

Tilburg University

Care & cure combined

Pieters, A.J.H.M.; van Oorschot, K.E.; Akkermans, H.A.

Published in:

Proceedings of the 30th International Conference of the System Dynamics Society (ICS DS 2012)

Publication date:

2012

[Link to publication in Tilburg University Research Portal](#)

Citation for published version (APA):

Pieters, A. J. H. M., van Oorschot, K. E., & Akkermans, H. A. (2012). Care & cure combined: Using simulation to develop organization design theory for health care processes. In E. Husemann, & D. Lane (Eds.), *Proceedings of the 30th International Conference of the System Dynamics Society (ICS DS 2012)* University of St. Gallen. <http://www.systemdynamics.org/conferences/2012/proceed/papers/P1431.pdf>

General rights

Copyright and moral rights for the publications made accessible in the public portal are retained by the authors and/or other copyright owners and it is a condition of accessing publications that users recognise and abide by the legal requirements associated with these rights.

- Users may download and print one copy of any publication from the public portal for the purpose of private study or research.
- You may not further distribute the material or use it for any profit-making activity or commercial gain
- You may freely distribute the URL identifying the publication in the public portal

Take down policy

If you believe that this document breaches copyright please contact us providing details, and we will remove access to the work immediately and investigate your claim.

Care & Cure Combined: Using Simulation to Develop Organization Design Theory for Health Care Processes

Angèle Pieters
Tilburg University
angele@angelepieters.com

Kim van Oorschot
BI Norwegian Business School
kim.v.oorschot@bi.no

Henk Akkermans
Tilburg University / Research in Business B.V.
henk@supplynetworkdynamics.org

Abstract

The health care sector is facing a multitude of problems at the same time: rising costs, increase in patients with lifelong diseases, and unsatisfying quality. There is a prominent role for conditions that require a combination of simple (care) and complex (cure) activities. These conditions require different provider expertise; one offering care expertise or more general, preventive monitoring, and the other offering cure expertise, or more specialized, medical monitoring/intervention. In organization design theory the focused factory concept is presented as a way of organizing such processes. However, the application of this concept does not always work well. For decennia, Dutch perinatal care is organized according to the focused factory concept, but recently there has been considerable debate with regard to its performance. Research has shown that the design of the Dutch perinatal care system might not be the right one (Pieters, Van Oirschot, & Akkermans, 2010). In response to its problems, the sector is seeking alternative organization designs. In this paper simulation modeling is used to evaluate these different organization design experiments. From these simulations, we seek to build organization design theory for this type of conditions (Davis, Eisenhardt, & Bingham, 2007; Schwaninger & Grösser, 2008).

Keywords inter-organizational collaboration, competition, trust, health care, perinatal care, system dynamics

1. Introduction

Improving the performance of the health care sector is a task of major societal importance. Not only is the health care sector a major industry in developed countries, representing more than 10% of the Gross National Product and employing over 10% of the national workforce (OECD, 2011), it is also facing a multitude of major problems at the same time: rising costs, aging population, an increase in patients with lifelong diseases, and unsatisfactory quality (McGlynn *et al.*, 2003). There is much debate about what has been causing these problems and what may be needed to resolve them. One root cause on which there appears to be a broad consensus is that the *design* of the services provided in health care is in urgent need of improvement. It is generally recognized that, in health care, “poor system design creates ‘accidents waiting to happen’” (Leape, 1995).

There is a prominent role in health care for conditions that require a combination of simple (care) activities and complex (cure) activities. These conditions require different provider expertise; one offering care expertise or more general, preventive monitoring, and the other offering cure expertise, or more specialized, medical monitoring and intervention. Examples of this type of conditions are increased cardiovascular risk, diabetes mellitus, chronic obstructive pulmonary disease, congestive heart failure, pregnancy, etc.

In organization design theory there is a theory on how to organize such processes: as focused factories (Skinner, 1974). Back in the 1970s, Skinner based this concept (which since then has been applied widely in the manufacturing sector) on the intuitive notion that a plant can achieve superior performance by organizing its resources around performing one task, instead of trying to meet all sorts of demands from internal and external sources. Skinner combined this notion of focusing on one task with the notion of “process choice”, that is, of choosing the type of manufacturing process best aligned with this task. He stressed that complex and simple tasks should not be performed by the same type of process, because then both tasks would be conducted sub-optimally.

However, the application of the focused factory concept in health care does not always work well. Dutch perinatal care is organized according to this concept: midwifery practices take care of low-risk pregnant women, and obstetric departments in hospitals take care of high-risk pregnant women. Recently, there has been considerable debate in the Netherlands with regard to the performance of this perinatal care system (e.g., NRC 2009) as a result of European studies which suggested that the high-quality Dutch perinatal care system has some of the worst performance outcomes in Europe regarding perinatal mortality (Mohangoo, Buitendijk, Hukkelhoven, Ravelli, & Rijninks-Van Driel, 2008). Research has shown that the design of the Dutch perinatal care system (the focused factory structure with midwifery practices and obstetric departments in hospitals) might not be the right one (Pieters *et al.*, 2010). In response of the performance issues, Dutch perinatal care is seeking alternative organization designs, from taking on extra midwives in hospitals next to independent midwifery practices all the way up to fully integrated care where midwifery practices and obstetric departments in hospitals merge together.

In this paper we use simulation to evaluate the different organization design experiments. After all, empirical research will be time-consuming, risky and it will be difficult to separate correlation from causality, due to the multitude of potentially explanatory factors. We seek to build theory from simulation (Davis et al., 2007), i.e. system dynamic modeling (Schwaninger & Grösser, 2008).

The results provide insight not only for Dutch perinatal care, but it provides a basis for building organization design theory. Finally, the results might be valuable to policy makers of perinatal care systems in other Western countries because these countries are moving more towards such a system with stronger midwife involvement for low-risk pregnancies (De Vries, Wiegers, Smulders, & Van Teijlingen, 2009; Goodman, 2007; Wagner, 2006).

This article is structured as follows. In the second section the literature is discussed. In the third section the method used are described. The fourth section focuses on the case setting, its structure, its performance and the improvements that are under investigation. Section five describes the structure of the system dynamic model, and section six presents the results of the different scenarios. Finally, conclusions are drawn with regard to the research question as formulated above.

2. Method

2.1 Building theory through simulation

We seek to build theory on the basis of simulation (Davis et al., 2007). Simulation is especially useful for theory development when the focal phenomena involve multiple and interacting processes, time delays, or other nonlinear effects such as feedback loops and thresholds (Davis et al., 2007), and when the theory seeks to explain phenomena that are challenging to study using empirical methods because of their time and data demands, as is often the case with organizational and strategic processes (Davis et al., 2007; Reppenning, 2002).

2.2 System dynamic modeling

In this research, system dynamics is used for theory development (Schwaninger & Grösser, 2008). System dynamics focuses on how causal relationships among constructs can influence the behavior of a system (Forrester, 1961; Sterman, 2000). It can provide theoretical insights that are not available from traditional operations management methods such as queuing theory or mathematical programming because it is a theory about the structure (and the resulting behavior) of social systems (Größler, Thun, & Milling, 2008).

2.3 Model development

The model is based on the following three types of data: mental, written and numerical data (Forrester, 1980). This data is elicited by the following projects. In the first project, mental models regarding collaboration between midwifery practices and obstetricians is elicited through questionnaires, interviews and group model building sessions. In this project, 16 obstetricians from 2 hospitals and 45 midwives from 12 midwifery practices were involved in (Pieters,

Akkermans, & Franx, 2011). In addition, in the second project, mental and written data is obtained by observation, interviews and clinical action research (Lewin, 1948; Schein, 1987). In the third project, numerical data about patient flows between a midwifery practice and a hospital is analyzed (Pieters et al., 2010). In addition, causal loop diagrams and a preliminary system dynamic model are developed with 2 obstetricians, one from each hospital. Finally, literature regarding the Dutch perinatal care system is studied.

The empirical data comes more or less from one particular region: Tilburg and its surrounding villages. However, the researchers feel that this data and the mental models they have elicited are representative for Dutch perinatal care, for as there are very few regional differences between the regional perinatal care systems in the Netherlands and for as some of the findings are backed up in the literature as well.

3. Case setting: Dutch perinatal care

Firstly, an overview is given of the structure of Dutch perinatal care. Secondly, the performance – praises and flaws – of Dutch perinatal care are presented. In the third sub-section, the root causes of these flaws are given, and in the fourth sub-section four different scenarios regarding how to improve Dutch perinatal care are discussed.

3.1 Structure

In the Netherlands, the health care system has three echelons (first, second and third). Each of these echelons has a gatekeeper function to the next, higher, echelon. Patients have to use the most efficient echelon first (often primary care), and it has to be prevented that patients receive care from a higher echelon when this is medically unnecessary (Structuurnota Gezondheidszorg, 1974). Perinatal care is organized according to this structure (Table 1). Pregnant women are assigned to an echelon on the basis of their initial risk. When the risk a pregnant woman faces changes during her pregnancy or delivery, she should be referred to another echelon. The risk and referral criteria are set up by the Royal Dutch Organization of Midwives (KNOV) and the Dutch Society of Obstetrics and Gynecology (NVOG). Low risk pregnancies are cared for in the first echelon (primary care) by independent midwifery practices. Intermediate and high risk pregnancies are cared for by the second and third echelon (secondary and tertiary care) in obstetric departments in hospitals. Perinatal care in a certain region (typically a city with some surrounding villages) consists of 1 or 2 hospitals and 5 till 20 midwifery practices.

