the Dutch healthcare system belongs to the most accessible, adequate, and qualitative healthcare worldwide. The KNOV describes her vision for 2030 in four items (Verloskundigen, De verloskundige in 2030, 2019):

1. Personal and continuous care leads to a more positive pregnancy and birth experience for the mother and a good start for the child.
2. Medical care is combined with social maternity care in which pregnant women take responsibility for their healthcare and midwives act up on signals of social vulnerability.
3. Pregnant women have close contact with their midwives and other pregnant women by actively applying technology.
4. Midwives are prepared for the continuously changing environment in which networking, regional differences, new technological possibilities, individualized care, and research play a crucial role.

1.2 Research motivation

Nowadays the capacity shortages are the biggest challenge to our healthcare system, including midwifery care. This raises the question of whether our current healthcare system is sustainable for the future. The Health and Youth Care Inspectorate (IGJ) analyzed the pressure on the midwifery care system and accounted it to the rising number of births on the one hand and the shortage of midwives on the other hand (Inspectie Gezondheid en Jeugd). Other developments within midwifery care are the concentration of acute care, the increasing healthcare expenditures, the rising workload for midwives, and the current rules for integral financing (Verloskundigen, De verloskundige in 2030, 2019) (Zorgcijfers monitor, 2021). KNOV wants to secure midwifery care for the future by anticipating these (inter)national developments.

One of the possible ways to anticipate is using capacity pooling, which is the focus of this thesis. Pooling resources is an efficient strategy for managing uncertainty (Karsten, Slikker, & Van Houten, 2015). Instead of having dedicated, separate resources for each customer, pooling resources refers to an arrangement in which a collection of shared resources is held for multiple customers. Depending on the service characteristics, pooling resources among service providers can result in a

more efficient use of capacity and offers the chance to gain from economies of scale (EOS). This gain from EOS can be explained best by comparing a focused situation with a pooled situation through modelling the situation as a queuing system (Cattani & Schmidt, 2005) (Vanberkel, Boucherie, Hans, Hurink, & Litvak, 2012). In the focused situation, customer A is waiting in a queue for one service provider while the queue for the other service provider is free. In the pooled situation, both service providers have the same queue, and the waiting customer A would have been served earlier. The impact of pooling in a queuing system depends on the average service time, the utilization of the service providers, the variability in customer arrivals, and the number of service providers being pooled.

Healthcare facilities are under increasing pressure to offer a higher quality of care while lowering costs through increased efficiency. The pooling principle is a way to efficiently organize the delivery of care by aggregating healthcare services. This could imply that a pooled healthcare facility that serves multiple patient types is more efficient than several healthcare facilities focusing on a more limited range of patient types. A common example of capacity pooling within healthcare is the Integrated Emergency Post (IEP). IEPs provide appropriate treatment within one health care facility, with less complex care being provided by general practitioners (GPs) or specially trained nurses, while more complex care is provided by Accident and Emergency (A&E) doctors. In the Netherlands, more and more GP posts and A&E departments are integrating care into IEPs to optimize patient flow (Kool, Kamphuis, & Homberg, 2008). Inefficient patient flow in A&E departments is a common problem in many countries. Kool, Kamphuis and Homberg measured patient flow based on the percentage of self-referrals, the time spent at the GP post and the total number of patients seen out of hours at the A&E department, the GP post, or the IEP. The creation of IEPs resulted in a reduction in waiting times, consultation times, and the proportion of self-referrals (Kool, Kamphuis, & Homberg, 2008) (Mes, Vliegen, & Doggen, A quantitative analysis of integrated emergency posts, 2021). Besides, the development of IEPs shows a shift of emergency consultations from secondary care to primary care.

1.3 Problem description

Recently, KNOV started the project “Birth center of the future”. In this project the KNOV wants to quantitatively assess the effects of pooling midwifery capacity (Koninklijke Nederlandse Organisatie van Verloskundigen, 2022). Pooling midwifery capacity could be a way to strengthen and profile midwives in the region by taking a shared effort in providing care for a larger group of women. The goal of implementing the pooling principle within the midwifery profession is to reduce the workload for midwives and increase the quality of care for women. Pooling the midwifery care system can be realized in multiple ways, based on the type of care the midwives are providing together. KNOV established three concepts for pooling midwifery capacity which are listed below and illustrated in Figure 2.

- Women’s center: a central place where women can go for physical, mental/emotional, and social health questions. It provides continuity of care for women during their fertile stage of life. The focus is on positive health, prevention, and self-awareness, in addition to providing medical, technological, and innovative care.
- Midwifery acute care center: a midwifery-managed location for low (and average) risk clients where midwives provide antenatal and postnatal acute care. The Dutch triage standard (NTV) is used to determine how severe the complaints are, and which treatment or referral is needed.
- Birth center: a midwifery-managed location where low (and average) risk pregnancies can take place in which midwives take primary professional responsibility for care (Midwifery Unit Network, 2018).The birth center may be located away from (freestanding) or adjacent to (alongside) an obstetric service or hospital.

Figure 2 Three concepts for pooling midwifery capacity

Pooling midwifery capacity within one of these concepts or variations on these concepts could be a solution to create cooperation between midwives. Implementations of capacity pooling within healthcare show that aggregating healthcare services can result in a decrease in waiting/consultation times, a decrease in self-referrals and a shift from secondary to primary care (Kool, Kamphuis, & Homberg, 2008). But how does healthcare in general differ from maternity care? Eri et al. emphasize the difference in epistemological basis between health care and maternity care (Eri, et al., 2020). Healthcare is based on values and attitudes, and these are often expressed in theoretical frameworks and models of care. These frameworks are guiding tools in the organization of healthcare and facilitate awareness in having an epistemological basis. Other than healthcare in general, maternity care is subject to other epistemological statuses during the different phases of a woman's pregnancy and childbirth. An example of the differences in epistemological basis is the fact that pregnancy is on the boundary of illness and health, which raises the question to whether pregnant women should be treated as ill or well. Therefore, maternity care is often provided by multiple health care professionals, both facilitating health and treating illness. This requires close cooperation between midwives and obstetricians while there is currently a clear distinction between primary, secondary and tertiary care. The different care levels have separated organizational and financial structures, which enables them to act relatively autonomously (Lips, Molenaar, & Schuitmaker-Warnaar, 2020). Besides, facilitating maternity healthcare is currently characterized by a shift towards a more risk-averse approach to childbirth in combination with increased medicalization (MacKenzie Bryers & van Teijlingen, 2010). Taking the more risk-averse approach, the distinction between the care levels and the differences in epistemological statuses between maternity care and healthcare into account, we cannot assume the same effects of capacity pooling. The lack of knowledge on the effects of capacity pooling within the midwifery profession is the core problem we address in this study.

1.4 Problem approach

The theoretical contribution of this study is the development of a method that is able to assess these effects of capacity pooling within the midwifery profession. The practical contribution of this study is to contribute to a more sustainable midwifery profession. Insight in the effects of capacity pooling is needed to be able to react on (inter)national developments and thereby secure the midwifery profession for the future. We define the following research goal:

Assess the potential of capacity pooling within the midwifery profession.

To achieve the research goal, we divided our research into sub-questions. We now present these sub-questions, followed by a brief explanation of the methodology:

1. How is the midwifery profession currently organized?

In Chapter 2 we analyze the context of this study based on literature research, observations at multiple midwifery practices and active participation in the pilot group "Birth center of the future" at the KNOV. We elaborate on the definition of the midwife and the midwifery profession, how pregnant women in the Netherlands receive care through the midwife-led continuity of care model and the different ways to provide midwife-led continuity of care.

2. How can we assess the effects of capacity pooling within healthcare, and in the midwifery profession in particular?

In the following chapter, Chapter 3, we conduct literature research to explore the current knowledge on the effects of capacity pooling within healthcare. Besides, we describe the effects of centralization of acute obstetric care to learn from earlier centralization which is closely related to midwifery care. We conclude this chapter by incorporating knowledge on the effects of centralization within acute obstetric care to assess the effects within midwifery care.

3. How can we integrate the midwifery profession into a mathematical model that is able to determine the effects of capacity pooling?

After evaluating the existing literature on the effects of capacity pooling, in Chapter 4, we explain how we model the midwifery profession using Discrete Event Simulation, in order to assess the effects of capacity pooling based on Key Performance Indicators (KPIs).

4. What are the effects of capacity pooling within the midwifery profession based on the KPIs?

In Chapter 5 we introduce the case study at cooperation VeRVe, describe their existing concept of pooling capacity within the midwifery profession and perform a data analysis to generate input for our mathematical model. Thereafter, based on our mathematical model we assess the effect of capacity pooling and describe the results in Chapter 6.

We conclude our research in Chapter 7, where we present the main conclusion, discuss the limitations, and provide future research opportunities.

2 Introduction

In this chapter, we analyze the context of this study. In Section 2.1 we elaborate on the definition of the midwife and the midwifery profession. In Section 2.2 we describe the current way of organizing maternity care in the Netherlands. In Section 2.3 we discuss continuity of care.

2.1 The midwifery profession

The term “midwife” is derived from the old English words “mid” and “wife”, meaning “with” and “women” (De Jonge, 2021). A midwife is therefore a care provider who is “with the women”. In contrast to the Dutch term “verloskundige”, the word midwife refers to the woman at the center of the process rather than the caregiver. The definition of the term “midwife” is established by the World Health Organization (WHO) Expert Committee on Midwifery in 1964 (World Health Organization, 2017). Over the years, multiple amendments were made to emphasize the true status of the midwife, to underline their relationship with the women and to reflect on the concerns about medicalization. The latest agreement on the “Definition of the Midwife” is revised and adopted by the International Confederation of Midwives (ICM) in 2017 (see Panel 1) (International Confederation of Midwives, 2017).

Panel 1: The midwife (International Confederation of Midwives, 2017, p. 1)

“A midwife is a person who has successfully completed a midwifery education program that is based on the ICM Essential Competencies for Basic Midwifery Practice and the framework of the ICM Global Standards for Midwifery Education and is recognized in the country where it is located; who has acquired the requisite qualifications to be registered and/or legally licensed to practice midwifery and use the title ‘midwife’; and who demonstrates competency in the practice of midwifery.”

Midwives provide a large part of maternity care, in collaboration with obstetricians, nurses, maternity care assistants and several other care providers. Together they provide supportive care that enables women to be pregnant and to give birth in a way that suits them best. The Lancet series of international studies on midwifery emphasizes the need for a definition of “midwifery” as a continuum of care (see Panel 2) (Renfrew, et al., 2014). This definition identifies the aspects of midwifery care and provides structure for the evaluation of the quality of midwifery care.

Panel 2: The practice of midwifery (Renfrew et al, 2014, p. 1130)

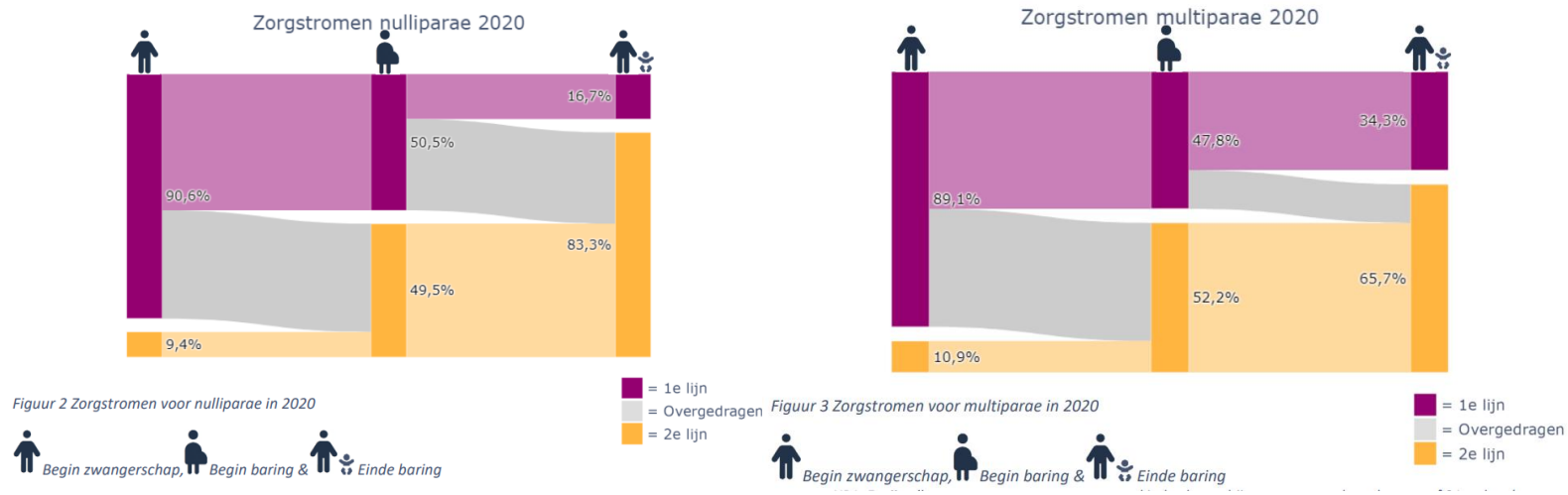
“The skilled, knowledgeable, and compassionate care for childbearing women, newborn infants, and families across the continuum throughout pre-pregnancy, pregnancy, birth, post-partum, and the early weeks of life. Core characteristics include optimizing normal biological, psychological, social, and cultural processes of reproduction and early life; timely prevention and management of complications; consultation with and referral to other services; respect for women’s individual circumstances and views; and working in partnership with women to strengthen women’s own capabilities to care for themselves and their families”.

2.2 Midwife-led continuity of care

There are several ways to provide maternity care and women are often faced with multiple opinions on which model of care is best for them. In some countries the maternity care services are only

provided by medical doctors, while in other countries care is provided through the medical-led care model, midwife-led continuity of care model or shared models of care (Sandall, Soltani, Gates, Shennan, & Devane, 2015).

Pregnant women in the Netherlands receive primary care by midwives through the Midwife-Led Continuity of Care model, more often called the MLCC model. The MLCC model aims to provide care to healthy women as long as pregnancy and childbirth occur without complications (Wiegers, 2009). Whenever there is an increased risk of complications, the midwife refers the client to secondary obstetric care. Figure 3 illustrates the division between primary and secondary care during multiple phases of a woman's pregnancy for nulliparous and multiparous in the Netherlands (Perined, 2021). A nulliparous is a woman that is pregnant of her first child and the term multiparous refers to a pregnant woman who had one or more live births before. Of all women receiving primary midwife-led continuity of care at the start of their pregnancy, 44,26% (nulliparous) and 46,35% (multiparous) are referred to secondary care before the start of labor. Intrapartum referrals are 66,93% (nulliparous) and 28,24% (multiparous). Intrapartum referrals occur during the act of birth and are calculated by comparing the decrease in primary care from the start of labor till the end of labor with the original percentages of primary care clients.



Figuur 2 Zorgstromen voor nulliparae in 2020

Figuur 3 Zorgstromen voor multiparae in 2020

Figure 3 The division between primary and secondary care for nulliparous and multiparous (derived from Perined)

The WHO distinguishes between two ways to provide MLCC: team midwifery and case-load midwifery (World Health Organization, 2016). Team midwifery provides continuity of care through a small group of midwives that support the woman during the antenatal, natal, and postnatal period. Case-load midwifery aims to offer continuity of care by a single known and trusted midwife. The dominant model in Dutch maternity care is team midwifery and is often referred to as the "regular primary midwifery care" in the Netherlands. Team midwifery is offered by self-employed midwives who practice in teams of three or more and together they share antenatal, natal, and postnatal care for all pregnant women attending their midwifery practice. This research focusses on team midwifery. When we refer to a woman and "her midwife", we refer to a team of midwives sharing antenatal, natal, and postnatal care.

3 Theoretical framework

On the one hand, the Dutch midwifery profession is characterized by offering continuity of care through small groups of midwives which is related with good health outcomes for newborn infants. On the other hand, the Dutch midwifery profession is under pressure due to the rising workload which requires us to look for more efficient ways to provide care and thereby secure the midwifery profession for the future. In Section 3.1 we describe how to assess the effects of capacity pooling in healthcare based on the existing literature. In Section 3.2 we explain the effects of centralization of obstetric care and in Section 3.3 we describe the importance of continuity of care within the midwifery profession and in Section 3.4 we conclude this chapter with our contribution.

3.1 Assessing the effects of capacity pooling in healthcare

Due to fluctuations in patient demand and resource availability, healthcare systems face challenges in capacity planning and often experience inefficiencies in resource utilization. As described in the introduction, pooling can be a way to efficiently organize the delivery of care by aggregating healthcare services. Vanberkel et al. (2012) examined several service and patient group characteristics to study under which conditions centralization or decentralization is more efficient. Access time was considered as the main measure for the efficiency and depends on the arrival rate of new patients and the throughput of the health care facility. The arrival rate is assumed to be the same regardless of a centralized or decentralized situation, while the throughput is influenced by a gain or loss from EOS. The main factors effecting EOS losses due to decentralization are clinic load, proportional size of the patient groups, server allotment and variability in appointment length. Mes et al. (2021). consider the length of stay (LOS) of patients as a primary performance indicator for assessing the effects of integrating emergency departments (ED) and general practitioner cooperatives (GPC) into integrated emergency posts (IEP). An example of centralization in health care which is closely related to assessing the effects of centralization within midwifery care is the centralization of acute obstetric care. In the following section we elaborate on the effects of capacity pooling within obstetric care.

3.2 Centralization of acute obstetric care

Due to centralization of acute obstetric care in the Netherlands, the number of hospitals providing 24/7 acute obstetric care decreased from 84 to 74 between 2014 and 2022 (Rijksinstituut voor Volksgezondheid en Milieu, 2022). Although currently 99.7% of all citizens lives within 45 minutes of a hospital, 31 of the 74 hospitals offering acute obstetric care are categorized as a “sensitive hospital”, indicating that closure of acute obstetric care in this hospital would result in a substantial number of women being unable to access acute obstetric care within 45 minutes. The number of “sensitive hospitals” increased from 17 to 31 hospitals between 2021 and 2022. The advantages and disadvantages of centralization within acute obstetric care have been evaluated in multiple studies. In Norway, decreased neonatal mortality is observed in areas where a great majority of births occurred in large hospitals (Moster, Terje LIe, & Markestad, 2001). Another benefit of centralization is that health care professionals, such as obstetricians, pediatricians, and anesthesiologists, are available full-time. This allows for easy access to interventions during childbirth and enables rapid identification and management of unexpected complications. Maintaining quality of care after centralization involves several aspects, including ensuring safety, a clear vision on maternity care and making innovative adaptions (van den Berg, et al., 2021). Primary care midwives, in particular, mention that the quality of care based on their vision on maternity care was compromised after the centralization. Increasing the number of midwives to cover longer distances due to centralization reduces continuity of carer. Continuity of care is an important aspect of the Dutch MLCC model, but

what is continuity of care and how to incorporate this while assessing the effects of centralization in midwifery care?

3.3 Continuity of care

Continuity of care (CC) allows time for the pregnant women and her midwife to clarify expectations, to get to know each other and to understand important values in the woman's life that reflect her choices during pregnancy. CC is care provided based on a woman's preferences and wishes and is characterized by "a relationship of sharing between the woman and her midwife, involving trust, shared control and responsibility and shared meaning through mutual understanding" (Guilliland & Pairman, 1999).

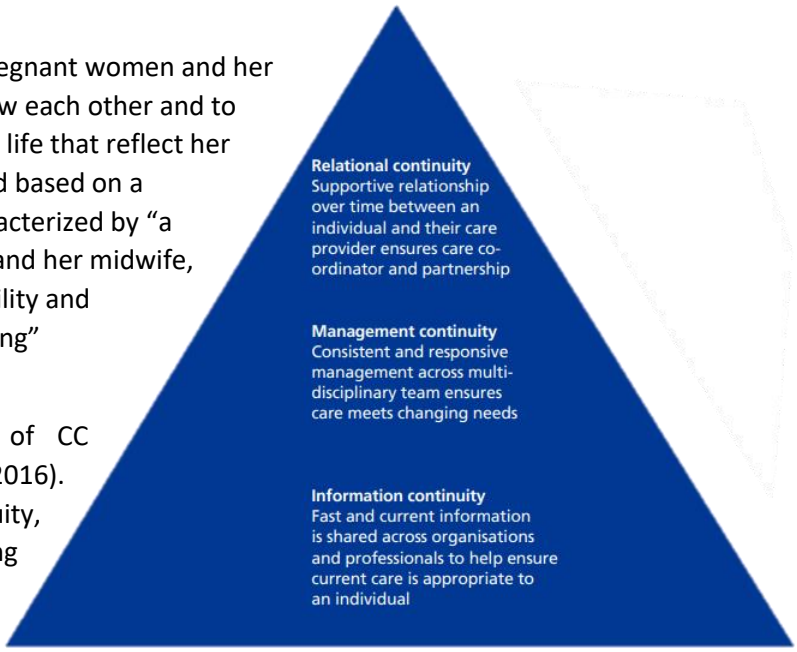


Figure 4 Hierarchical levels of continuity of care (derived from Coxon & Jones, 2016)

Figure 4 shows the hierarchical levels of CC (Haggerty, et al., 2003) (Coxon & Jones, 2016). The lowest level is informational continuity, which focusses on personalized care using knowledge on personal circumstances and past events. The next level of CC is management continuity, which reflects a responsive and consistent approach to managing a health condition that adapts to the changing needs of the pregnant women. The highest level of CC is relational continuity. Relational continuity reflects an ongoing supportive relationship between a pregnant woman and her midwife. This relationship ensures that midwives, acting as primary care providers, place the woman and her family at the center of care to improve communication with other health care professionals (see Figure 5). Freeman et al., support this hierarchical structure (Freeman, et al., 2007). They describe and limit the concept of continuity within six empirical primary care projects and found that informational continuity is always at the service of either management or relational continuity.

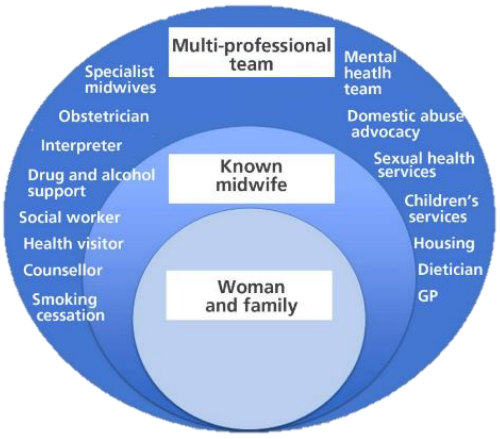


Figure 5 Relational continuity: the woman and her family at the center of the maternity care process (derived from Freeman, et al., 2007)

For example, informational continuity is needed for decision making and management continuity is needed to implement these shared decisions. Relational continuity can in some situations even mitigate gaps between informational continuity and management continuity.

A Cochrane review conducted by Sandall et al. compared the MLCC model with other models of care in which obstetricians, general practitioners or multiple health care professionals are primarily responsible for the coordination and provision of care for mother and child (Sandall, Soltani, Gates, Shennan, & Devane, 2015). Four studies offered MLCC through caseload midwifery and 10 studies provided care within the team midwifery MLCC model. Levels of continuity of care are measured by the proportion of births with attendance by a known midwife. Primary outcomes show that women who received care within the MLCC model are 7 times more likely to be attended at birth by a known midwife, 24% less likely to give birth before 37 weeks (preterm birth), 19% less likely to lose

their baby before 24 weeks pregnancy and 16% less likely to lose their baby at any pregnancy duration. Besides, women are more likely to have a vaginal birth, are less likely to have interventions (regional analgesia or an episiotomy) and are more likely to experience a more positive pregnancy and birth. All primary outcomes of the Cochrane systematic review are illustrated in Figure 6.

Figure 6 Primary outcomes midwife-led continuity of care model, Cochrane review (Sandall, Soltani, Gates, Shennan, & Devane, 2015) (Coxon & Jones, 2016)

Although primary maternity care in the Netherlands is provided within the MLCC model, relational continuity of care is limited (Offerhaus, Jans, Hukkelhoven, de Vries, & Nieuwenhuijze, 2020). On average, a midwifery practice in the Netherlands provides care for 90 to 100 pregnant women per midwife per year. In a practice with a team of four midwives, pregnant women may interact with all four midwives antenatally. Each midwife in such a practice provides her share of antenatal consultations to approximately 400 pregnant women who visit the practice every year. A pregnant woman cared for in this group practice does not know who of the four midwives will be present to support her when her labor starts. Midwives often work in shifts of 12 or 24 hours and these shifts determine who will be present when a woman needs urgent care. Apart from the working shifts, there is a possibility that one or multiple other women receiving care from the same midwifery practice, need urgent care at the same moment. In this situation an on-call midwife or a substitute midwife will attend her birth. You could ask yourself the question: “To what extent are midwives currently able to provide relational continuity within team midwifery?”.

3.4 Our contribution

Sandall et al. (2015) show that women who received care within the MLCC model where seven times more likely to be attended by a known midwife at birth, which is positively related with good health outcomes for mother and child. While assessing the effects of capacity pooling in midwifery we have to consider to what extend midwives, providing continuity of care through team midwifery, are currently able to provide continuity of care and how this is affected by capacity pooling. We propose discrete event simulation (DES) modelling to assess the effects of capacity pooling on multiple key performance indicators. This type of simulation is well applicable to assess pooling interventions, e.g. in healthcare in general (Günal & Pidd, 2010), emergency care (Mes & Bruens, 2012) (Fletcher, Halsall, Huxham, & Worthington, 2007) (Sinreich & Marmor, 2005) and outpatient clinics (Joustra, Van Der Sluis, & Van Dijk, 2010).

4 Conceptual model

The first step in designing the conceptual model is describing the general care pathway of pregnant women in Section 4.1. In Section 4.2 we describe the arrival process and in Section 4.3 we specify the client variables. Each process step within the care pathway of a client requires specific resources and we identify these in Section 4.4. In Section 4.5 we present several performance indicators to assess the effects of capacity pooling within the simulation model.

4.1 Identifying the process steps

The first step in designing the conceptual model is to identify the processes within a team midwifery practice. The simulation model is driven by prenatal consultations of pregnant women which are categorized as regular or urgent consultations.

Regular consultations

Pregnancy has three trimesters and is considered full-term at 40 weeks. In 2016, the WHO advised at least eight regular consultations within prenatal care to decrease perinatal mortality and to increase positive birth experience. Figure 7 provides an overview of the current prenatal care schedule for low-risk pregnant women in the Netherlands (Koninklijke Nederlandse Organisatie van Verloskundigen, 2021). Within the first trimester, regular consultations consist of an intake consultation, a counseling for prenatal screening and an optional check-up consultation. The regular consultation within the second and third trimester consist of a variable number of check-up consultations. Care provider and caretaker could both initiate to increase the total number of regular consultations based on medical care, needs and preferences.

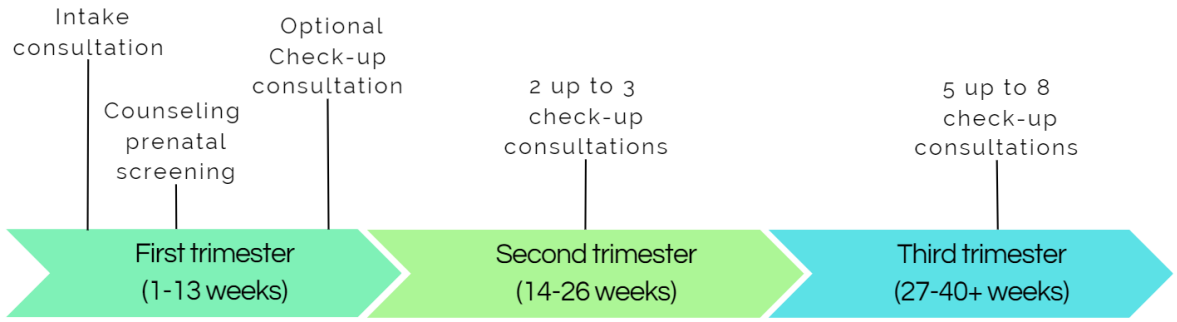


Figure 7 Prenatal care schedule for low-risk pregnant women in the Netherlands

Urgent consultations

In addition to the planned regular consultations, clients may contact the midwifery practice's emergency number in the event of an acute care request or the start of labor. The midwife on-duty answers the phone and performs telephone triage through the Dutch triage system. The Dutch triage system is an evidence-based guideline for obstetric telephone triage developed by Engeltjes et al. (2020). They found that acute obstetric care requests over the telephone could be grouped into five categories based on the following symptoms: vaginal bleeding, fluid loss, abdominal pain, non-somatic symptoms, and other somatic symptoms (Figure 8). Based on the symptom categorization and an urgency level, the midwife determines if an urgent consultation is needed, by which provider, and where to provide it. Given the scope of our research, we exclude urgent consultations provided by other healthcare providers than midwives in the simulation model.