During the pregnancy, low-risk pregnant women receive about 13 consultations (Heineman, Bleker, Evers, & Heintz, 2004) and some more specialized examinations such as blood tests, ultra-sound scans, and prenatal screening. Intermediate- and high-risk pregnant women will receive more care. When a pregnant woman who is being cared for in the midwifery practice faces a change in risk, she can either go to the hospital for an obstetric consultation and return to the midwifery practice afterwards, or she will be referred to the hospital and has the rest of her care delivered by the hospital. Low-risk pregnant women give birth at home or in a home-

like birthing center under the responsibility of a midwife; intermediate- and high-risk pregnant women give birth in the hospital under the responsibility of an obstetrician. If medically allowed, women will recover at home. A maternity nurse will come in every day to help with daily activities and the medical responsibility lies with a midwifery practice.

Insurance, which is obligatory for all inhabitants of the Netherlands, compensates all costs of perinatal care. Although low risk pregnant women who want to deliver at the hospital have to pay a modest sum themselves.

Dutch perinatal care adheres to the midwifery model – stating that being pregnant and giving birth are healthy and natural events, physiological processes, involving no illness or disease –, instead of to the medical model as in most of the developed countries.

Table 1 Structure of Dutch perinatal care

	primary care	secondary care	tertiary care
risk pregnant women	low-risk	intermediate- and high-risk	high-risk
organization	midwifery practice	hospital	academic hospital
professional	midwives	obstetricians, residents and midwives	
specialty	care	cure	
philosophy	Having a pregnancy that is as “natural” as possible, without any unnecessary medicalization	Trained in risk reduction; in case of doubt, it is strongly preferable to have events unfold in the hospital	
number of professionals	+/- 1850 midwives ¹	+/- 675 obstetricians ² +/- 550 advanced midwives ¹	

1. (Hingstman & Kenens, 2009)

2. (Van der Velden, Bennema-Broos, & Hingstman, 2001)

3.2 Performance

The Dutch perinatal care system is often set as an example to learn from, for example in the United Kingdom and the United States (Bradley & Bray, 1996; De Vries et al., 2009; Johnson, Callister, Freeborn, Beckstrand, & Huender, 2007; Mander, 1995; Oppenheimer, 1993; Wagner, 2006) Why? The percentage of home births is exceptionally high (30% in 2004) (Anthony, Amelink-Verburg, Jacobusse, & Van der Pal-de Bruin, 2005), compared to, for example, the percentage in the United States (2%) (Young, 2008). In addition, the number of obstetric interventions is low compared to neighboring countries (Amelink-Verburg et al., 2007), and certainly compared to the United States, where six of the fifteen most performed hospital procedures in the entire population are associated with childbirth (Sakala & Corry, 2008). And although the overall caesarean section rate rose from 8.1 to 13.6% between 1993 and 2002 (Kwee, Elferink-Stinkens, Reuwer, & Bruinse, 2007), the Netherlands still has one of the

smallest number of caesarean deliveries in the world (for example compared to 30% in the United States) (QuickStats, 2005). Much of this is attributed to the philosophy and structure of the Dutch perinatal care system (see Section 4.1).

However, since the first results of the Euro-Peristat project in 2003, more and more flaws of the Dutch perinatal care system have been revealed (see also (EURO-PERISTAT, 2008)): relatively high perinatal morbidity and mortality rates (Buitendijk, Zeitlin, Cuttini, Langhoff-Roos, & Bottu, 2003; Mohangoo et al., 2008), and relatively high maternal morbidity and mortality rates (Schutte, Schuitemaker, Van Roosmalen, & Steegers, 2008; E. A. Steegers, 2005; Zwart et al., 2008). And although the quality of care experienced by women during the care process is high (Wiegers, 2009), it is different for labor, especially when a woman needs a referral from midwifery practice to hospital (Christiaens, Gouwy, & Bracke, 2007; Rijnders et al., 2008).

From a cost perspective, the Dutch perinatal system appears to be working fairly well. The costs associated with pregnancy and childbirth in 2007 were about 2.4% of total health care expenditure (Slobbe, Smit, Groen, Poos, & Kommer, 2011), which is comparable to other European countries (OECD, 2006). Incidentally, this percentage is much lower than in the United States, where the costs of the maternity care system are about 20% of all health care expenditures (Goodman, 2007). Moreover, the costs associated with a normal delivery are one of the lowest of eight European countries (Bellanger & Or, 2008).

3.3 Root causes of malfunctioning

The root causes for the malfunctioning in Dutch perinatal care (i.e. maternal and perinatal mortality and morbidity rates and dissatisfaction) can be put in three categories; the characteristics of the pregnant women, the efficiency of the system, and whether or not the structure of the system is the right one.

Firstly, characteristics of the pregnant women, such as ethnicity, income, smoking, age, twin births, obesities, and less use of prenatal screening compared to other countries, might be the cause of the higher perinatal and maternal mortality and morbidity rates (Achterberg, 2005; Advies Stuurgroep Zwangerschap en Geboorte, 2009; Bais, Eskes, & Bonsel, 2004; Zwart et al., 2011).

The second category of root causes concerns the efficiency of the current system, which appears to be not optimal. Firstly, regarding the availability, both midwives and obstetricians are not available 24 hours per day, 7 days per week, which results in delays in treatment. For example, obstetricians are not in the hospital at evenings and in the weekends and have to be called in by residents (De Graaf et al., 2010), and midwives do not stay the whole time with a pregnant woman who is in labor (Reuwer, 2008). Secondly, regarding the competences of staff, there are doubts about the competences of midwives to identify complications during labor (Amelink-Verburg & Buitendijk, 2010; Reuwer, Bruinse, & Franx, 2009). Thirdly, the information that is given to pregnant women concerning pregnancy, risks, healthy living etc. can be unclear and ambiguous (Advies Stuurgroep Zwangerschap en Geboorte, 2009).

Thirdly, there are doubts about whether the current structure of the system (i.e. midwifery practices are responsible for low-risk pregnant women and hospitals are responsible for high-risk pregnant women) is the right system. The system does not operate the way it is organized: low-risk pregnancies are also being cared for in hospitals and high-risk pregnancies are being cared for in midwifery practices (Pieters et al., 2010). In addition, controversy exists about the safety of home deliveries, especially because of the time it takes to transport a woman in labor from home to the hospital in case of complications. Some state home births are as safe as hospital births (De Jonge et al., 2009), while others doubt this (A. C. C. Evers et al., 2010; Visser & Steegers, 2008).

3.4 Improvements

From root causes to improvements

Putting the root causes in the perspective of operation design, this research focuses on the third root cause: is the current structure of Dutch perinatal care the right one? This does not imply that the other root causes are not important, on the contrary, but if one would focus only on the first two, one would ignore the broken structure underlying the system. As a result, one would only be doing the wrong thing more efficient. We believe that the current system (i.e. the focused factory system where midwifery practices are responsible for low-risk pregnant women and where hospitals are responsible for high-risk pregnancies) is not the right system for Dutch perinatal care, due to the following reasons.

Firstly, the *ex ante* predictability of the complexity of a pregnancy is low. It is a medical “fact of life” that it cannot be known at the initial assessment if a pregnancy will develop as a low-risk or a high-risk one. In addition, in Dutch perinatal care there are serious doubts as to the adequacy of the selection of women with low risk of complications (Reuwer et al., 2009) and more research is needed to better determine the risk status and the optimal type of care and care provider for each individual woman in her specific situation, taking into account the risk of both under- and over-treatment (Amelink-Verburg & Buitendijk, 2010).

Secondly, the very fact that there are two separate kinds of organizations, each with their own professional cultures, may create organizational inertia and “stickiness” in patient referral from one type of organization to the other. The fact that collaboration between midwifery practices and obstetric departments in hospitals is not as smooth as one would wish for does not help either. In order to deliver high quality care, there should be an exchange of pregnant women when they need to, there should be an exchange of information about these women, and there should be an exchange of knowledge about perinatal care in general. Professionals in the field recognize the advantages of collaboration, but they also admit that feelings of competition stand in the way (De Veer & Meijer, 1996; Pieters et al., 2011).

Thirdly, pregnant women certainly have their own predilections and behavioral patterns with regard to choice of treatment; their preferences and behavior are aligned towards high-level care. For example, when a woman becomes pregnant through in vitro fertilization, she normally

has no ex ante reason to expect a complex pregnancy. However, as she has become accustomed to visiting “her” obstetric department in the hospital, she often prefers to not go to the midwifery practice but to continue her consultations in the hospital instead.

Fourthly, the process of being pregnant and giving birth requires by definition both psychosocial and medical care. However, midwives focus on the first, obstetricians on the latter. The needs and wishes of mother and child should be leading in the care delivery process, not only their medical needs, as is currently the norm, but also their psychosocial needs (Advies Stuurgroep Zwangerschap en Geboorte, 2009).

Based on the above, five scenarios have been defined. The first three are some more basic scenarios and scenario four and five are combined ones.

Scenario 1. Improved hospital model

This first scenario represents a trend that is currently found in obstetric departments of hospitals: advanced/clinical midwives are employed by the hospital. At first the reasons for employment were staff shortages in labor wards and a growing preference among midwives for a salaried position with regular work hours. Later, it is recognized that these midwives improve the quality of care because they are a specialist in physiological care; they have specific knowledge of the physiology of pregnancy and giving birth. (Wiegers & Hukkelhoven, 2010). In this scenario, the collaboration between midwifery practices and hospitals does not change explicitly.