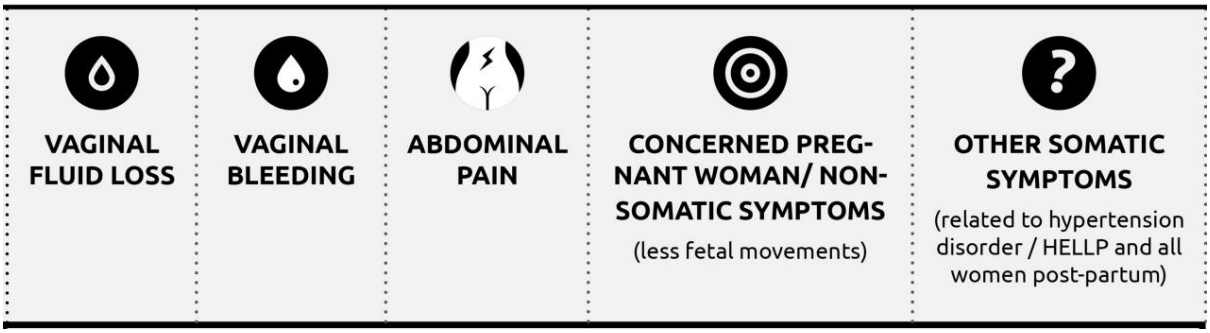


Figure 8 Overview of categories for acute obstetric care requests over the telephone (Engeltjes et al. 2020)

4.2 Client arrival rates

We assume pregnant women enter the simulation model on the first day of their pregnancy according to a time-dependent Poisson process, with arrival rate $\lambda_{d,w}$. Upon this arrival the client schedules her first appointment and is referred to waiting at home. The parameter $\lambda_{d,w}$ refers to the average number of clients arriving on day d in week w. The arrival rate $\lambda_{d,w}$ is calculated by multiplying the day factor β_d with the week factor γ_w. The day factor represents the fluctuations in the number of daily arrivals within a specific week. The week factor represents seasonal fluctuations in the number of arrivals within a specific year. The arrival rate is calculated according to Equation 4.1.

Equation 4.1	*Arrival Rate*	$\lambda_{d,w} = \beta_d \cdot \gamma_w$	$\forall\, w \in 1, \dots, 53$ $\forall\, d \in 1, \dots, 7$
Equation 4.2	*Day factor*	$\beta_d = \frac{1}{Y} \cdot \frac{1}{W} \sum_{\forall y} \sum_{\forall w} \frac{X_{d,w,y}}{\frac{1}{5} \cdot \sum_{\forall d'} X_{d',w,y}}$	$\forall\, d \in 1, \dots, 7$
Equation 4.3	*Week factor*	$\gamma_w = \frac{1}{Y} \cdot \sum_{\forall y} \frac{\sum_{\forall d} X_{d,w,y}}{\frac{1}{52} \cdot \sum_{\forall d} \sum_{\forall w'} X_{d,w',y}}$	$\forall\, w \in 1, \dots, 53$

We consider a possible relative difference in arrivals per weekday between the weeks by calculating the day factors per week for each year. We refer to these separate day factors by $\beta_{d,w,y}$. To determine the day factor $\beta_{d,w,y}$ we divide the total number of arrivals of day d by the average number of arrivals in the specific week w of day d, according to Equation 4.2. We calculate the final day factor β_d for a specific day by taking the average of the day factors $\beta_{d,w,y}$ over all weeks in all years. To check if the workdays have a statistically significant different number of average arrivals, we perform two-sample t-tests. The week factor $\gamma_{w,y}$, which we calculate to determine any seasonality, is calculated by dividing the total number of arrivals on the days in week w by the average number of arrivals in that specific year y, as illustrated in Equation 4.3. Again, we consider a possible relative difference in seasonal fluctuations per year by calculating the week factors per year. The average of a week factor over all years determines the final week factor γ_w for a specific week. Every time a new day starts the arrival rate $\lambda_{d,w}$ is determined based on the day and week factors to create Poisson arrivals.

4.3 Entities

The entities represent the clients that require regular and urgent consultations. Clients are characterized by attributes as their current pregnancy duration, intake consultation date and the start of labor. In this section we discuss the client attributes that we include in our simulation model.

Current pregnancy duration. In general, pregnant women contact their midwifery practice as soon as the know about the pregnancy. This allows her midwife to provide early prenatal care and guidance throughout the full-term pregnancy. We assume clients enter the simulation model on the first day of their pregnancy, schedule an intake consultation and wait at home until the intake consultation date. After the first day of pregnancy, we keep track of a client's current pregnancy duration in days.

Intake consultation date. Most women schedule their intake consultation between 8- and 10-weeks pregnancy, but the distribution of women's pregnancy durations at intake consultation differs per midwifery practice. We use an empirical distribution to describe the pregnancy durations of clients at their intake consultation. The simulation model assigns an intake consultation date based this empirical distribution.

Number of consultations. We keep track of the client's total number of regular consultations.

Start of labor. The start of labor for clients is simulated by the daily odds of spontaneous labor relative to a due date of 40 weeks pregnant as illustrated in Figure 9 (Data Yze, sd) (Kieler, Axelsson, Nilsson, & Waldenström, 1995).

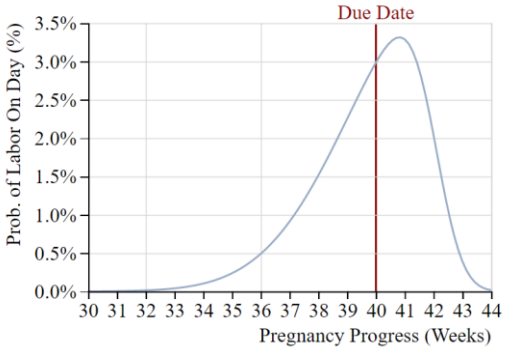


Figure 9 Daily odds of spontaneous labor relative to the due date (Data Yze, sd)

4.4 Resources

We distinguish resources in two types: staff and rooms. Staff are the midwives of the midwifery practice sharing midwifery care for women during pre-pregnancy, pregnancy, birth, post partum, and the first weeks of the newborn's lives. There are two types of services that midwives can provide, and these are provided within three types of shifts (Table 1).

Table 1 Midwifery shifts

Shift	Duration	Service
Midwifery practice	8 hours	Regular consultations
On-duty	24 hours	Urgent consultations
On-call	24 hours	Urgent consultations

Each midwifery practice has a number of midwives available, and a daily midwifery schedule determines which midwife provides which service on a given day. Several rooms are taken into account. The consultation rooms are specifically designated for regular consultations that take place within the midwifery practice. Other rooms are used to support the visualization of the model ("waiting at home" and "waiting room" areas). We do not consider specific equipment needed in the midwifery processes.

4.5 Processing times

For the processing times of regular and urgent consultations we assume stochasticity since each consultation takes a different amount of time for each client. We assume that the duration of consultations is normally distributed, as presented in Table 2. The mean corresponds to the standardized consultation duration established by the midwifery practice. The standard deviation is determined based on the coefficient of variation (CV), which is a commonly used measure for the variability of consultation times. Empirical studies report CV values that range from approximately 0.35 to 0.85 (Cayirli & Veral, 2003). We set the CV values at two levels: "CVlow" indicates a low variability for regular consultation duration and "CVhigh" indicates a high variability for urgent consultation duration. We simulate the duration of labor based on a lognormal distribution with a mean of 420 minutes and a standard deviation of 255 minutes (Mejia A, 1998).

Table 2 Processing times prenatal consultations

Prenatal consultations	Process	Distribution
Regular consultations	Intake consultation	Normal distribution with (μ = 50, σ = 17.5)
	Counseling prenatal screening	Normal distribution with (μ = 15, σ = 5.25)
	Check up	Normal distribution with (μ = 15, σ = 5.25)
Urgent consultations	Acute care request	Normal distribution with (μ = 15, σ = 12.75)
	Labor	Lognormal distribution with (μ = 420, σ = 225)

4.6 Prioritization and appointment scheduling rules

In our simulation model, each midwifery practice maintains a midwifery schedule, containing the working shifts of the midwives and an appointment schedule that keeps track of the currently planned appointments. When a client enters the midwifery practice according to the time-dependent Poisson process, with arrival rate $\lambda_{d,w}$, the module "setting appointment time" is triggered. This module schedules the intake consultation based on the client variable "intake consultation date". When there is no time slot available on the "intake consultation date", the module tries to schedule the client one day before and one day after the preferred intake consultation date. Additional days are added until the module succeeds to schedule the client. Eventually, the client moves to "waiting at home" and returns to the waiting room of the midwifery practice on her intake consultation day. After a client's intake consultation, the "setting appointment time" method is initiated to assign a new appointment for a regular consultation. To ensure that the number of regular consultations align with the advised number of consultations within each trimester (Figure 7), it is necessary to schedule the next appointment within a specific time interval (Table 3). When there is no time slot available on the preferred schedule date, the module continues with evaluating all schedule dates within the specified interval. If we did not succeed to schedule the client within the interval, the client gets an appointment time at the first available time slot after the interval.

Table 3 Time interval regular consultations

Pregnancy duration	Preferred	Min	Max
1-24 weeks	28 days	21 days	35 days
25-32 weeks	21 days	17 days	25 days
33-36 weeks	14 days	10 days	18 days
36-40 weeks	7 days	3 days	10 days

Prioritization determines which midwife to assign to which client and which client to see first. The simulation model randomly determines which midwife to assign to which clients based on a combination of the appointment schedule and the midwifery schedule. A client gets an appointment day and time based on the first available time slot within the appointment schedule of one of the consultation rooms. Eventually, midwives are randomly assigned to the consultation rooms based on the midwifery schedule. In cases where multiple pregnant women are waiting for the same midwife in the waiting room, the woman with the earliest appointment time is always given priority.

4.7 General assumptions and simplifications

For the simulation model we need assumptions and simplifications. A summary of all assumptions made to simulate team midwifery in the Netherlands is given below:

- Clients arrive at the midwifery practice on their first day of pregnancy and have their first regular consultation (intake consultation) according to the distribution of pregnancy duration at intake consultation.
- Consultation hours at the midwifery practice start at 9:00 and end at 17:00 with a break between 12:00 and 13:00. There are no consultation hours on weekend days and evenings.
- We exclude telephonic consultations.
- Client punctuality refers to the act of clients arriving on time for their scheduled regular consultation. Negative values for client punctuality reflect early arrivals and positive values reflect tardy arrivals. We assume a mean client punctuality of -20.46 minutes with a standard deviation of 17.91 (Williams, Chambers, Dada, McLeod, & Ulatowski, 2014).
- The midwifery schedule randomly assigns midwives to shifts.
- Each consultation room has an appointment schedule.
- The appointment schedules of the consultation rooms determine the required “midwifery practice” shifts.
- During an on-call or on-duty shift the midwife is available for 24 hours. These shifts are needed on both weekdays and weekends.
- If a client contacts the midwifery practice due to an acute care request or the start of labor, she will be referred to the midwife who is currently on-duty. However, if the on-duty midwife is unavailable due to attending another pregnant woman, the client will be directed to the midwife who is on-call. When the midwife on-duty and the midwife on-all are both unavailable, the midwifery practice is forced to arrange a substitute midwife.
- The frequency of urgent consultations resulting from acute care requests ranges from one to four consultations during a women’s pregnancy with equal probabilities. Acute care requests occur randomly between intake consultation and due date.
- The expected due date of all clients is according to 40 weeks of pregnancy.
- Labor starts according to the daily odds of spontaneous labor relative to the expected due date. Processing times for care provision during labor are assumed equal for pre-term (<37 weeks) and regular births.
- We assume that all equipment to support midwifery care is always available. For example, the ultrasound equipment which support midwives to evaluate the baby’s growth and development.

4.8 Key Performance Indicators

The performance of the current midwifery care profession is determined using four Key Performance Indicators (KPIs): utilization, continuity of care, accessibility, and length of stay (LOS). In this section, we elaborate on the definitions and the calculations of the KPIs.

Utilization

The utilization of midwives at the midwifery practice or the center is our first KPI. The utilization is defined as the percentage of resource capacity that is used and is calculated by dividing the amount of time a midwife is busy with a client by the total number of hours within the midwifery shift. The average utilization measure includes the shifts on which the midwife did not provided care to a pregnant woman due to for example zero acute care requests or births. An average utilization of 3%

could therefore imply that we observed one day with an utilization of 30% and nine days with a utilization of 0%. Results on the average utilization are therefore textually elaborated with information on the daily chance of a shift being occupied and the utilization of an occupied shift. These two measures together create the average utilization. We distinguish between three types of utilization: the utilization of the midwife present at the consultation room of the midwifery practice, the midwife on-duty, and the midwife on-call.

Continuity of care

Continuity of care is measured as the extent to which relational continuity of care is provided during the antenatal period within the team midwifery model. The performance indicator continuity of care is measured in three ways. We measure the total number of caregivers (midwives) who shared antenatally care for a pregnant woman. We measure the percentage of urgent consultations attended by a known midwife and the percentage of births attended by a known midwife. We define a known midwife as a midwife who already provided a regular or urgent consultation during the current pregnancy of a woman. An unknown is a midwife within a women's own practice/center that did not provide a regular or urgent consultation earlier. When there are no midwives available the midwifery practice/center is forced to arrange a substitute midwife.

Accessibility of care

The accessibility of care is defined as the possibility for a client to schedule her next regular consultation within a certain time interval. Depending on the duration of a woman's current pregnancy, she should have a regular consultation within a specified time interval. The time intervals are presented in Table 3.

Length of stay

We define the length of stay (LOS) as the time between the client entering the midwifery practice and discharge. We do not include the waiting time for telephonic consultation since this research is scoped on regular and urgent consultations.

5 Case study (data analysis)

In this chapter we examine the current organization of team midwifery through a case study at cooperation VeRVe (Verbond van Rijnmondse Verloskundigen). In Section 5.1 we introduce cooperation VeRVe and their concept on capacity pooling. In Section 5.2 we analyze the client arrival rates based on historical data. In Section 5.3 we specify the client variable "intake consultation date" and in Section 5.4 we describe the available resources for each midwifery practice. Before we are able to experiment with interventions under different scenarios, we have to verify that the programmed simulation model corresponds to the conceptual model and that it is an accurate representation of team midwifery within cooperation VeRVe. In Section 5.5 and 5.6 we provide explanations regarding the validation and verification of our model, respectively.

5.1 Cooperation VeRVe

Six midwifery practices in the region South/West of the Netherlands decided to collaborate within the cooperation VeRVe to be able to increase the quality of midwifery care. Due to concentration of acute obstetric care within the hospitals of their region, midwives were forced to look for alternatives in providing acute care for pregnant women and thereby the midwifery profession for the future. Midwives within the cooperation VeRVe initiated the "Verloskundig Prenataal Triage Centrum" (VPTC) which is a midwifery-managed location for low (and average) risk clients where

midwives from the cooperation can provide urgent consultations. Our research includes four midwifery practices from cooperation VeRVe, which are categorized to practice size. Two “small” midwifery practices, one “medium” and one “large” practice. The categories “small”, “medium” and “large” indicate a total of 250, 400 and 600 clients per year respectively.

5.2 Client arrival rates

In this section we perform a historical data analysis in order to determine the client arrival rates per midwifery practice. The arrival rates $\lambda_{d,w}$ of the small (B), medium and large midwifery practice are calculated based on historical data on the expected due dates of clients from 2014 to 2020. The arrival rates $\lambda_{d,w}$ of the small (A) midwifery practice are calculated based on historical data from 2021 to 2022 since the midwifery practice started in 2020. The first day of pregnancy is calculated by subtracting 280 days from the expected due date. Figure 10 illustrates the day factors for each midwifery practice. Based on a visual judgement, we assume that all week and weekend days are not significantly different regarding the number of client arrivals. To check if there is a statistically significant different number of average arrivals between the days, we performed two-sample t-tests. The results for each midwifery practice are presented in Table 4. We see that there are no days significantly different from every other day ($p<0.05$).

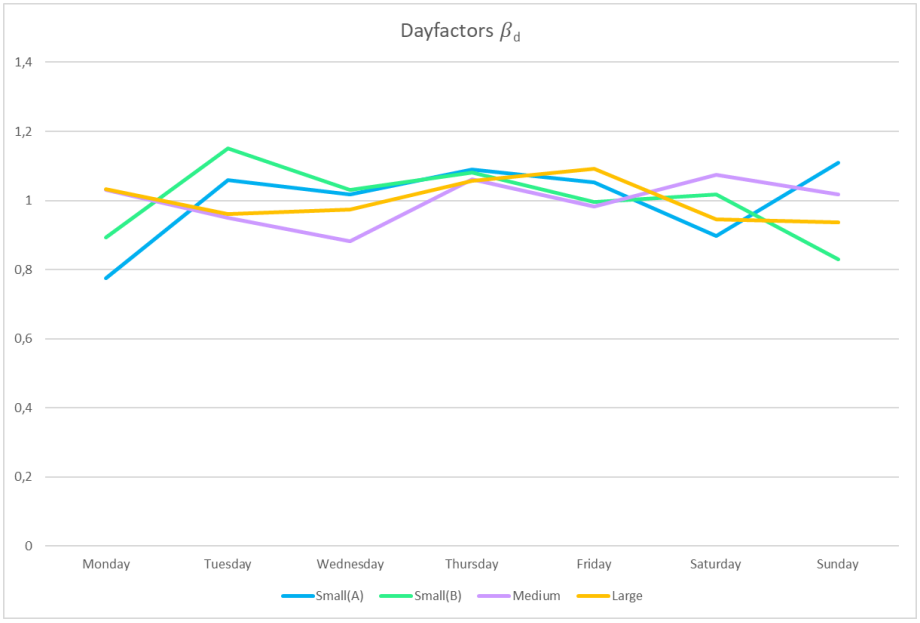


Figure 10 Day factors β_d

Table 4 P-values two sample t-test days (significant difference with p<0.05)*

Small (A)	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday	Sunday
Monday	X	0.108	0.159	0.064	0.088	0.440	0.046*
Tuesday	X	X	0.839	0.874	0.972	0.341	0.798
Wednesday	X	X	X	0.702	0.856	0.491	0.626
Thursday	X	X	X	X	0.845	0.257	0.913
Friday	X	X	X	X	X	0.367	0.756
Saturday	X	X	X	X	X	X	0.176
Sunday	X	X	X	X	X	X	X

Small (B)	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday	Sunday
Monday	X	0.016*	0.184	0.063	0.321	0.207	0.495
Tuesday	X	X	0.287	0.544	0.177	0.238	0.002
Wednesday	X	X	X	0.651	0.758	0.908	0.052
Thursday	X	X	X	X	0.434	0.546	0.008*
Friday	X	X	X	X	X	0.840	0.103
Saturday	X	X	X	X	X	X	0.065
Sunday	X	X	X	X	X	X	X

Medium	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday	Sunday
Monday	X	0.279	0.064	0.709	0.539	0.566	0.878
Tuesday	X	X	0.366	0.123	0.638	0.085	0.349
Wednesday	X	X	X	0.025*	0.183	0.014*	0.095
Thursday	X	X	X	X	0.330	0.858	0.598
Friday	X	X	X	X	X	0.223	0.652
Saturday	X	X	X	X	X	X	0.458
Sunday	X	X	X	X	X	X	X

Large	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday	Sunday
Monday	X	0.231	0.328	0.690	0.347	0.140	0.119
Tuesday	X	X	0.833	0.110	0.023	0.798	0.697
Wednesday	X	X	X	0.151	0.043*	0.637	0.560
Thursday	X	X	X	X	0.567	0.059	0.049*
Friday	X	X	X	X	X	0.010*	0.008*
Saturday	X	X	X	X	X	X	0.865
Sunday	X	X	X	X	X	X	X

Results of the week factors γ_w for week $w \in 1, \ldots, 53$ are presented in Figure 11. The number of arrivals is highly fluctuating over the year, but no seasonal effect can be distinguished. The week factors of the small (A) midwifery practice are fluctuating more than the other midwifery practices, since these are based on two years of historical data instead of seven years of historical data.

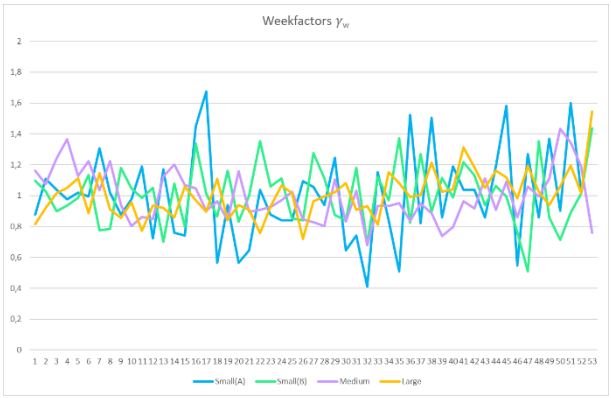


Figure 11 Week factors γ_w

5.3 Entities

In this section we provide information on the distributions of pregnancy duration at intake consultation for each midwifery practice based on historical data from 2021 up to 2022 for midwifery practice small (A) and from 2014 up to 2020 for midwifery practice small (B), medium and large. Figure 12 illustrates the average pregnancy duration at intake consultation for each midwifery practice. The majority of all clients has an intake consultation between 7 and 9 weeks of pregnancy.

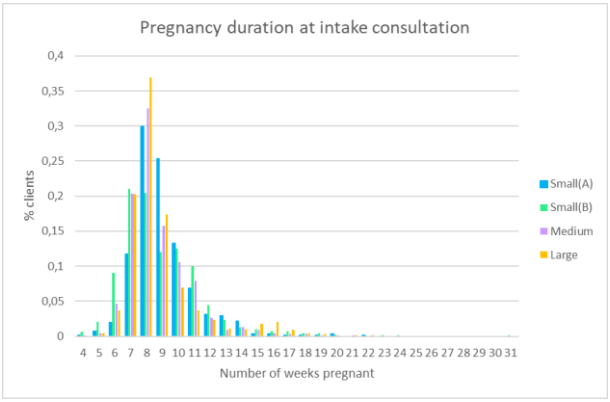


Figure 12 Pregnancy duration at intake consultation

5.4 Resources

In Section 4.4 we explained that the midwives are scheduled according to their shift. We distinguish the midwifery shifts in “consultation room”, “on-duty”, and “on-call” shifts. Each midwifery practice has a total number of midwives, which are scheduled on these shifts according to the midwifery schedule. The small sized midwifery practices have a total of three midwives, each providing one shift a day. The medium sized midwifery practice B works with five midwives in total, and each shift (“consultation room”, “on-duty” and “on-call”) requires one midwife. The large sized midwifery practice consists of nine midwives and requires three midwives on the “consultation room” shift, one midwife “on-duty” and one midwife “on-call.

5.5 Verification

One of the important steps of model building is model verification. In this step, the comparison of performance between the conceptual model and the model that is built is checked. To verify the model, all modules were debugged to see whether they work as expected. Next to code debugging, the model is presented to multiple stakeholders from the midwifery practices with animation of the clients moving through the midwifery practices.

5.6 Validation

The next step in model building is the model validation. Here we determine whether the model represents the midwifery practices within the cooperation VeRVe by comparing the output data of the model with historical data of the midwifery practices. Validation of arrival patterns are presented in Figure 13.

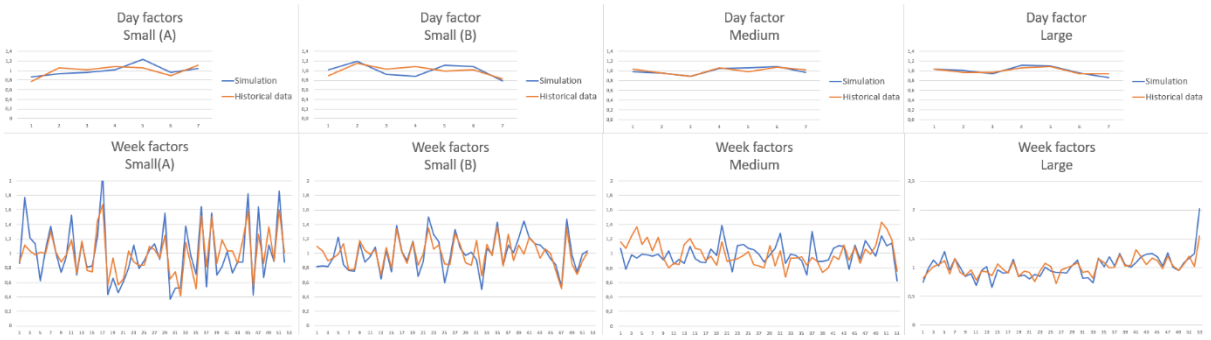


Figure 13 Validation day and week factors

Besides validation of arrivals we pattern, we analyze if the number of regular consultations simulated by the model correspond with the prenatal care schedule provided in Section 4.1. Results show that pregnant women cared for in a small, medium or large sized midwifery practice had on average 12 regular consultations and 2 urgent consultations. An average of 12 regular consultations corresponds to the prenatal care schedule and the total number of consultations (regular and urgent consultations) correspond to research conducted by Gitsels-van der Wal et al. (2020) who studied the prevalence, determinants, and underlying causes of frequent attendance in midwife-led care. Pregnant women in Netherlands have on average 14 face-to-face visits in pregnancy, which is the highest number for low-risk women worldwide.

5.7 Experiment design

In this section, we describe the experiments we perform to analyze the effects of multiple factors on the key performance indicators. For the experimental design we determine which factors to vary, which levels to choose for each factor, and which combination of factor levels to simulate. First, we simulate the current scenario. Next, we study the effects of two factors: urgent consultation slots

and capacity pooling of midwifery shifts. Urgent consultation slots are additional to the availability for acute care requests of the midwife on-duty and the midwife on-call. Practices use these urgent consultation slots to reserve additional midwifery capacity within the appointment schedule to increase the opportunity to answer all acute care requests within their own team. We consider urgent consultation slots as a possibility to use capacity pooling within the midwifery practice, while capacity pooling of midwifery shifts is overarching multiple midwifery practices. For capacity pooling of midwifery shifts we distinguish four capacity pooling levels (CPLs). The first level (CPL1) centralizes all acute care request that are initially answered by midwives "on-call". The second level (CPL2) centralizes all urgent consultations (acute care requests and births) that are initially answered by midwives "on-call". Within the third capacity pooling level (CPL3) all acute care requests provided by both midwives "on-duty" and "on-call" are centralized. The last capacity pooling level (CPL4) centralizes all urgent consultations (acute care requests and births) provided by both midwives "on-duty" and "on-call". Table 5 provides the configuration of all experiments.

Table 5 Configurations for experiments

Configuration	Urgent consultation slots		Capacity pooling of midwifery shifts	
	Start time of slot	Length of slot	Shift	Type of urgent consultation
Current situation	X	X	X	X
Morning slot	10:00	0:15	X	X
Afternoon slot	15:00	0:15	X	X
CPL1	X	X	On-call	Acute care requests
CPL2	X	X	On-call	Acute care requests & births
CPL3	X	X	On-duty & on-call	Acute care requests
CPL4	X	X	On-duty & on-call	Acute care requests & births

6 Case study (results)

In this chapter, we present the effects of capacity pooling within the MLCC model based on the case study VeRVe. In Section 6.1 we determine the simulation settings. We describe the results on the performance indicators for the current situation in Section 6.2, followed by results on the experiments with urgent consultation slots in Section 6.3 and capacity pooling of midwifery shifts in Section 6.4.