Scenario 2. Collaborative model

The second scenario focuses on improving the collaboration between midwifery practices and obstetric departments. Examples of improvements in collaboration are the following. On a national level, the risk and referral criteria are improved by the professional associations of the midwives and the obstetricians (Amelink-Verburg & Buitendijk, 2010), so it becomes more clear who should be caring for which pregnant women. On a regional level, the collaboration in Obstetric Co-operative Groups or maternity care collaboratives can be improved (Advies Stuurgroep Zwangerschap en Geboorte, 2009), (De Veer & Meijer, 1996), (Boesveld-Haitjema, Waelput, Eskes, & Wiegers, 2008). The objective of these types of groups is to define policy at a regional level, to discuss specific problems, and to find solutions together. One can intensify the collaboration between midwifery practices and hospitals even further by partly integrating some aspects of the care process and by sharing and developing knowledge (Pieters et al., 2011). Regarding the provision of information, shared electronic health records can be developed so that information of pregnant women is always available for anyone who needs to (currently, midwifery practices and hospitals each have their own information system). Overall, most of this collaboration is voluntarily; there are no checks on whether or not organizations comply with the agreements made, and there are no sanctions when organizations don't comply.

Scenario 3. Integrated care model

The third scenario is the one where midwifery practices and obstetric departments in hospitals merge into one organization. Or as Meuwissen proposed back in 1979: “Create obstetric centers where midwives, obstetricians, GP’s, pediatricians work together. Care can be provided both in

the hospital and on location, but the focus is on professionals collaborating in order to provide the care that the women and her child need” (Meuwissen, 1979). These obstetric centers never have been put into practice.

Scenario 4. Improved hospital + model: combining scenario 1 and 2

In the fourth scenario, scenario 1 and 2 are combined. Thus, advanced/clinical midwives are added in the hospital, in order to improve the quality of care the hospital delivers, and the collaboration between the hospitals and midwifery practices is intensified. This strategy is applied more and more in practice.

Scenario 5. Integrated care + model: combining scenario 2 and 3

In the fifth scenario, scenario 2 and 3 are combined. Thus a certain percentage of the midwifery practices integrates with the hospitals and the collaboration between the hospitals and the independent midwifery practices is improved. This strategy is for example applied in Tilburg (5th city of the Netherlands), where two midwifery practices (out of the 12) integrated with one hospital (out of the 2) and where the collaboration with the other midwifery practices is intensified. The percentage of integration is set at 20%, for as in Tilburg 2 out of the 12 has been integrated with a hospital.

4. Model description

Firstly, this section presents a high level stock and flow diagram with the main causal loops of the SD model. Secondly, the main variables of the SD model are described in more detail. Thirdly, the outcome variables that we will be focusing on will be explained. The values of the variables and the graphs used are available in the model documentation.

4.1 High level stock and flow diagram

Figure 1 presents the high level stock and flow diagram with the main causal loops of the SD model. The green variables in the causal loop diagram relate to midwifery practices, the blue variables to hospitals, and the red variables to common variables such as collaboration. The diagram is characterized by five main feedback loops.

The first causal loop is a self-reinforcing feedback loop (R1). The more low-risk pregnant women are being cared for in hospitals, the less trust midwifery practices have in hospitals, the less high-risk pregnant women midwifery practices refer to hospitals, the higher the number of high-risk pregnant women in midwifery practices and the less trust hospitals have in midwifery practices. As a result, hospitals refer less low-risk pregnant women to midwifery practices, which results in a higher number of low-risk pregnant women in hospitals. This reinforcing loop is called the trust-loop. In addition, the number of pregnant women being referred between organizations is determined by the level of collaboration. For example, the more guidelines on referring pregnant women to each other, the more this will occur.

The second loop is a self-reinforcing feedback loop (R2a for midwifery practices and R2b for hospitals). The higher the work pressure, the lower the quality of care, and the higher the number of high-risk pregnancies in an organization. A higher number of high-risk pregnancies results in a higher work load. This second reinforcing loop is called the quality-of-care-loop.

The third loop is a balancing feedback loop (B1). The lower the quality of care of midwifery practices, the more low-risk pregnant women develop a high-risk pregnancy, and thus the higher the number of high-risk pregnant women in midwifery practices. As a result, trust of hospitals in midwifery practices decreases which results in less referrals of low-risk pregnant women from hospitals to midwifery practices, and thus to less low-risk pregnant women in the midwifery practice. As a result, the work pressure lowers and the quality of care increases.

The fourth loop is a balancing feedback loop (B2). The higher the number of low-risk pregnant women in hospitals, the lower the trust of midwifery practices in hospitals and the less high-risk pregnant women the midwifery practices refer to the hospitals. As a result the less high-risk pregnant women there are in the hospitals and thus also the less high-risk pregnant women in hospitals that will recover, and thus the lower the number of low-risk pregnant women in hospitals.

The fifth loop is a balancing feedback loop (B3). The more low-risk pregnant women are referred from hospitals to midwifery practices, the more low-risk pregnant women there are in midwifery practices, and also the more pregnant women will develop a high-risk pregnancy in midwifery practices and thus the more high-risk pregnant women in midwifery practices. This decreases the trust hospitals have in midwifery practices and this decreases the referrals of low-risk pregnant women from hospitals to midwifery practice.

In addition, the work pressure in hospitals is determined by the number of high-risk pregnancies in midwifery practices; these pregnant women will have obstetric consultations in hospitals. Note also that an increase in the quality of care in hospitals results in more low-risk pregnant women in hospitals, which has a negative effect on the trust midwifery practices have in hospitals.

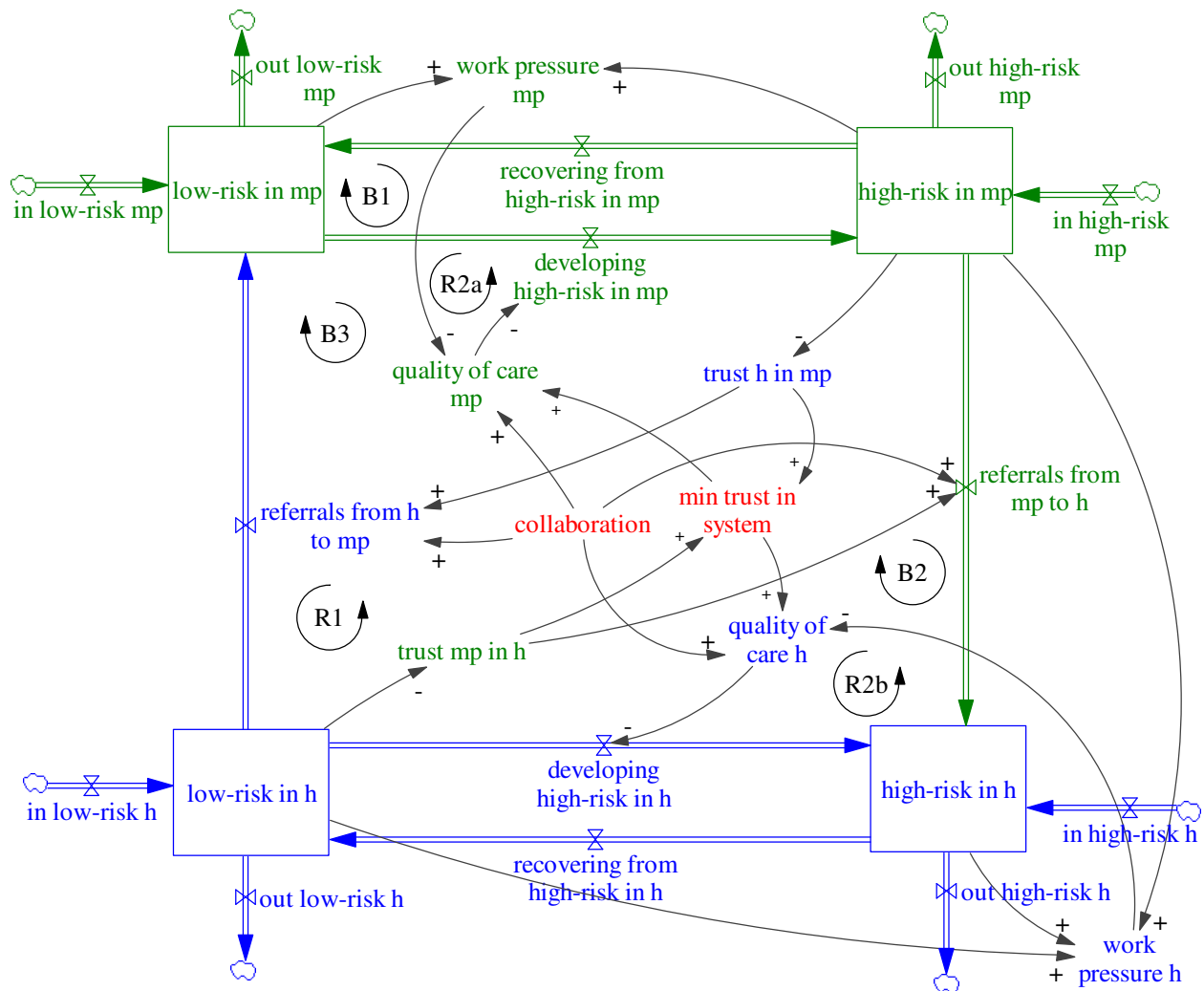


Figure 1 High level stock and flow diagram

Green variables represent the midwifery practices, blue variables represent hospitals.