6.1 Simulation settings

Before we start with our experiments, we must first determine after how many days we observe a steady state. The number of days needed to get in a steady state is the warm-up period. To determine the length of the warm-up period we use Welch's graphical procedure where we observe the KPI utilization for all midwifery shifts (Law, 2015). We start with 10 independent replications, each with a length of 10 years. Subsequently, we calculate the moving averages with windows 3, 5, 10, 20, 30, 40 and 50 days to smooth out possible irregularities. The graphs in Figure 14, 15, and 16 show that after day 280, the utilization output for the midwifery shift "consultation room" is stable, while the shifts "on-call" and "on-duty" show steady state cycles after 365 days. The length of the warm-up period is set to 365 days, i.e. one year.

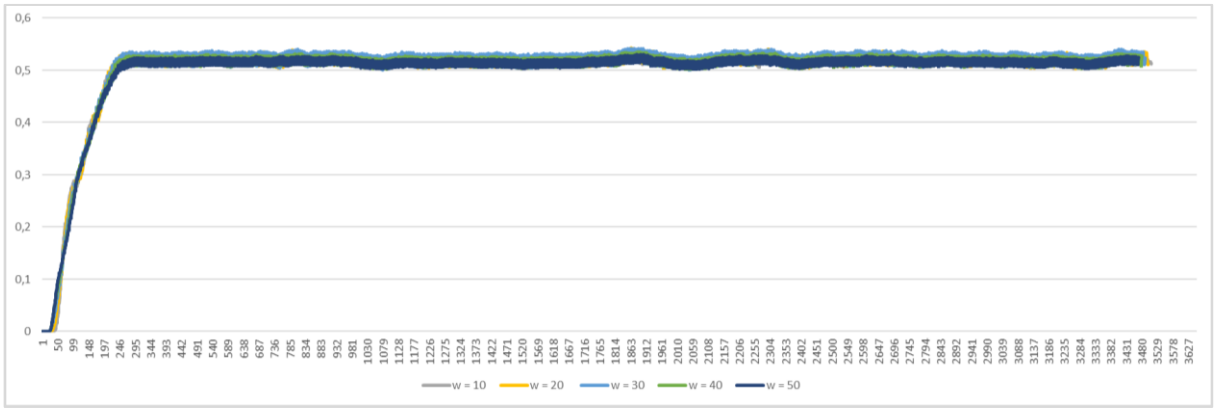


Figure 14 Welch's graphical procedure on the KPI utilization for the "consultation room" shift.

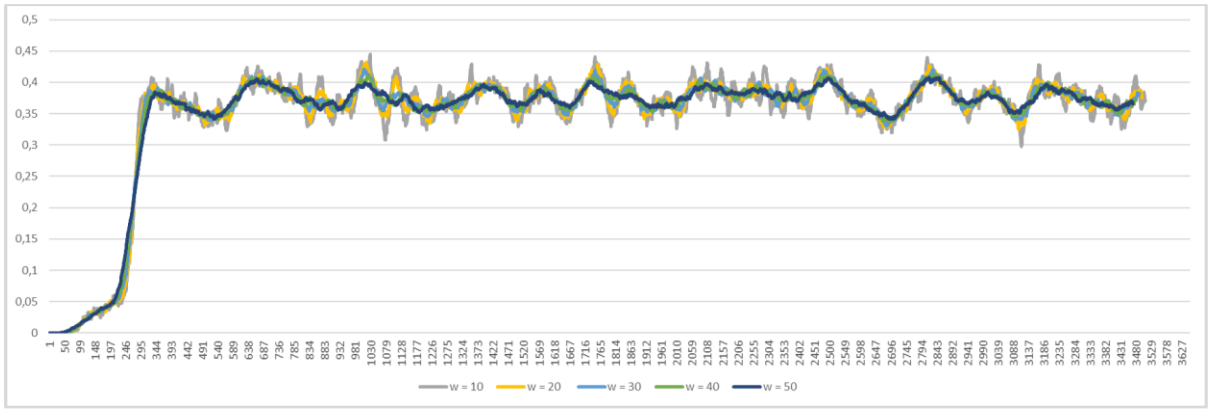


Figure 15 Welch's graphical procedure on the KPI utilization for the "on-call" shift.

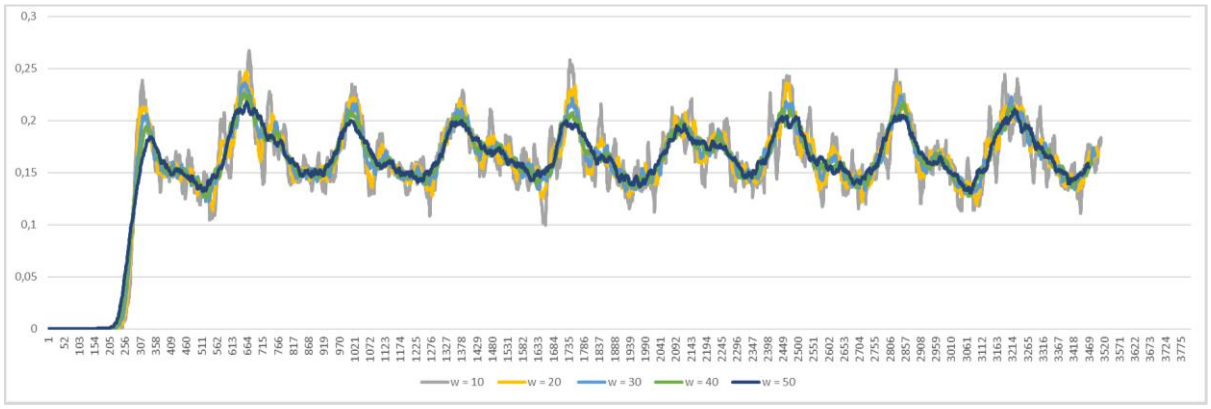


Figure 16 Welch's graphical procedure on the KPI utilization for the "on-duty" shift.

The length of the warm-up period needs to be at least 1/10 of the total run length. Using Welch's graphical method, the warm-up period was set to one year. The minimum run length is therefore 10 years. The number of replications is determined by the sequential procedure. We performed a number of replications in advance and thereafter checked which number of replications would have been sufficient. The allowed relative error was set to $\gamma = 0.05$ and we created a confidence interval of 95% by setting α to 0.05. According to the sequential procedure results, a minimum of nine replications are required for each experiment to achieve a relative error of $\gamma = 0.05$ on the utilization of all midwifery shifts within each midwifery practice. For simplicity, we choose to set the number of replications at ten.

6.2 Current situation

In the current situation the small, medium and large sized midwifery practices provide team midwifery to approximately 250, 400 and 600 clients per year respectively. The small and medium sized midwifery practices have one consultation room available for regular consultations each working day, while the large midwifery practice has three consultation rooms for regular consultations. Figure 17 illustrates the results on the KPI utilization. The average utilization of the

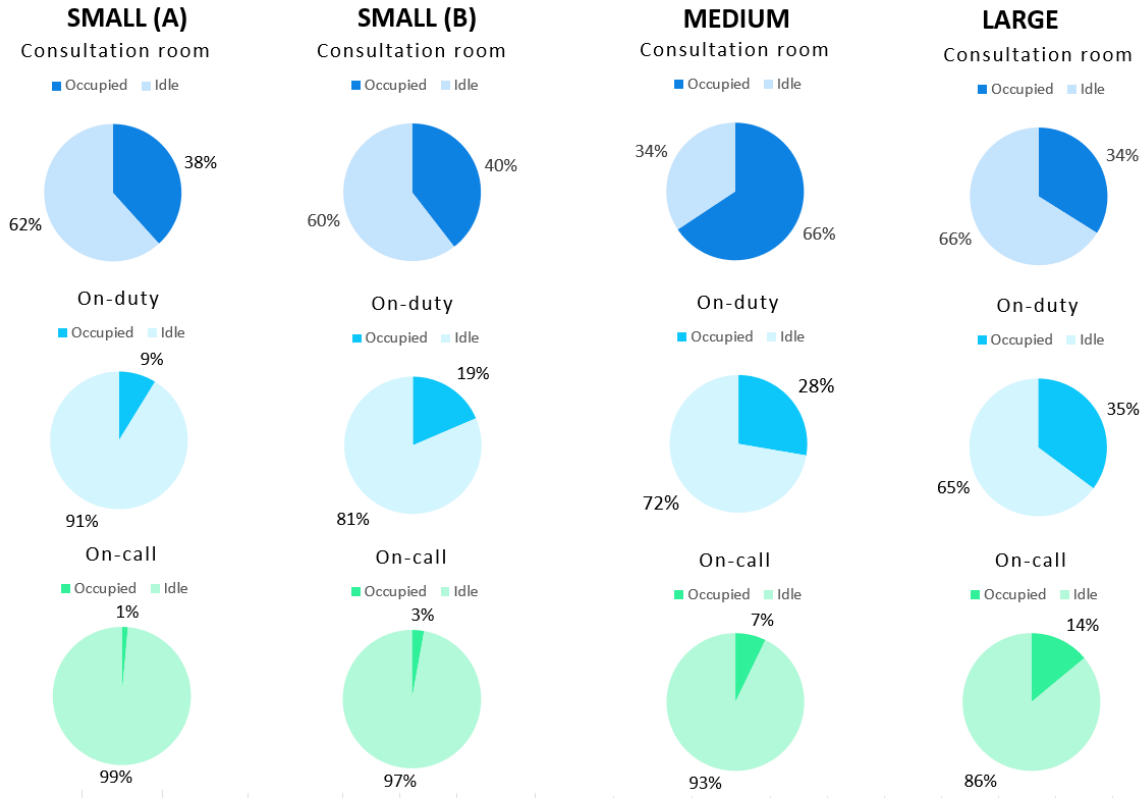


Figure 17 KPI Utilization (current situation)

"consultation room" shift for the medium sized midwifery practice is 65.70% (95% CI [65.12, 66.28]) and significantly higher than the utilization of 38.28% (95% CI [37.58, 38.99]) for a small sized midwifery practice (A), 39.52% (95% CI [38.83,40.22]) for small (B) and 33.92% (95% CI [33.76,34.08]) for a large sized midwifery practice. We explain this difference by the yearly number of clients per consultation room shift. Yearly, a medium sized midwifery practice provides care to approximately 400 clients per consultation room shift, while a small and large midwifery practice provide care to 250 and 200 clients per consultation room shift. Looking at the utilization for the "on-duty" and "on-call" shift, we see that the average utilization increases with the size of the midwifery practice as expected.

The average number of caregivers per client, the percentage of acute care requests attended by a known midwife and the percentage of births attended by a known midwife are measures for continuity of care and the results on these measures are illustrated in Figure 18, 19 and 20 respectively. Pregnant women cared for in a small midwifery practice, consisting of three midwives, saw on average all three midwives antenatally during regular consultations. 68% up to 76% of all acute care requests were provided by a known midwife and for 96% up to 98% of all pregnant women, a known midwife attended her during birth. These percentages decrease when considering a midwifery practice with a larger scale. A larger midwifery practice has a larger team of midwives

sharing antenatal care and therefore lowers the chance that a pregnant woman knows the midwife attending her acute care request or birth. Our results show that in the current situation a large midwifery practice (nine midwives in total) provides approximately half of the continuity of care a small midwifery practice (three midwives in total) is able to provide during acute care requests.

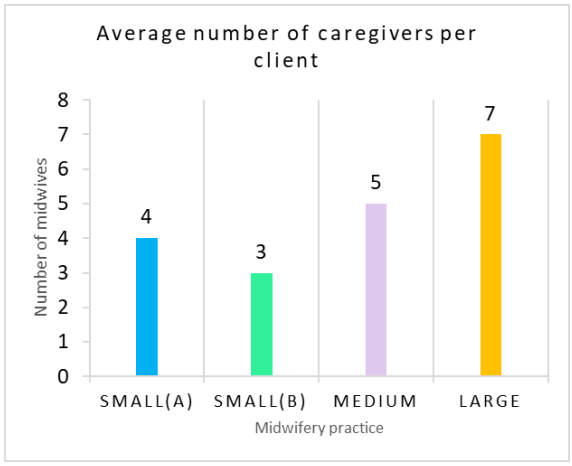


Figure 18 KPI CC: Average number of caregivers per client (current situation).

Considering one "on-duty" and one "on-call" shift per day, a midwifery practice is unable to achieve an average of 100% on the percentage of acute care requests and/or births with attendance of a known midwife. There is always a small chance of three acute care request and/or births at the same time which forces the midwifery practice to arrange a substitute midwife. In the current situation the daily chance of arranging a substitute midwife due to a third urgent consultation is a 2%, 11% and 26% for a "small", "medium" and "large" sized midwifery practice respectively. Figure 19 shows that on average 2%, 4% and 9% of all acute care requests are therefore attended by a substitute midwife for a "small", "medium" and "large" midwifery practice respectively. We observe the same percentages for the births with attendance of a substitute midwife as shown in Figure 20.

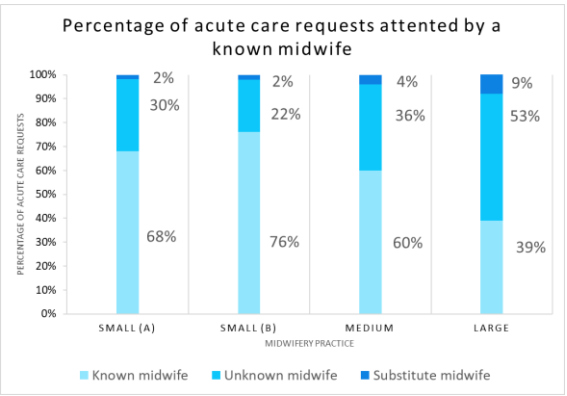


Figure 20 KPI CC: Percentage of acute care requests attended by a known midwife (current situation).

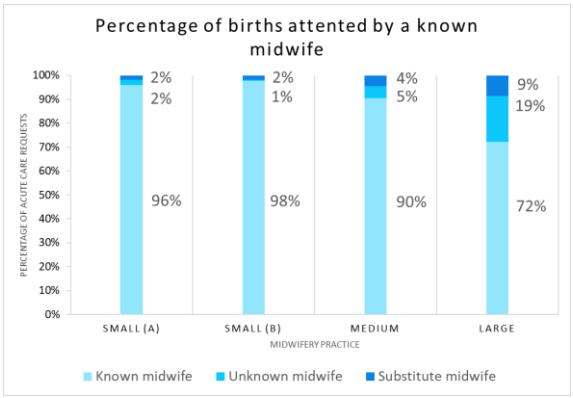


Figure 19 KPI CC: Percentage of births attended by a known midwife (current situation).

Table 6 shows the access to care for regular consultations. In 98% of the regular consultations, a pregnant women cared for in the medium sized midwifery practice was able to receive care within the defined time interval. For the remaining 2% of planned regular consultations, the additional waiting time for a client was on average three days. For small and large sized midwifery practices, 100% of all regular consultations were planned within the defined time interval. One reason for a lower access to care at the medium sized midwifery is the higher utilization of consultation room shift, compared to the small and large sized midwifery practices. Table 7 shows the LOS for clients with a regular consultation, making a distinction between intake consultations and counselling/check-up consultations. The average waiting times are low as expected due to the assumption that clients are arriving on average 20.46 minutes before their appointment time.

Table 6 KPI Access (current situation)

Midwifery practice	Appointments within the interval	Appointments outside the interval	Average additional waiting time (in days)
Small (A)	100%	0%	0
Small (B)	100%	0%	0
Medium	97.79% (95% CI [97.39, 98.19])	2.21% (95% CI [1.81, 2.61])	3.22 (95% CI [3.02, 3.42])
Large	100%	0%	0

Table 7 KPI Length of Stay (current situation)

	Type of regular consultation	Average service time (minutes)	Average waiting time (minutes)	Average length of stay (minutes)
Small (A)	Intake	49.94 (95% CI [49.53,50.35])	5.20 (95% CI [5.05,5.35])	55.14 (95% CI [54.70,55.59])
	Counselling/ check-up	14.98 (95% CI [14.94,15.03])	8.19 (95% CI [8.03,8.35])	23.17 (95% CI [23.00, 23.35])
Small (B)	Intake	50.15 (95% CI [49.79,50.50])	5.20 (95% CI [4.97,5.44])	55.35 (95% CI [54.79,55.91])
	Counselling/ check-up	14.99 (95% CI [14.97,15.02])	8.46 (95% CI [8.37,8.55])	23.46 (95% CI [23.35, 23.57])
Medium	Intake	50.12 (95% CI [50.00,50.24])	6.19 (95% CI [6.07,6.30])	56.31 (95% CI [56.14,56.48])
	Counselling/check-up	15.01 (95% CI [15.00,15.02])	7.89 (95% CI [7.82,7.96])	22.90 (95% CI [22.83,22.97])
Large	Intake	50.05 (95% CI [49.93,50.16])	3.76 (95% CI [3.69,3.83])	53.81 (95% CI [53.67,53.95])
	Counselling/ check-up	15.01 (95% CI [15.00,15.02])	8.65 (95% CI [8.61,8.69])	23.66 (95% CI [23.61, 23.71])

6.3 Urgent consultation slots

Midwifery practices have different protocols on where to provide care in case of an acute care request. Some practices reserve specific slots within the appointment schedule to answer acute care requests at the midwifery practice. These slots are additional to the availability for acute care requests of the midwife on-duty and the midwife on-call. Other midwifery practices choose to assign full responsibility for acute care request to the midwife on-duty and the midwife on-call. Both situations have advantages and disadvantages. Reserving specific slots for urgent consultations, increases the availability of midwives for acute care requests and therefore increases the chance that an urgent care request can be answered within their own team of midwives. It may therefore have a positive effect on the continuity of care a midwifery team is able to provide. A disadvantage of reserving time slots could be the utilization of midwives. Valuable time of midwives is unused when there are no acute care requests during a reserved time slot. Within the experiments we introduce one urgent consultation slot per weekday at each midwifery practice and we vary between the start times. Within the urgent consultation slot, the midwife at the consultation room provides care for a woman with an acute care request. We assume that within each urgent consultation slot one pregnant woman with an acute care request can be seen. We assume that the

urgency of the acute care requests allows the women to wait until the start of the urgent consultation slot on that specific day.

6.3.1 Urgent consultation slot in the morning

An urgent consultation slot for acute care requests in the morning (10 a.m.) is occupied for on average 42%, 30% and 53% of all weekdays for a small, medium, and large sized midwifery practice respectively. The differences in average waiting time and length of stay for regular consultations at the midwifery practice given the introduction of a morning urgent consultation slot are presented in Table 8. We observe a significant decrease in average waiting time and average length of stay for small and medium sized midwifery practices. One reason for the decrease in waiting times could be the idleness of the urgent consultation slots when there are no acute care requests in the morning. Table 9 presents the differences in access to care for regular consultations. For small and large sized midwifery practices the access to care remains 100%, indicating that all clients are able to receive care within the defined time interval. For the medium sized midwifery practice the percentage of regular consultations that are not provided within this interval increases with 3.92% given the introduction of a morning urgent consultation slot, resulting in on average 4.27 days of additional waiting time.

Table 8 KPI Length of Stay (Morning slot)

	Type of regular consultation	Average service time (minutes)	Average waiting time (minutes)	Average length of stay (minutes)
Small (A)	Intake	49.95 (95% CI [49.55, 50.36])	2.98 (95% CI [2.81,3.15]) (↓ -2.22)	52.93 (95% CI [52.50,53.36]) (↓ -2.21)
	Counselling/check-up	14.97 (95% CI [14.93,15.00])	4.91 (95% CI [4.84,4.98]) (↓ -3.28)	19.88 (95% CI [19.80, 19.96]) (↓ -3.29)
Small (B)	Intake	50.15 (95% CI [49.80,50.50])	2.97 (95% CI [2.77,3.17]) (↓ -2.23)	53.12 (95% CI [52.58, 53.66]) (↓ -2.23)
	Counselling/ check-up	15.00 (95% CI [14.98,15.03])	4.94 (95% CI [4.87,5.01]) (↓ -3.52)	19.94 (95% CI [19.87, 20.02]) (↓ -3.52)
Medium	Intake	50.12 (95% CI [50.01,50.23])	3.62 (95% CI [3.50,3.74]) (↓ -2.57)	53.74 (95% CI [53.60,53.87]) (↓ -2.57)
	Counselling/ check-up	15.02 (95% CI [15.00,15.04])	5.61 (95% CI [5.54,5.68]) (↓ -2.28)	20.62 (95% CI [20.56, 20.69]) (↓ -2.28)
Large	Intake	50.03 (95% CI [49.91,50.15])	3.62 (95% CI [3.55,3.68]) (↓ -0.14)	53.65 (95% CI [53.54,53.76]) (↓ -0.16)
	Counselling/ check-up	15.01 (95% CI [14.99,15.02])	8.60 (95% CI [7.70,9.51]) (↓ -0.05)	23.61 (95% CI [22.71, 24.50]) (↓ -0.05)

Table 9 KPI Access (Morning slot)

Midwifery practice	Appointments within the interval	Appointments outside the interval	Average additional waiting time (in days)
Small (A)	100%	0%	0
Small (B)	100%	0%	0
Medium	93.87% (95 CI [93.18, 94.57]) (↓ -3.92%)	6.13% (95% CI [5.43, 6.82]) (↑ 3.92%)	4.27 (95% CI [4.03, 4.50]) (↑ 1.05)
Large	100%	0%	0

Introducing an urgent consultation slot in the morning reduces the utilization of the on-duty shifts with 1% (small A, large) or 2% (small B, medium) as illustrated in Figure 21. The utilization of the on-call shifts remains the same (small A, small B and medium) or reduces with 1% (large). In the current situation, an acute care request from a pregnant woman is answered by the midwife on-duty as long as she is not occupied by providing care to another pregnant women. An urgent consultation slot creates the opportunity to answer this acute care request (before 10:00) by the midwife present at the consultation room, which lowers the chance that a midwife on-duty is occupied. Eventually, a lower utilization of the midwife on-duty results in a lower utilization of the midwife on-call.

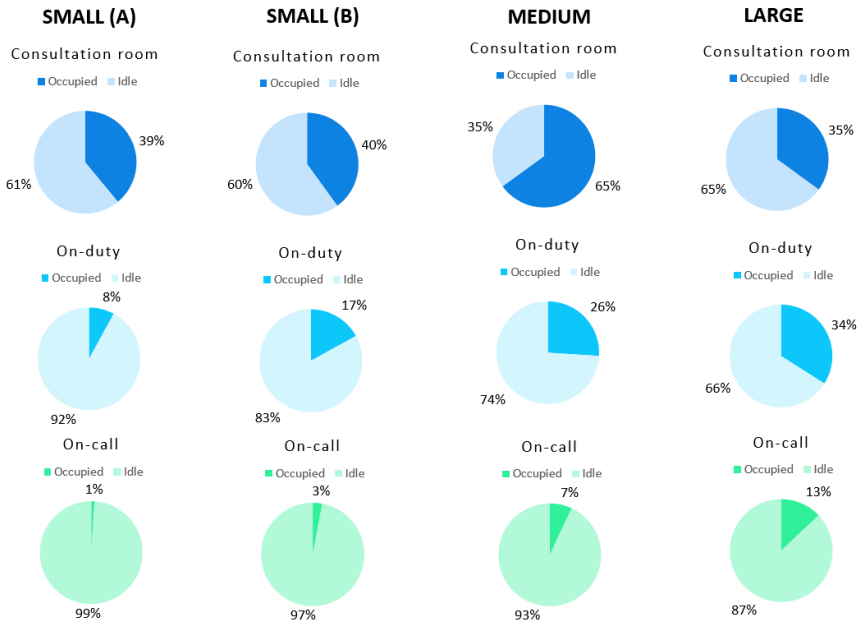


Figure 21 KPI Utilization (morning slot)

We measure the effect of an urgent consultation slot on the continuity of care by the percentage of acute care requests attended by a known midwife. Introducing an urgent consultation slot of 15 minutes at 10 a.m. increases the average continuity of care provided within acute care requests with 7%, 6% and 7% for a small, medium, and large midwifery practice (Figure 22).

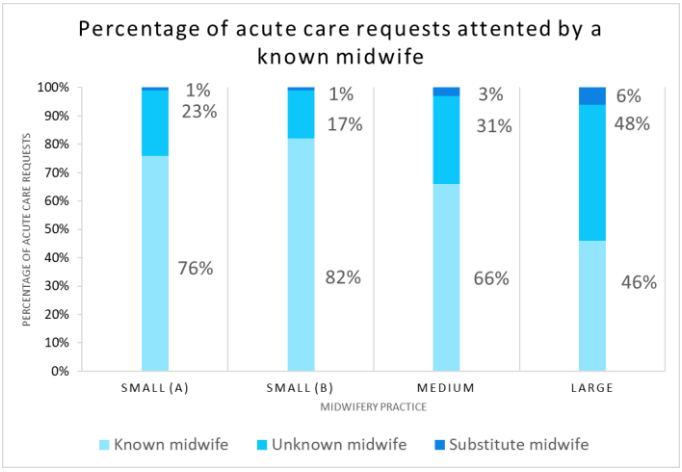


Figure 22 KPI CC: Percentage of acute care requests attended by a known midwife (morning slot).

6.3.2 Urgent consultation slot in the afternoon

An urgent consultation slot for acute care requests in the afternoon (3 p.m.) is occupied for on average 53%, 39% and 62% of all weekdays for midwifery practice a small, medium and large sized midwifery practice respectively. We present the results on the waiting time and length of stay in Table 10. The confidence intervals overlap with the confidence intervals from Table 7, which means that we do not observe a significant difference in waiting times and length of stay after the introduction of an urgent consultation slot in the afternoon. Table 11 presents the differences in access to care for regular consultations. For small and large sized midwifery practices the access to care remains 100%, indicating that all clients are able to receive care within the defined time interval. For a medium sized midwifery practice the percentage of regular consultations that are not provided within this interval increases with 3.89%, resulting in on average 4.27 days of additional waiting time.

Table 10 KPI Length of Stay (Afternoon slot)

	Type of regular consultation	Average service time (minutes)	Average waiting time (minutes)	Average length of stay (minutes)
Small (A)	Intake	49.93 (95% CI [49.52, 50.35])	5.08 (95% CI [4.95,5.22]) (↓ -0.12)	55.02 (95% CI [54.53,55.51]) (↓ -0.12)
	Counselling/check-up	14.99 (95% CI [14.97,15.01])	8.20 (95% CI [8.05,8.34]) (↑ 0.01)	23.19 (95% CI [23.04, 23.34]) (↑ 0.02)
Small (B)	Intake	50.16 (95% CI [49.80,50.52])	5.04 (95% CI [4.80,5.28]) (↓ -0.16)	55.20 (95% CI [54.62, 55.77]) (↓ -0.15)
	Counselling/ check-up	15.01 (95% CI [14.99,15.03])	8.41 (95% CI [8.29,8.52]) (↓ -0.05)	23.42 (95% CI [23.29, 23.55]) (↓ -0.05)
Medium	Intake	50.12 (95% CI [50.01,50.23])	6.09 (95% CI [5.95,6.23]) (↓ -0.10)	56.21 (95% CI [56.04,56.38]) (↓ -0.10)
	Counselling/ check-up	15.01 (95% CI [15.00,15.03])	7.60 (95% CI [7.53,7.67]) (↓ -0.29)	22.62 (95% CI [22.53, 22.70]) (↓ -0.28)
Large	Intake	50.03 (95% CI [49.91,50.14])	3.79 (95% CI [3.73,3.85]) (↑ 0.03)	53.82 (95% CI [53.67,53.96]) (↑ 0.01)
	Counselling/ check-up	15.00 (95% CI [14.99,15.02])	8.65 (95% CI [8.59,8.72]) (↓ -0.00)	23.66 (95% CI [23.58, 23.74]) (↓ -0.00)

Table 11 KPI Access (Afternoon slot)

Midwifery practice	Appointments within the interval	Appointments outside the interval	Average additional waiting time (in days)
Small (A)	100%	0%	0
Small (B)	100%	0%	0
Medium	93.90% (95% CI [93.17, 94.62]) (↓ -3.89%)	6.10% (95% CI [5.38, 6.83]) (↑ 3.89%)	4.27 (95% CI [4.04, 4.50]) (↑ 1.05)
Large	100%	0%	0

Introducing an urgent consultation slot in the afternoon reduces the utilization of the on-duty shift with 1% (small A, medium and large) or 2% (small B). The utilization of the on-call shifts remains the same (small A, small B and medium) or reduces with 1% (large) (Figure 23). The continuity of care as the percentage of acute care requests attended by a known midwife increases with on average 5%, 3% and 3% for a small, medium, and large midwifery practice respectively (Figure 24).