4.2 Main variables and their relations

Pregnant women

Pregnant women are defined based on their position in the system: by their level of risk (low- or high-risk) and by who is responsible for their care (midwives in midwifery practices or obstetricians in hospitals). This results in four stocks: low-risk pregnant women in midwifery practices, high-risk pregnant women in midwifery practices, low-risk pregnant women in hospitals, and high-risk pregnant women in hospitals. Note that no pregnant women with intermediate risks are modeled. They are absorbed in the category of high-risk pregnant women.

The model presents the number of pregnant women in each of these categories at a certain point in time. This is determined by whether or not pregnant women have a high-risk pregnancy when presenting themselves to the system, by to which type of organization pregnant

women present themselves, by the number of pregnant women that develops a high-risk pregnancy, by the number of pregnant women that recover from a high-risk pregnancy, and by the number of pregnant women that are referred between organizations. It is assumed that all pregnant women will deliver a child and that there are no miscarriages.

Trust

Obstetricians and midwives have a certain level of trust in each other. Trust is modeled as a stock with the feedback structure of adaptive expectations (Sterman, 2000). The level of trust is determined by how the pregnant women are divided over the four categories. The more high-risk pregnant women in midwifery practices, the lower the trust hospitals have in midwifery practices. The higher the number of low-risk pregnant women in hospitals, the lower the trust midwives have in hospitals. It is assumed that there is complete transparency in who is taking care of which type of pregnant women. Midwives have insight into the number of low-risk pregnant women hospitals take care of because midwives are responsible for the aftercare of all pregnant women. Obstetricians have insight into the number of high-risk pregnant women midwifery practices take care of because these women often have to be referred to the hospital due to complications during delivery.

Trust has three effects. Firstly, the higher the trust, the higher the percentage of women that is referred between organizations. Secondly, the higher the trust, the higher the quality of care that can be delivered by the organizations. Thirdly, the higher the trust, the more pregnant women from midwifery practices will be seen by hospitals and vice versa, for as each organization brings its own specialties to the table.

Collaboration

The level of collaboration between midwifery practices and hospitals is exogenous¹. Collaboration in the model represents a collaboration that the organizations have agreed upon. Three effects of collaboration are modeled. Firstly, the higher the collaboration, the higher the percentage of women that is referred between organizations. Secondly, the higher the collaboration, the higher the quality of care that can be delivered by the organizations. Thirdly, the higher the collaboration, the more pregnant women from midwifery practices will be seen by hospitals and vice versa, for as each organization brings its own specialties to the table.

Perceived work pressure and capacity

The perceived work pressure is modeled as a stock with the feedback structure of adaptive expectations (Sterman, 2000). Perceived work pressure is determined by the number of consultations pregnant women demand. This number differs for each of the four categories. There is a fixed amount of regular consultations and a fixed amount of extra consultations for high-risk pregnant women. Who is conducting the consultations is determined by the organization which is responsible for the care process, by the level of collaboration, and by the level of trust. The higher the levels of collaboration and trust, the more pregnant women from

¹ Shouldn't there need to be a relation between trust between organizations and the level of collaboration?

hospitals are also seen by midwives, and the more pregnant women from midwifery practices are seen by hospitals. This “outsourcing” of consultations aims at improving the quality of care that organizations can deliver to their client population. Capacity is expressed in the number of consultations that can be conducted, and is adjusted to the perceived work pressure. Perceived work pressure has an effect on the delivered quality of care.

Referral behavior

The percentage of pregnant women that is referred between organizations is modeled as a stock with the feedback structure of adaptive expectations (Sterman, 2000), and depends on two things. Firstly, the level of trust has an effect on referral behavior between midwifery practices and hospitals. The higher the level of trust, the higher the percentage of high-risk pregnant women that is referred from midwifery practices to hospitals, and the higher the percentage of low-risk pregnant women that is referred from hospitals to midwifery practices. It is assumed that when there is no trust at all, still some high-risk pregnant women are referred from midwifery practices to hospitals due to medical necessity. Secondly, the level of collaboration has an effect. The higher the collaboration, the higher the percentage of pregnant women that will be referred between organizations. It is assumed that professionals are capable of judging the risk-level of pregnant women perfectly; thus obstetricians honestly know when a pregnant woman has a low-risk pregnancy, and midwives are capable of discovering all complications that make a pregnancy a high-risk one. A constant average time is defined for how long it takes before pregnant women will be referred between organizations.

Quality of care

Midwifery practices and hospitals can deliver a maximum amount of quality of care, due to their competences. Midwives lack cure competences and obstetricians lack care competences. The maximum quality of care that an organization can deliver is affected by the number of consultations that an organization is offering to the pregnant women of the other organization. Midwives lack cure and sending their pregnant women for an obstetric consultation in a hospital compensates for this lack. Even so, obstetricians lack care and by sending their pregnant women to a midwifery practice will compensate to a certain degree for this lack.

The delivered quality of care of hospitals and midwifery practices is modeled as a first-order information delay (Sterman, 2000), and is determined by the perceived work pressure, the level of collaboration, and the level of trust. The higher the perceived work pressure, the lower the quality of care and the higher the level of collaboration and trust, the higher the quality of care. Quality of care has an effect on the percentage of low-risk pregnant women that develop into a high-risk pregnant women.

Developing a high-risk pregnancy and recovering from it

The quality of care has an effect on the number of pregnant women that will develop a high-risk pregnancy. Due to the nature of being pregnant, a minimum percentage of pregnant women will develop a high-risk pregnancy, regardless of the quality of care. It is assumed that the number of pregnant women recovering from a high-risk pregnancy will be constant and independent of the

quality of care. A constant average time is defined for how long it takes before a low-risk pregnancy will develop in a high-risk pregnancy, and vice versa. The percentage of pregnant women that will develop a high-risk pregnancy is modeled as first-order information delay (Sterman, 2000),

4.3 Outcome variables

Three outcome variables are defined. Firstly, the total percentage of high-risk pregnant women is calculated as a measure of how well the system is functioning from a physical wellbeing point of view. Secondly, the percentage of high-risk pregnant women that receives care from midwifery practices is calculated as a measure on how effective the system is in treating the right patients. These two outcome variables are expected to have a direct relation with maternal and perinatal morbidity and mortality rates. In addition, the percentage of high-risk pregnant women that receives care from midwifery practices is expected to be a predecessor of the satisfaction of pregnant women, for as these women are most likely to have a referral from the midwifery practice to the hospital during labor, which negatively affects their satisfaction.

Thirdly, the costs of the system are calculated, by multiplying the capacity of each organization with a certain cost factor. It is assumed that the costs associated with pregnant women who are being cared for in midwifery practices are half of the costs of pregnant women who are being cared for in hospitals. In addition, it is assumed that midwives who are working in the hospital cost as much as the obstetricians, due to an increase in the usage of medical tests. Although currently costs of the Dutch perinatal care system are not subject to discussion, this might be an important factor in evaluating new organizational structures.

5. Simulation

The model is designed to investigate different organizational designs for Dutch perinatal care. The model is intended to deal with the dynamics of inter-organizational collaboration and competition in a tiered system. The model as presented in this paper shows the effects of improvements that are currently being implemented. The current way of working (base case) and three different basic organizational designs are compared in the model. In addition to these three basic designs, two combinations of designs are tested (Table 2). A more detailed description of the scenarios is given in Section 4.4. The model runs in weeks, for 10 years (520 weeks). The transition to a new organizational design is introduced at $t=10$. In all scenarios it is assumed that pregnant women present themselves as in the base case, so independent of the quality of care the organizations deliver.

Table 2 Overview of scenarios

Color	Scenario	Description of the scenario
Black	Base case	

Blue	1. Improved hospital model	Advanced/clinical midwives are employed by the hospital
Red	2. Collaborative model	Improving the collaboration between midwifery practices and obstetric departments in hospitals
Green	3. Integrated care model	Midwifery practices and obstetric departments in hospitals merge into one
Pink	4. Improved hospital + model: improved hospital model & collaborative model	Advanced/clinical midwives are employed by the hospital and collaboration between midwifery practices and obstetric departments in hospitals is improved
Orange	5. Integrated care + model: partly integrated care model & collaborative model	A certain percentage of midwifery practices integrated with a hospital and the collaboration between the hospitals and the other midwifery practices is improved.

The different scenarios will be discussed below according to the following format: first the changes in the settings compared to the base case are presented, followed by the results on the three main outcome variables are presented (total percentage of high-risk pregnant women in the system, total percentage of high-risk pregnant women that is being cared for by midwifery practices and costs). The last section provides us with a comparison of the five scenarios. In this section, the results of the sensitivity analyses are discussed also.

Regarding to the sensitivity analysis, the following process is followed (see also the model documentation). Firstly, on each individual scenario three types of tests are conducted: tests concerning the assumptions made in the scenario, tests concerning the relation between the variables that have changed in a particular scenario and their first effects, and tests concerning other relations in the model. Secondly, the combined scenarios are tested on only those assumptions that were found to be important ones in the first phase. The five scenarios have a particular order in how effective they are in terms of the outcome variables. In the third phase, it is tested whether the mutual order of the scenarios is changed when changing assumptions as tested in the first two phases.

5.1 Scenario 1: Improved hospital model

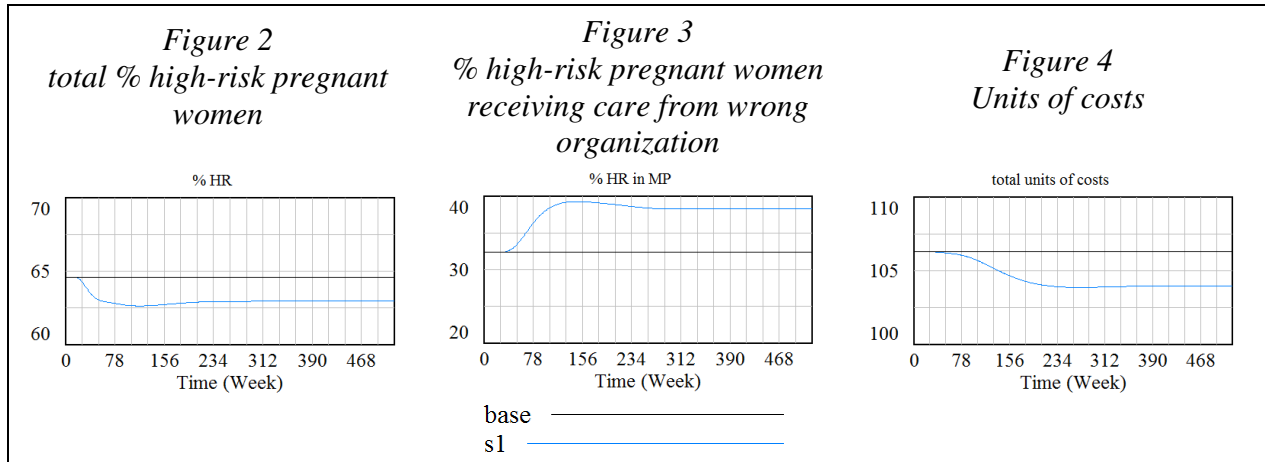
Description 1

On $t=10$ two changes are made. Firstly, the maximum quality of care in the hospital will increase to 1. When midwives are added to a hospital, the lack of care competences from the obstetricians will be compensated by the care competences from the added midwives. It is assumed that the new midwives and the obstetricians collaborate well and that they make sure that all pregnant women receive the right amount of care and cure. Secondly, the percentage of low-risk pregnant women that is referred from the hospitals to the midwifery practices will decrease to 0, because

there is no need to send these pregnant women to the midwifery practices, for as there are midwives in the hospital who can perfectly take care of these low-risk pregnant women.

Results 1

The results are shown in Figure 2 through Figure 4. The black line represents the base case and the blue line the scenario modeled.



Firstly, the percentage pregnant women with a high-risk pregnancy decreases (Figure 2). This is the result from the increase in quality of care in the hospital, which results in a decrease in the percentage of low-risk pregnant women in the hospital that develop a high-risk pregnancy. The maximum and delivered quality of care in the midwifery practice hardly has any effect in this.

Secondly, the percentage of high-risk pregnant women that receives care from the wrong organization increases (Figure 3). This is the result of the fact that the percentage high-risk pregnant women that is being referred from the midwifery practices to hospitals decreases, because the trust midwives have in hospitals decrease because hospitals are not referring low-risk pregnant women to the midwifery practices.

Thirdly, the costs of the improved hospital model are lower than the costs is the base case (Figure 4). This is the result of the fact that the total number of pregnant women in the hospital decreases (because midwifery practices do not refer high-risk pregnant women any more) and to the fact that because there are less high-risk pregnant women in the hospital due to increased quality, there are less consultations to do. The reduction in staff and costs in the hospital is higher than the increase in capacity and costs in the midwifery practice.

5.2 Scenario 2: Collaborative model

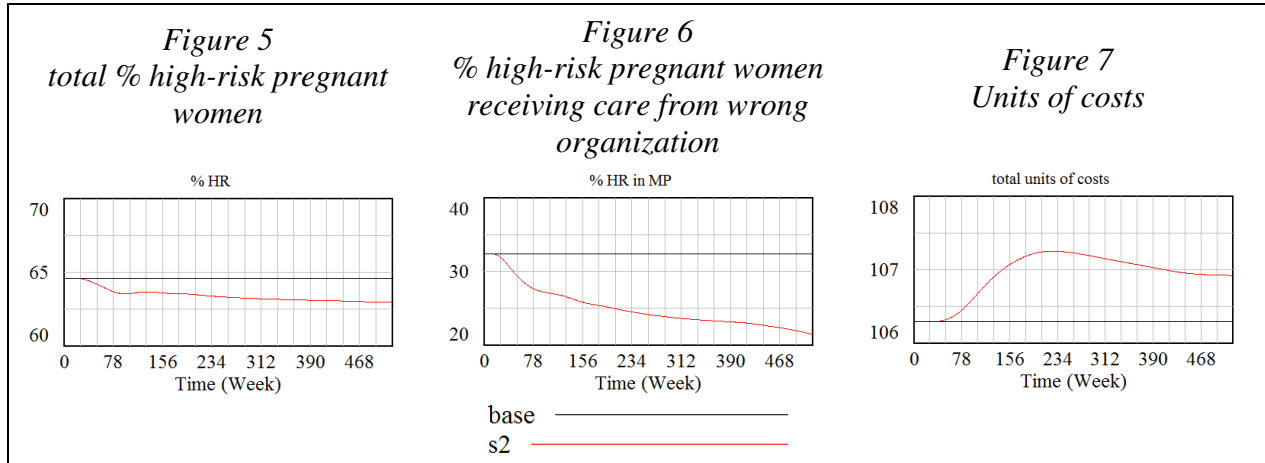
Description 2

On $t=10$ there is an increase in collaboration. The project takes 52 weeks and the goal of the new level of collaboration is 0.8 (out of 1) (the current level is 0.4). The degree to which the

collaboration is voluntarily is 0.8 (out of 1). This means that there are hardly any sanctions if one or more of the organizations do not act according to what is agreed upon.

Results 2

The results are shown in Figure 5 through Figure 7. The black line represents the base case and the red line the scenario modeled. Note: a collaboration of 0.8 is never reached because of the duration of the project and the adjustment time of collaboration (the level of collaboration after the project is 0.75).



Firstly, the percentage of high-risk pregnant women decreases (Figure 5). Due to the increase in collaboration, the delivered quality of care increases, which makes less pregnant women develop a high-risk pregnancy, both in the midwifery practices and in the hospitals.

Secondly, the percentage of high-risk pregnant women that is being cared for by the wrong organization decreases (Figure 6). Due to collaboration, the percentage of high-risk pregnant women that will be referred from midwifery practices to hospitals increases. This effect is enhanced by the reinforcing trust-loop (feedback loop R1).

Thirdly, the costs remain about the same (Figure 7). There is a decrease in pregnant women being cared for in the midwifery practices, and an increase in the number of pregnant women being cared for by the hospital. As a result, the number of midwives decreases and the number of obstetricians increases. Even though hospital capacity is more expensive than midwifery practice capacity, the net result on costs is about zero compared to the base case.

5.3 Scenario 3: 10% Integrated care model

Description 3

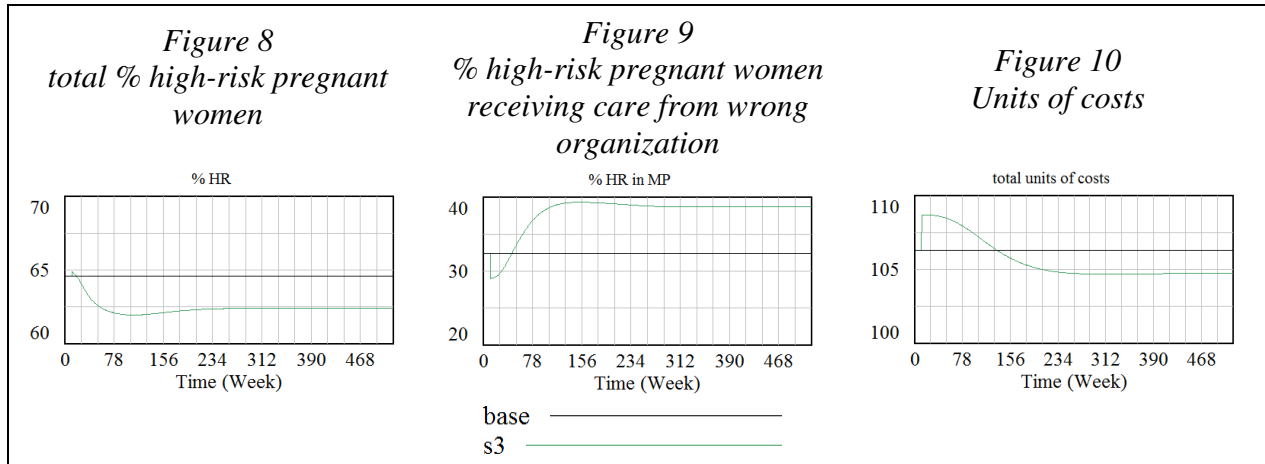
On $t=10$ four changes are made. Firstly, 10% of all pregnant women that are being cared for in midwifery practices will be transferred to the hospital. Secondly, 10% of all staff from the midwifery practices will be transferred to the hospital. Thirdly, the maximum quality of care in the hospital will increase to 1. When midwives are added to a hospital, the lack of care

competences from the obstetricians will be compensated by the care competences from the added midwives. It is assumed that the new midwives and the obstetricians collaborate well and that they make sure that all pregnant women receive the right amount of care and cure. And finally, the percentage of low-risk pregnant women that is being referred from hospitals to midwifery practices decreases to 0%, because there is no need to send these pregnant women to the midwifery practices, for as there are midwives in the hospital who can perfectly take care of these low-risk pregnant women.