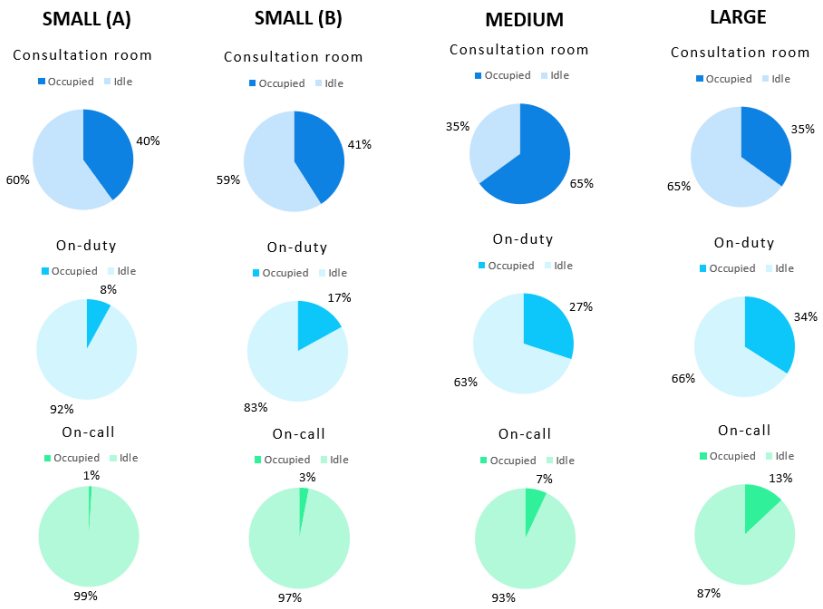


Figure 23 KPI Utilization (afternoon slot)

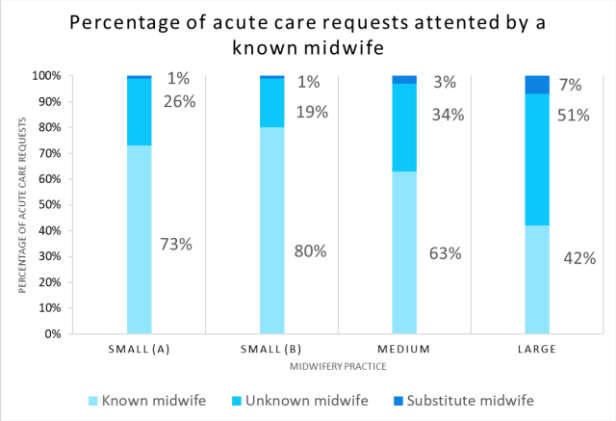


Figure 24 KPI CC: Percentage of acute care requests attended by a known midwife (afternoon slot).

6.4 Capacity pooling

If a client contacts the midwifery practice due to an acute care request or the start of labor, she will be referred to the midwife who is currently on-duty. However, if the on-duty midwife is unavailable due to attending another pregnant woman, the client will be directed to the midwife who is on-call. Sharing capacity of on-duty and/or on-call midwives among multiple midwifery practices may increase the total availability for urgent consultations but how does it affect the likelihood of pregnant women being able to see a known midwife? As explained in Section 5.7 we present four levels of capacity pooling (illustrated in Figure 25) and evaluate the results on utilization in Section 6.4.1 and the results on continuity of care in Section 6.4.2.

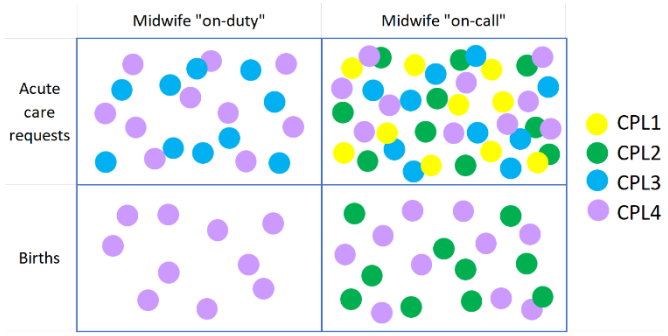


Figure 25 Capacity pooling levels (CPLs)

6.4.1 Utilization

Within the first level of capacity pooling (CPL1), all acute care request that are initially answered by midwives “on-call” are now referred to the VPTC. The daily chance of at least one acute care requests at the VPTC, which equals the chance of an occupied “VPTC midwife 1” shift, equals 79%. This occupied shift has an average utilization of 4%, which results in an overall average utilization of 3.27% (95% CI [3.16,3.38]). The overall average utilization of a second midwife present at the VPTC equals less than 0.5% and is therefore assumed to be negligible. The average utilization of the midwives “on-call” reduces with at most 1% for small and medium sized midwifery practices and with 3% for the large sized midwifery practice. Figure 26 illustrates the results.

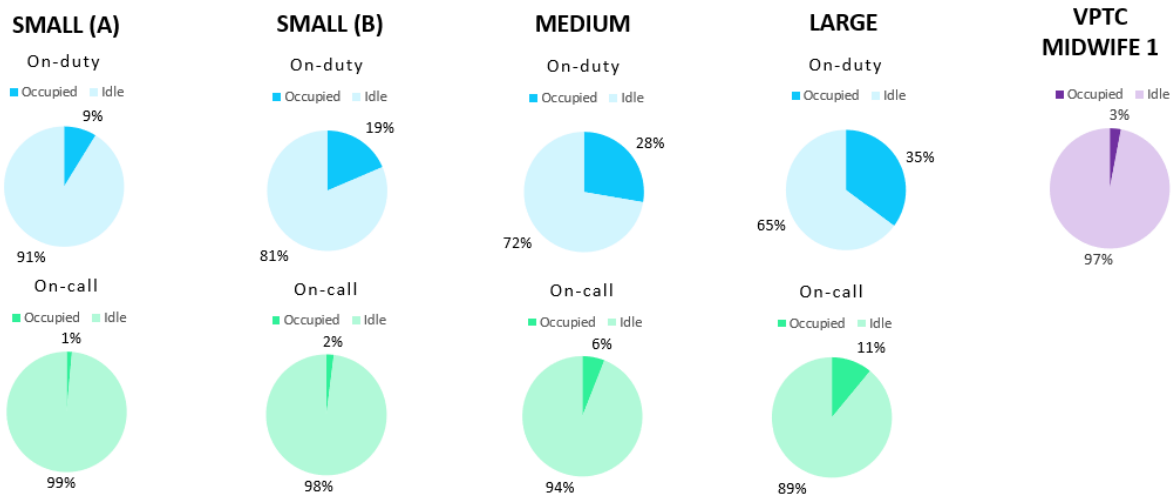


Figure 26 KPI Utilization VPTC1

Figure 27 illustrates the results on the second level of capacity pooling. Within this level (CPL2), both acute care requests and births that are initially answered by midwives “on-call” are referred to the VPTC. The utilization of the midwives “on-call” at all midwifery practices is therefore 0%. The chance of at least one urgent consultation per day at the VPTC equals 87%. Considering a day with at least one urgent consultation, the observed utilization is 27%, resulting in an overall average utilization of 23.53% (95% CI [23.33,23.73]). The daily chance of two urgent consultations at the same time equals 43% and the observed utilization of this shift is 17%, resulting in an average overall utilization of 7.28% (95% CI [7.10, 7.47]). The chance that we need a third midwife at the VPTC is 13% with an occupied utilization of 13%, resulting in an overall average utilization of 1.69% (95% CI [1.62,1.77]). The overall average utilization of a fourth midwife at the VPTC equals less than 0,5% and is therefore assumed to be negligible. The total number of midwives required decreases from eight midwives in the decentralized situation to seven midwives in the centralized situation which is a decrease in overall midwifery capacity of 12.5%.

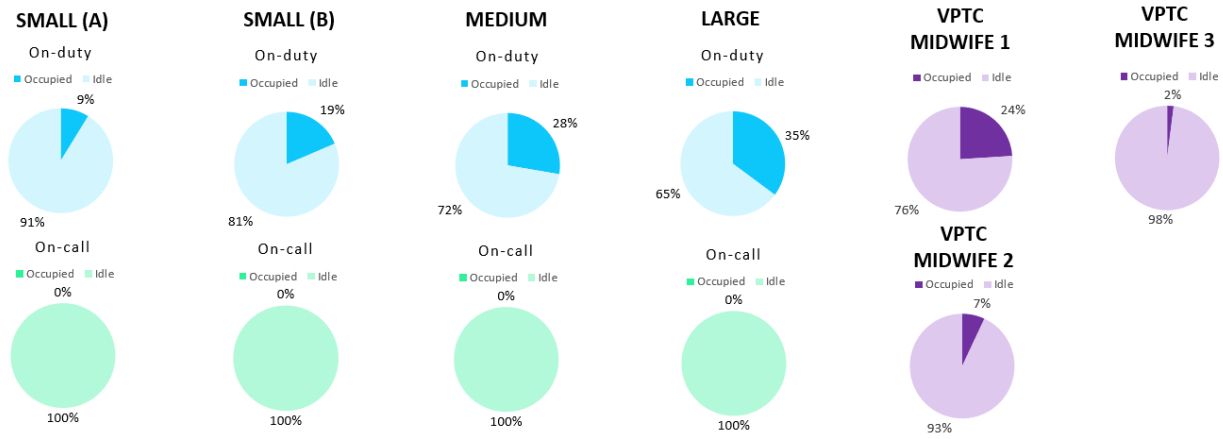


Figure 27 KPI Utilization VPTC2

Within the third level of capacity pooling (CPL3), acute care requests provided by both midwives on-duty and on-call are referred to the VPTC. The utilizations of the midwifery shifts are illustrated in Figure 28. There is a chance of 100% for at least one urgent consultation per day at the VPTC and the midwife answering these acute care requests (VPTC midwife 1) has an overall average utilization of 13.25% (95% CI [13.04, 13.45]). The chance of two urgent consultations at the same time equals 38% and the observed utilization of this VPTC midwife2 shift is 2% which results in an overall average utilization of 0.75% (95% CI [0.71, 0.80]). The overall average utilization of a third midwife available at the VPTC is smaller than 0.5% and therefore negligible. The utilization of the "on-duty" and "on-call" midwives for all practices decrease.

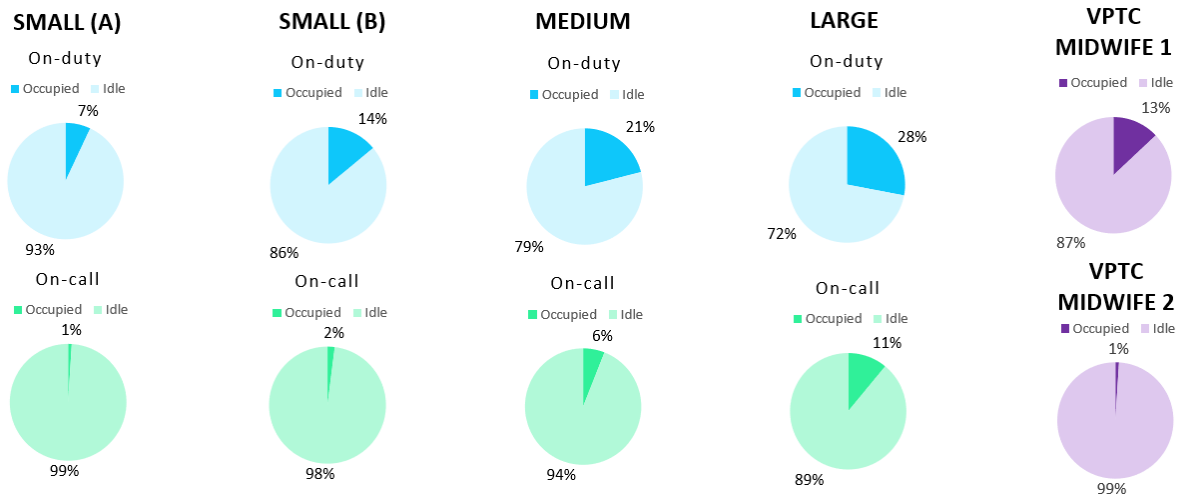


Figure 28 KPI Utilization VPTC3

Within the fourth level of capacity pooling (CPL4), all acute care requests and births provided by both the midwives on-duty and on-call are referred to the VPTC. There is a chance of 99% for at least one urgent consultation per day at the VPTC. The chance of two, three, four, five or six urgent consultations at the same time equals 96%, 75%, 41%, 15% and 6% respectively. The utilization of the occupied shifts for midwife 1, 2, 3, 4, 5 and 6 providing these urgent consultations is 43%, 36%, 25%, 17%, 16% and 18% respectively. Combining these percentages results in the overall average utilization of 43.07% (95% CI [42.99, 43.15]) for VPTC midwife1, 34.29% (95% CI [34.07, 34.50]) for VPTC midwife2, 18.49% (95% CI [18.26, 18.73]) for VPTC midwife3, 7.00% (95% CI [6.83, 7.16]) for VTPC midwife4, 2.10% (95 CI [2.03, 2.17]) for VPTC midwife5 and 0.53% (95% CI [0.49, 0.57]) for VPTC midwife 6 as illustrated in Figure 29. The overall average utilization of a seventh and eighth midwife at the VPTC are lower than 0.5% and therefore negligible. The total number of midwives required decreases from eight midwives in the decentralized situation to six midwives in the centralized situation which is a decrease in overall midwifery capacity of 25%.