A scenario is chosen of 10% integrated care. In the Netherlands, in practice, in some cities, such as Nieuwegein, one or two midwifery practices in a region have integrated with a hospital. A higher percentage of integration is in practice not realistic yet.

Results 3

The results are shown in Figure 8 through Figure 10. The black line represents the base case and the green line the scenario modeled.



The first outcome variable, the percentage of pregnant women with a high-risk pregnancy, decreases and stabilizes to a point lower than in the base case (Figure 8). Overall, the decrease in percentage of total high-risk pregnant women is caused by the fact that the integrated organization is able to provide care as well as cure to all pregnant women.

The second outcome variable, the percentage of high-risk pregnant women that receives care from the wrong organization/professional (Figure 9), increases because midwifery practices have less trust in hospitals for as they are taken care of more and more low-risk pregnant women. As a result midwifery practices refer less high-risk pregnant women to hospitals. The sharp decrease at $t=10$ is caused by the introduction of the new system and the sudden move of pregnant women and staff at $t=10$ from midwifery practices to hospitals. After this sudden move, the dynamics of the system take over and a new equilibrium is found.

Thirdly, the costs of the system increase at first but decrease later compared to the base case (Figure 10). The costs go up because in the beginning, hospitals have more staff because of the added midwives. After a while, however, the effects of the integrated care organization

become visible and because of the higher performance (less high-risk pregnant women) capacity in the integrated care organization can be brought down. The capacity in midwifery practices increases under this scenario, but the higher costs in the midwifery practices do not outweigh the lower costs in the integrated care organization. It is assumed that the costs of midwives in the integrated care facility will be the same as for obstetricians.

5.4 Scenario 4: Improved hospital + model

Description 4

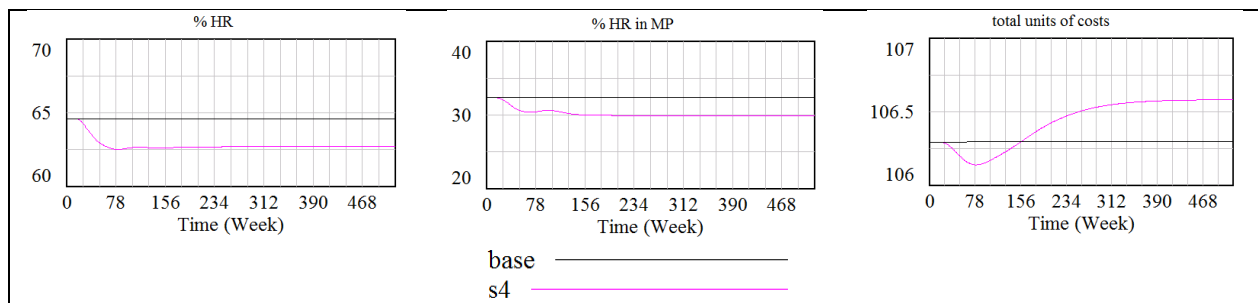
In line with the improved hospital model, on t=10 the maximum quality of care in the hospital will increase to 1. When midwives are added to a hospital, the lack of care competences from the obstetricians will be compensated by the care competences from the added midwives. It is assumed that the new midwives and the obstetricians collaborate well and that they make sure that all pregnant women receive the right amount of care and cure. However, because the objective of this scenario also is to increase collaboration between midwifery practices and hospitals, the percentage of low-risk pregnant women that is referred from the hospitals to the midwifery practices will not decrease to 0. In theory, the extra midwives in the hospital are employed to improve the quality of care that hospitals deliver to high-risk pregnant women, for as they need both cure from obstetricians and care from midwives and therefore it will be agreed upon that obstetricians will refer low-risk pregnant women to midwifery practices as the dynamics of the system dictate.

In line with the collaborative model, on t=10 there is an increase in the collaboration. The project takes 52 weeks and the goal of the new level of collaboration is 0.8 (out of 1). The degree to which the collaboration is voluntarily is 0.8 (out of 1). This implies that there are hardly any sanctions if one of the organizations does not act according to what is agreed upon. The only difference with the collaborative model is that the hospitals won't outsource consultations to midwifery practices, for as they have their own midwives employed.

Results 4

The results are shown in Figure 11 through Figure 13. The black line represents the base case and the pink line the scenario modeled.

<i>Figure 11</i> <i>total % high-risk pregnant women</i>	<i>Figure 12</i> <i>% high-risk pregnant women receiving care from wrong organization</i>	<i>Figure 13</i> <i>units of costs</i>
---	--	---



Firstly, the percentage of pregnant women with a high-risk pregnancy decreases (Figure 11). The maximum quality of care in the hospital increases due to the added midwives. As a result, less low-risk pregnant women in the hospital will develop a high-risk pregnancy. In addition, due to the increase in collaboration, the delivered quality of care of both the midwifery practices and the hospitals increase, both with the result that less low-risk pregnant women will develop a high-risk pregnancy.

Secondly, the percentage high-risk pregnant women that receive care from the wrong organization decreases (Figure 12). Due to the increase in collaboration, the percentage of pregnant women that is referred between the two types of organization increases, which results in a higher trust and in more appropriate referrals (trust-loop). For example, the percentage of low-risk pregnant women that is being referred from hospitals to midwifery practices increases from about 5% till about 15%.

Thirdly, the total costs remain about the same (Figure 13). The number of midwives; the number of high-risk pregnant women in the midwifery practices decreases, but the number of low-risk pregnant women in midwifery practices increases with about the same number. The number of obstetricians remains the same; the number of low-risk and high-risk pregnant women in the hospital both stay about the same.

5.5 Scenario 5: Integrated care + model

Description 5

In this scenario, 20% of the midwifery practices will integrate with the hospitals. 20% integration is chosen because in Tilburg about 20% of the midwifery practices integrated with the hospitals and in addition, a project is conducted to improve collaboration with the midwifery practices.

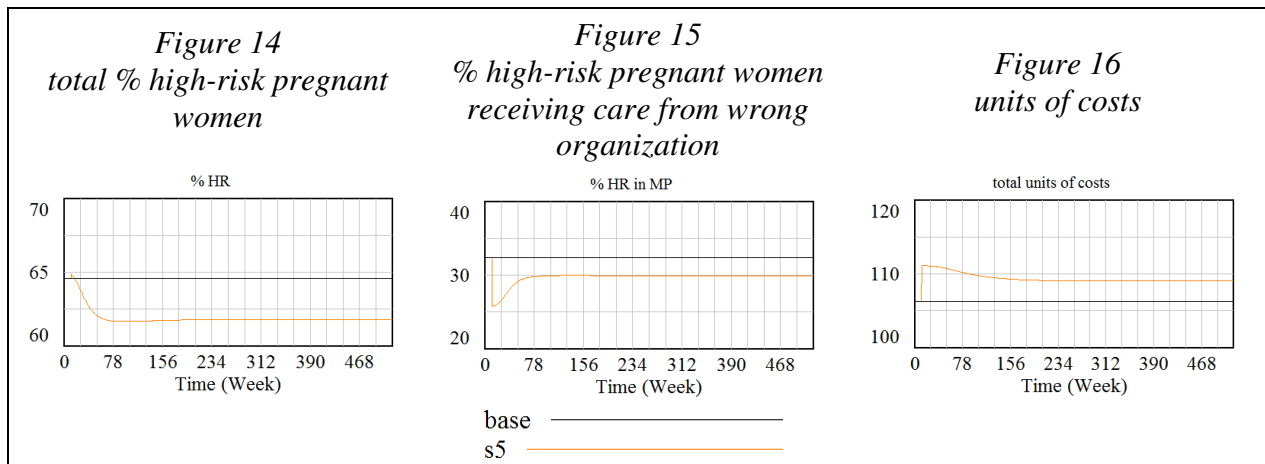
In line with the integrated care model, on $t=10$ three changes are made. Firstly, 20% of all pregnant women that are being cared for in midwifery practices will be transferred to the hospital. Secondly, 20% of the staff from the midwifery practices will be transferred to the hospital. And thirdly, the maximum quality of care in the hospital will increase to 1. When midwives are added to a hospital, the lack of care competences from the obstetricians will be compensated by the care competences from the added midwives. It is assumed that the new midwives and the obstetricians collaborate well and that they make sure that all pregnant women receive the right amount of care and cure. However, because the objective of this scenario also is

to increase collaboration between the independent midwifery practices and hospitals, the percentage of low-risk pregnant women that is referred from the hospitals to the midwifery practices will not decrease to 0. Note that the referral percentage from hospitals to midwifery practices does not decrease to 0, but is – in line with the collaborative model – subject to the dynamics of the system.

In line with the collaborative model, on $t=10$ there is an increase in the collaboration with the independent midwifery practices. The project takes 52 weeks and the goal of the new level of collaboration is 0.8 (out of 1). The degree to which the collaboration is voluntarily is 0.8 (out of 1). This means that there are hardly any sanctions if one of the organizations does not act according to what is agreed upon. The only difference with the collaborative model is that the hospitals won't outsource consultations to midwifery practices, for as they have their own midwives employed.

Results 5

The results are shown in Figure 14 through Figure 16. The black line represents the base case and the orange line the scenario modeled.



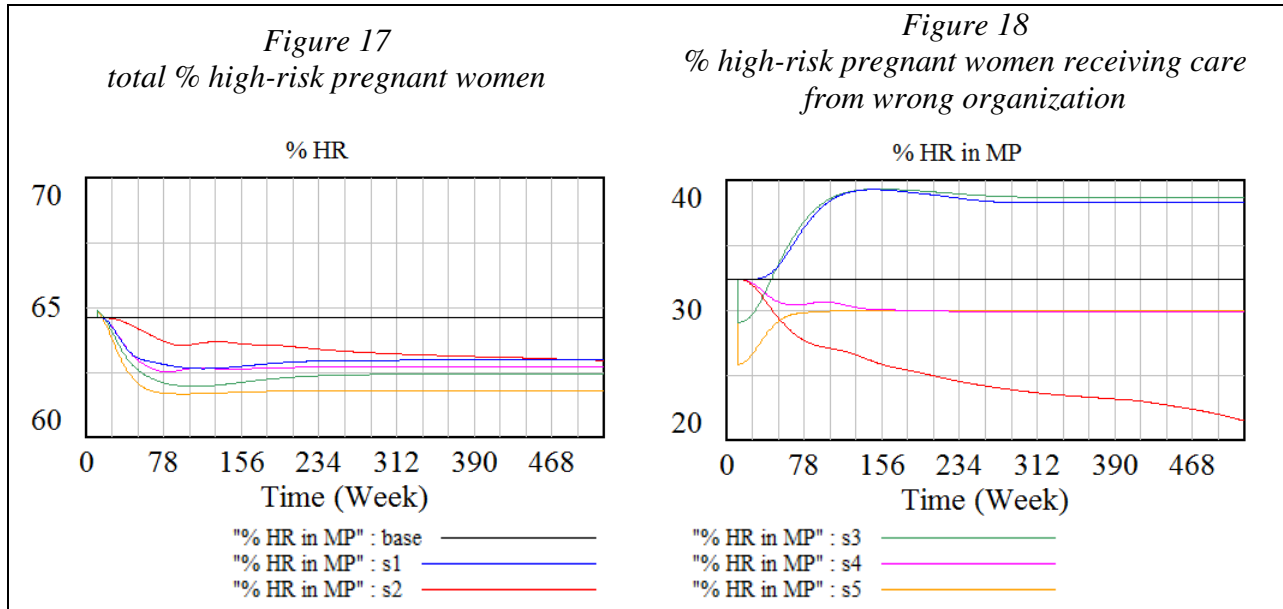
Firstly, regarding the percentage of high-risk pregnant women in the system. This number lowers because more pregnant women are being taken care of in the integrated care organization, where the maximum quality of care that can be delivered equals 1. In addition, because of the improved collaboration, the quality of care that midwifery practices can deliver improves slightly.

Secondly, regarding the percentage of high-risk pregnant women that is being taken care of by the wrong organization, the sharp decrease at $t=10$ is caused by the introduction of the new system and the sudden move of pregnant women and staff at $t=10$ from midwifery practices to hospitals. After this sudden move, the dynamics of the system take over and a new equilibrium is found. This percentage is less than in the base case because due to collaboration the referral rates between organizations increase, resulting in more trust and more pregnant women being taken care of in the right organization.

Thirdly, the total costs increase due to the fact that midwives move from midwifery practices to hospitals and the costs for a midwife in a hospital equals that of an obstetrician.

5.6 Summary of the results

This paper presents five alternative scenarios about how one might organize Dutch perinatal care; the improved hospital model, the collaborative model, the integrated care model, the improved hospital + model, and the integrated care + model. The different scenarios will be judged based on their performance on the total percentage of high-risk pregnant women in the system (effectivity) and by the percentage of high-risk pregnant women receiving care from the wrong organization, i.e. midwifery practices (efficiency). However, in our opinion, efficiency is more important than effectivity, for as having high-risk pregnant women receiving care from the wrong organization results in last-minute panic actions by midwives and obstetricians and thus in poor outcomes regarding wellbeing and in poor outcomes regarding satisfaction. The total percentage of high-risk pregnant women is monitored because one would want to monitor this percentage to know how the system is performing overall. In line with this the desired order of the scenarios is the following: 1. collaborative model, 2. 20%integrated care + model, 3. improved hospital + model, 4. 10% integrated care model, and 5. the improved hospital model.



Sensitivity analyses are conducted in order to investigate if the mutual order of the scenarios will change when changing assumptions made in the scenarios or in the model. Note that when an assumption is changed, it is changed for all scenarios, and note that no two assumptions are changed at the same time.

Table 3 presents an overview of how the mutual order changes when assumptions in the scenarios change.

Table 3 Mutual order of the scenarios

SA	description	scenario 1: improved hospital model	scenario 2: collaborative model	scenario 3: 10% integrated care model	scenario 4: improved hospital + model	scenario 5: 20% integrated care + model
----	scenarios as defined	3	1	3	2	2
6-1	max QoC _H of 0.9 (instead of 1)	4	1	5	2	3
6-2	voluntariness of CO of 0.25 (instead of 0.8)	2	1	2	1	1
6-3	intended level of CO of 0.6 (instead of 0.8)	4	1	4	3	2
6-4	percentage of integration of 60% (instead of 10% or 20%)	5	2	3	4	1

In general, this shows us that scenario 2, the collaborative model, when focusing on the mutual order, is the most stable one and that scenario 1, the improved hospital model, performs the worst. See for more detailed information the model documentation.

Note that, even though some reinforcing loops might be dominant, none of the scenarios keeps getting better or worse. This is due to boundary conditions set in the model. For example, the soft variables such as collaboration, trust and quality of care are all defined on a 0-1 scale. In addition, the existence of boundary conditions corresponds to reality. Due to the conditions that pregnancy is, it will never occur that all pregnant women will develop a high-risk pregnancy, or that all pregnant women will have a low-risk pregnancy.

6. Conclusion

6.1 Research limitations

Five limitations will be discussed here. The first focuses on the type of model chosen – a quantitative system dynamic model. The other focus on assumptions made in the model itself.

Firstly, health care is beset with problems of uncertainty, largely arising from the need to deal with human beings and their frailties in the context of medical opinion on appropriate regimes of treatment, and therefore it might be best to only use qualitative modeling (Coyle, 2000). Regardless, a quantitative model is made in this research. A qualitative model only will give us insight into the particular dynamics of different organizational structures for perinatal care. However, just because the care process and the behavior of the actors involved are so complicated and full of feedback loops, it is hard to tell, based on a qualitative model alone,

when which of the scenarios described would be the most favorable. The quantitative model designed definitely has some soft variables, such as quality of care, collaboration and trust, with all the flaws involved in that (Coyle, 2000). Still, although all models are wrong (Sterman, 2002), a quantitative model has its strengths, as long as one realizes that it will not present a definite answer to the research question: it allows one to play with assumptions and test different scenarios and it will present more insight into the problem in question than a pure qualitative model would do.

Secondly, regarding the behavior of pregnant women, the model assumes that their behavior does not change because of the quality of care that the different organizations deliver. One might argue that pregnant women might be attracted to the type of organization with the highest quality of care. However, due to the two-tiered structure in Dutch perinatal care, it is more or less prescribed that pregnant women presents themselves to the lowest type of care possible, i.e. midwifery practices in primary care. The high-risk pregnant women that present themselves to midwifery practices often don't know they have a high risk, and the low-risk pregnant women that deliver themselves to the hospitals don't present themselves "out of the blue", they already have a history with the obstetric department. The behavior of how pregnant women present themselves to the organizations is therefore independent of the quality of care that the organizations actually deliver. And yes, pregnant women might present themselves to a different provider within a category (to a different midwifery practice or to a different hospital in the region), but the scope of this model (inter-organizational dynamics between types of care providers) does not allow for modeling individual midwifery practices and individual hospitals in a region.

Thirdly, one might argue that dynamics within organizations are of importance. For example the collaboration between midwives and obstetricians working in the hospital might have an effect on the quality of care that is delivered. However, the scope of the model is the inter-organizational level; we are interested in the dynamics between organizations and its effect on outcome. Modeling the dynamics within an organization or department is therefore too detailed.

This model assumes a certain health care system. The health care system in the Netherlands hardly knows any competition in terms of quality or effectiveness. In addition, insurance companies hardly have any say in which type of care gets refunded. The model might be different for systems where insurance companies have a greater influence in the actual delivery of care.

6.2 Research recommendations

Recommendations for Dutch perinatal care

The perspective taken in this research is that of improving the perinatal care system as a whole, in contrast to improving performance of a single type of organizations. As such, for Dutch perinatal care, which has currently the structure of a two-tiered focused factory, the best thing to

do is to implement the collaborative model, i.e. to improve collaboration between independent midwifery practices and obstetric departments in hospitals. Basically, regardless of the settings of this scenario (intended level, duration of the project, and voluntariness of collaboration), it will always result in improved performance.