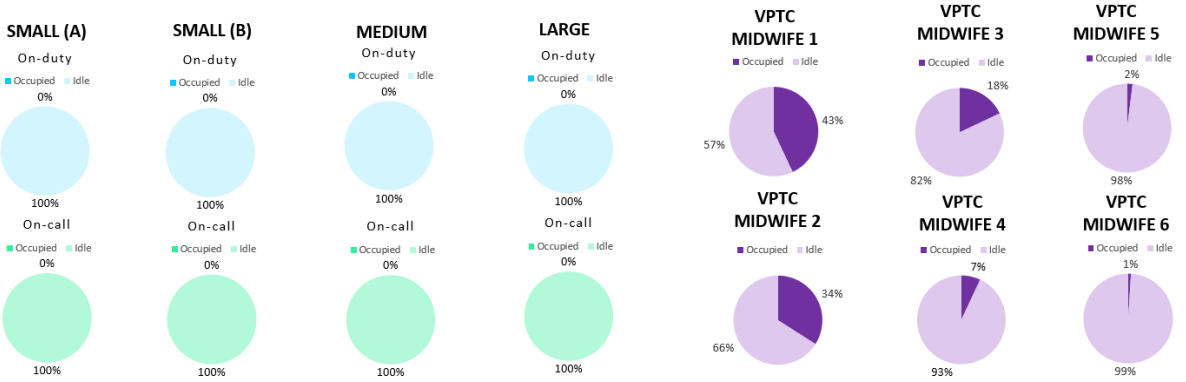


Figure 29 KPI Utilization VPTC4

6.4.2 Continuity of care

Figure 30 illustrates the average number of caregivers per client for all levels of capacity pooling. The average number of caregivers increases for CPL3 and CPL4, indicating an increase in the number of caregivers only if both “on-duty” and “on-call” midwives are pooled.

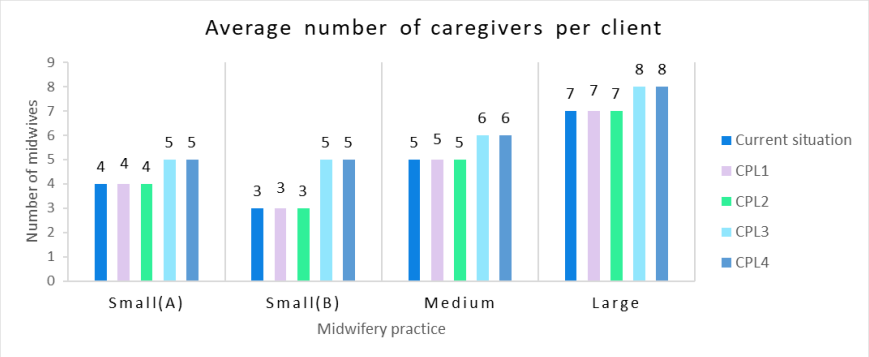


Figure 31 KPI CC1 Average number of caregivers per client.

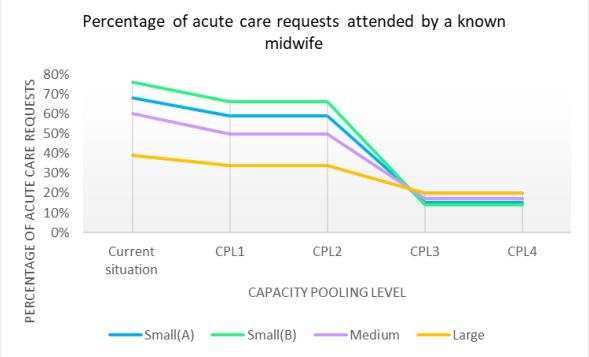


Figure 32 KPI CC2: Percentage of acute care requests attended by a known midwife

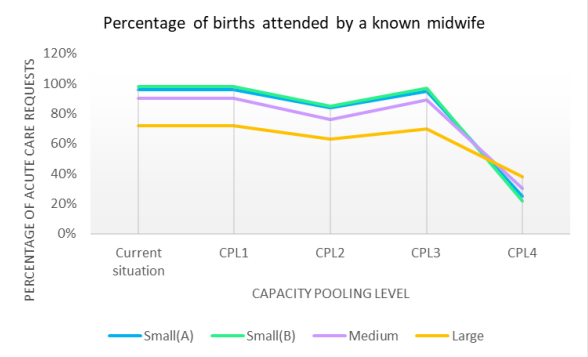


Figure 30 KPI CC3: Percentage of births attended by a known midwife.

In the current situation the percentage of acute care requests attended by a known midwife is between 76% and 68% for small midwifery practices, 60% for a medium sized midwifery practice and 39% for a large midwifery practice. As Figure 31 illustrates, due capacity pooling of “on-call” midwives (CPL1 and CPL2) these percentage decrease with on average 10% for a small and medium sized midwifery practices and 5% for a large sized practice. For capacity pooling of “on-duty” and “on-call” midwives (CPL3 and CPL4) the percentages of continuity of care in the current situation decrease with 58%, 43% and 19% for a small, medium, and large sized practice respectively.

The percentages of births attended by a known midwife for all levels of capacity pooling are presented in Figure 32. Sharing midwifery capacity for care provision during acute care requests has no (CPL1) or very little (CLP3) influence on the continuity of care offered during birth. For CPL1 the percentage of births attended by a known midwife remains on average 97% for small midwifery practice, 90% for a medium sized midwifery practice and 72% for a large midwifery practice. For CPL3 these percentages decrease to with 1%, 1% and 2% for a small, medium, and large sized midwifery practice respectively. The small decrease in continuity of care offered during birth is not surprising since births are still provided within a women’s own team of midwives and capacity pooling is only applied for care provision of acute care requests. One reason for the small decrease in continuity of care in CPL3 could be the fact that capacity pooling for acute care requests reduces the chance for a pregnant woman to get to know a midwife within her own practice by whom she is not attended before (if applicable). Sharing capacity of “on-call” midwives for both acute care

requests and births (CPL2) decreases the percentage of births attended by a known midwife with 13%, 14% and 9% for a small, medium, and large sized midwifery practice respectively. Capacity pooling for both “on-duty” and “on-call” midwives on acute care requests and births (CPL4) decreases these percentages with 72%, 60% and 34% for a small, medium and large sized midwifery practices respectively.

Both measures of continuity of care (percentages of acute care requests and births attended by a known midwife) illustrate a smaller decrease in continuity of care for a large midwifery practice than a small or medium sized midwifery practice. One reason for a smaller decrease in continuity of care is the smaller increase in the total number of caregivers for women cared for in a large midwifery practice compared to women cared for in a small or medium sized midwifery practice (Figure 30). Besides the smaller decrease in continuity of care, results on CPL4 illustrate that while a larger midwifery practice in the current situation provides lower continuity of care than a smaller practice, the implementation of CPL4 leads to a higher level of continuity of care being offered by the larger midwifery practice in comparison to the smaller midwifery practice. CPL4 is the highest level of capacity pooling and in this situation, all acute care requests and births can be provided by midwives from all four the practices. A large midwifery practice has the largest number of midwives within this “pool” of midwives and a client cared for in this practice has therefore the highest change of seeing a midwife from her own practice.

6.5 Conclusion

Our research provides insights in the utilization of midwifery shifts within the current situation and the expected utilization of midwifery shifts after the introduction of an urgent consultation slot and the implementation of multiple capacity pooling levels (CPLs). Additional to these insights, we provide information on the increase or decrease in continuity of care, the effects on waiting time and access to care for regular consultations. The introduction of an urgent consultation slot in the morning results in a decrease of the “on-duty” and “on-call” shifts ranging from 1% to 2%. Continuity of care provided during acute care requests and births increases with on average 7% for a small or large sized midwifery practice and 6% for a medium sized midwifery practice. Access to care decreases with 3.92% for a medium sized midwifery practice with one consultation room, resulting on average 4 days of additional waiting time. We observe similar results for the introduction of an afternoon urgent consultation slot, although the increase in continuity of care is smaller (5%, 3% and 3% for a small, medium, and large sized midwifery practice respectively). Besides the introduction of an urgent consultation slot, we evaluate the effects of capacity pooling using four CPLs. Results on CPL1 show that we require one additional midwife at the center to provide care for acute care requests with an expected utilization of 13% and that the continuity of care provided during acute care requests decreases with on average 10%, 10% and 5% for a small, medium, and large sized midwifery practice respectively. Results on CPL2 show a decrease of 12.5% in the required midwifery capacity. Continuity of care provided in a small, medium, and large midwifery practice decreases with 10%, 10% and 5% for acute care requests and with 13%, 14% and 9% for births respectively. Implementation of CPL3 requires two additional midwives with an expected overall utilization of 13% and 1% and a decrease in continuity of care for acute care requests of 58%, 43% and 19% for a small, medium, and large midwifery practice respectively. The highest level of capacity pooling (CPL4) decreases the required midwifery capacity with 25% and continuity of care provided in a small, medium, and large midwifery practice decreases with 58%, 43% and 19% for acute care requests and with 72%, 60% and 34% for births respectively.

7 Conclusion

In this chapter we present the main conclusions of this research in Section 7.1, we discuss the limitations in Section 7.2, and we elaborate on the opportunities for further research considering capacity pooling within the midwifery profession in Section 7.3.

7.1 Conclusion

The goal of this research is to assess the potential of capacity pooling within the midwifery profession and thereby contribute to a more sustainable future midwifery profession. In the current Dutch midwife-led continuity of care (MLCC) model, pregnant women in the Netherlands receive primary midwife-led care as long as pregnancy and childbirth occur without complications. Within this model continuity of care requires time to provide personalized care and time to build a relationship of sharing between the woman and her midwife. While assessing the effects of capacity pooling within midwifery care we have to consider to what extend midwives in the Netherlands are currently able to provide continuity of care and how this is affected by various pooling interventions. We developed a discrete-event simulation model including multiple performance indicators, taking into account the utilization of midwives, access to midwifery care, length of stay at the midwifery practice and continuity of care. We measure continuity of care based on the total number of midwives sharing antenatal care for a pregnant woman and the percentage of urgent consultations (acute care requests and births) attended by a known midwife. In our simulation model, we evaluated the effects of capacity pooling usings varying settings on the number of urgent consultations slots and multiple levels of pooling midwifery shifts among practices. The introduction of an urgent consultation slot decreases the utilization of “on-duty” and “on-call” midwives with on average 1% and increases continuity of care offered during acute care requests with on average 7%. Besides, introducing this urgent consultation slot in the morning (10.00 a.m.) decreases the average waiting times from 6.69 to 4.46 minutes. Results on capacity pooling for both the care provision for acute care requests and births show a 12.5% and 25% decrease in required midwifery capacity for CPL2 and CPL4 respectively. Capacity pooling only for acute care requests requires one midwife with a utilization of 13% for CPL1 and two additional midwives with a utilization of 13% and 1% for CPL3. The percentage of acute care requests provided by a known midwife decreases with on average 8%, 8%, 44% and 44% for CPL1, CLP2, CPL3 and CPL4 respectively. The percentage of births attended by a known midwife decreases with on average 0%, 12%, 1%, 60% for CPL1, CPL2, CPL3 and CPL4 respectively.

The practical contribution of this study is to contribute to a more sustainable midwifery profession. Several regions in the Netherlands are hesitant to implement capacity pooling due to the potential loss of continuity of care provided antenatally. The results of our study, which quantitatively evaluated both utilization of midwifery shifts and continuity of care, provide midwives in the Netherlands with the ability to balance these measures against each other, empowering them to make an informed decision. In order to enhance decision-making not just from the perspective of midwifery, but for maternity care as a whole, we have to consider the influence of capacity pooling broader. Further research should evaluate the effects of capacity pooling within primary care next to secondary and tertiary obstetric care. Multiple studies suggest that women cared for in smaller practices offering continuity of care experience fewer referrals to obstetrician-led secondary or tertiary care (Fontein, 2010) (Offerhaus, Jans, Hukkelhoven, de Vries, & Nieuwenhuijze, 2020). Further research should investigate how capacity pooling is related with referral rates to obstetrician-led care.

This study is the first to develop a discrete event simulation model for primary midwifery care in the Netherlands and for our knowledge the first quantitative research into the effects of capacity pooling on the provision of continuity of care. We contributed to theory by developing a discrete event simulation model that is able to evaluate multiple levels of capacity pooling with the Dutch MLCC model based on the utilization of midwifery shifts, access to care, waiting time and continuity of care provided in both acute care requests and births. Lack of available data on the frequency and characteristics of urgent consultations within primary midwifery care highlights the need for further research in this area to study the effects of urgent consultations on the provision of midwifery care and to identify the variability caused by these processes. Registration of acute care requests within midwifery practices is therefore a prerequisite.

7.2 Discussion

In this section, we discuss the limitations and the strengths of our research. We start by evaluating our ability to study the effects of capacity pooling based on the capacity pooling concepts established by the KNOV and described in Section 1.3. We developed a discrete event simulation model that enables us to evaluate the effects of capacity pooling based on a case study at cooperation VeRVe. This cooperation established the idea of a “Verloskundig Prenataal Triage Centrum” (VPTC). The VPTC is similar to the capacity pooling concept “midwifery acute care center” and could be elaborated by providing care to low and average risk women during the start of their labor. With our simulation model we provided results on both the “midwifery acute care center” and a combination of the “midwifery acute care center” with a “birth center”. However, we did not address the capacity pooling concept “women’s center”. A women’s center is a place where women can go for physical, mental/emotional, and social health questions which are often provided together with other health care professionals. Capacity pooling of midwives within this concept increases the opportunity to have additional health care professionals available and take the quality of midwifery care to a higher level. Unfortunately, there is no data available around the frequency by which midwives currently refer clients to these health care professionals and how this care is provided. This is the primary reason why we chose to focus solely on the capacity pooling concepts “midwifery acute care center” and “birth center”. The second reason is our desire to provide results on capacity pooling concepts that are in practice the closest to the needs of midwives in the Netherlands.

In our study, we made several assumptions that influence our results. First, we assume that all clients receive regular consultations according to the prenatal care schedule for low-risk women and no additional services are provided. This means that we exclude additional consultations such as “centering pregnancy”, “hartjesspreekuur” and “CTG” and we do not consider personalized care. The observed average utilization of the consultation rooms is therefore lower than expected. Second, we assume that all clients require one up to four urgent consultations during pregnancy, with equal probabilities. This assumption is based on a combination of regular consultations within the prenatal care visit and the average number of face-to-face visits as described in Section 5.6. Unfortunately, there is no further literature available on the frequency and characteristics of urgent care consultations within midwifery care. Third, appointment scheduling is based on the first available time slot in one of the consultation rooms at the midwifery practice. Eventually, the midwifery schedule determines which midwife will see the client at the consultation room. We do not consider additional prioritization based on for example a client’s preferences to see a specific midwife during her regular consultations or the preference to see all midwives at least ones during prenatal care.

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