In case a hospital chooses for an improved hospital model, the total % of high-risk pregnant women decreases, but the percentage of high-risk pregnant women that is being taken care of in the wrong organization (midwifery practices) increases. As such, total performance of the system decreases. The improved hospital model can increase performance, but only when the collaboration with the midwifery practices is increased substantially (scenario 4). Increasing collaboration just slightly still worsens the performance. Thus improving collaboration as “window-dressing” doesn’t improve the system compared to the current situation.

When a hospital and one or two midwifery practices decide to integrate, the performance in the system as a whole worsens. Increasing the percentage of midwifery practices that integrate makes performance better, as well as improving collaboration with the independent midwifery practices substantially. Here also, just improving collaboration slightly still has a negative effect compared to the current situation.

Note that the model is intended to deal with the dynamics of inter-organizational collaboration and competition in a tiered system. The model as presented in this paper shows the effects of improvements that are currently being implemented. As such the scenario of 100% integrated care is not modeled, for as then there is no inter-organizational setting any more. However, that doesn’t imply that we still feel that integrated care would be the best way forward.

Recommendations for perinatal care systems

For perinatal care systems which are build on the medical model and which are thinking about moving towards a more midwifery model, we would advise to be careful with introducing independent midwifery practices. Having independent midwifery practices only works well when there are high levels of collaboration and trust with the cure providers, i.e. obstetric departments in hospitals. Otherwise, feelings of competition will dominate and pregnant women will receive less optimal care.

Recommendations to health care system in general

When improving care processes for care/cure conditions it is recommended to investigate in detail the dynamics of the collaboration between the care providers. The findings from the Dutch perinatal care cannot be projected one-on-one to other conditions or systems. Some examples. In Dutch perinatal care, obstetric departments are able to take care of low-risk pregnant women, which results in competition between care and cure providers (respectively midwifery practices and obstetric departments). With other conditions, it might not be possible for the cure providers to also take care of the patients when needing only care. As a result, one organization might not have to fear the other organizations stealing patients. In addition, the care process for pregnant women encompasses 8 months. This affects professional behavior; when high-risk pregnant women develop a low-risk pregnancy later in the pregnancy, obstetricians are often reluctant to

refer them to midwifery practices for as they have been taking care for those women for already 6 months or so. Why change the continuity of caregiver for the last 2 months? For chronic diseases this referring behavior might be different.

Our recommendation to health care in general is to study the dynamics of the collaboration in relation to the condition specific characteristics in detail before deciding what organizational model might work best.

References

Achterberg, P. W. Met de besten vergelijkbaar? Internationale verschillen in sterfte rond geboorte. Bilthoven: RIVM, 2005.

Advies Stuurgroep Zwangerschap en Geboorte. Een goed begin. Veilige zorg rond zwangerschap en geboorte. Utrecht, 2009.

Amelink-Verburg, M. P., & Buitendijk, S. E. Pregnancy and Labour in the Dutch Maternity Care System: What Is Normal? The Role Division Between Midwives and Obstetricians. *Journal of Midwifery & Women's Health* 55 (2010): 216-225.

Amelink-Verburg, M. P., Verloove-Vanhorick, S. P., Hakkenberg, R. M. A., Veldhuijzen, I. M. E., Bennebroek Gravenhors, J., & Buitendijk, S. E. Evaluation of 280 000 cases in Dutch midwifery practices: a descriptive study. *BJOG An International Journal of Obstetrics and Gynaecology*, 115 (2007): 570-578.

Anthony, S., Amelink-Verburg, M. P., Jacobusse, G. W., & Van der Pal-de Bruin, K. M. De Thuisbevalling in Nederland 1995-2002 Rapportage over de jaren. Bilthoven: Stichting Perinatale Registratie Nederland, 2005.

Bais, J. M. J., Eskes, M., & Bonsel, G. J. Dutch perinatal mortality: high rates can be explained? Influence of population- and policy-related factors on perinatal mortality in a complete regional cohort (1990-1995). *Nederlands Tijdschrift Voor Geneeskunde*, 148 (2004): 1873-1878.

Bellanger, M. M., & Or, Z. What we can learn from a cross-country comparison of the costs of child delivery? *Health Economics*, 17 (2008): 47-57.

Boesveld-Haitjema, I. C., Waelput, A. J. M., Eskes, M., & Wieggers, T. A. Verloskundige samenwerkingsverbanden in Nederland: stand van zaken. *Nederlands Tijdschrift voor Obstetrie & Gynaecologie*, 121 (2008): 25-29.

Bradley, P. J., & Bray, K. H. The Netherlands' maternal-child health program: implications for the United States. *Journal of Obstetric, Gynecologic, and neonatal nursing*, 25(1996): 471-475.

Buitendijk, S. E., Zeitlin, J., Cuttini, M., Langhoff-Roos, J., & Bottu, J. Indicators of fetal and infant health outcomes. *European Journal of Obstetrics & Gynecology and Reproductive Biology*, 111 (2003): 66-77.

Christiaens, W., Gouwy, A., & Bracke, P. Does a referral from home to hospital affect satisfaction with childbirth? A cross-national comparison. *BMC Health Services Research*, 9 (2007): 1-9.

Coyle, G. Qualitative and quantitative modelling in system dynamics : some research questions. *System Dynamics Review*, 16 (2000): 225-244.

Davis, J. P., Eisenhardt, K. M., & Bingham, C. B. Developing theory through simulation methods. *Academy of Management Review*, 32 (2007): 480-499.

De Graaf, J. P., Ravelli, A. C. J., Visser, G. H. A., Hukkelhoven, C., Tong, W. H., Bonsel, G. J., & Steegers, E. A. P. Increased adverse perinatal outcome of hospital delivery at night. *BJOG An International Journal of Obstetrics and Gynaecology*, 117 (2010): 1098-1107.

De Jonge, A., Van Der Goes, B. Y., Ravelli, A. C. J., Amelink-verburg, M. P., Mol, B. W., Nijhuis, J. G., Bennebroek Gravenhorst, J., et al. Perinatal mortality and morbidity in a nationwide cohort of 529 688 low-risk planned home and hospital births. *BJOG: An International Journal of Obstetrics & Gynaecology*, (2009): 1-8.

De Veer, A. J. E., & Meijer, W. J. Obstetric care: competition or co-operation. *Midwifery*, 12 (1996): 4-10.

De Vries, R., Wiegers, T. A., Smulders, B., & Van Teijlingen, E. The Dutch obstretical system. Vanguard of the future in maternity care. In *Birth models that work*, edited by R. E. Davis-Floyd, L. Barclay, B. Daviss, & J. Tritten, 31-53. Berkeley: University of California Press, 2009.

EURO-PERISTAT. European perinatal health report. Health (San Francisco). <http://www.europeristat.com/publications/scientific-publications/index.shtml> (2008), visited on Feb 10th 2011.

Evers, A. C. C., Brouwers, H. A. A., Hukkelhoven, C. W. P. M., Nikkels, P. G. J., Boon, J., Van Egmond-Linden, A., Hillegersberg, J., et al. Perinatal mortality and severe morbidity in low and

high risk term pregnancies in the Netherlands: prospective cohort study. *British Medical Journal*, (2010): 1-8.

Forrester, J. W. *Industrial Dynamics*. Cambridge, MA: MIT Press, 1961.

Forrester, J. W. Information sourced for modeling the national economy. *Journal of the American Statistical Association*, 75 (1980): 555-566.

Goodman, S. Piercing the veil: the marginalization of midwives in the United States. *Social Science & Medicine*, 65 (2007): 610-621.

Größler, A., Thun, J.-H., & Milling, P. M. System dynamics as a structural theory in operations management. *Production and Operations Management*, 17 (2008): 373-384.

Heineman, M. J., Bleker, O. P., Evers, J. L. H., & Heintz, A. P. M. *Obstetrie en gynaecologie. De voortplaning van de mens*. Maarsen: Elsevier/Bunge, 2004.

Herzlinger, R. *Market-driven health care. Who wins, who loses in the transformation of America's largest service industry*, Assision-Wesley Publishing Compagny, Inc., New York, 1997.

Herzlinger, R. (Ed.), *Consumer-driven health care. Implications for providers, payers, and policymakers*, Jossey-Bass, San Fransisco, 2004.

Hingstman, L., & Kenens, R. J. *Cijfers uit de registratie van verloskundigen*. Utrecht: NIVEL, 2009.

Johnson, T. R., Callister, L. C., Freeborn, D. S., Beckstrand, R. L., & Huender, K. Dutch women's perceptions of Childbirth in the Netherlands. *The American Journal of Maternal/Child Nursing*, 32 (2007): 170-177.

Kwee, A., Elferink-Stinkens, P. M., Reuwer, P. J. H. M., & Bruinse, H. W. Trends in obstetric interventions in the Dutch obstetrical care system in the period 1993 – 2002. *European Journal of Obstetrics & Gynecology and Reproductive Biology*, 132 (2007): 70-75.

Leape. L.L., Bates, D.W., Cullen, D.J., Cooper, J., Demonaco, H.J., Gallivan, T., Hallisey, R., Ives, J., Laird, N., Laffel G. et al. Systems analysis of adverse drug events. *Journal of American Medical Association*, 274 (1995): 35-43.

Lewin, K. *Resolving Social Conflicts*. New York: Free Press, 1948.

Mander, R. The relevance of the Dutch system of maternity care to the United Kingdom. *Journal of Advanced Nursing*, 22 (1995), 1023-1026.

McGlynn, E.A.S., Adams, J., Hicks, J., DeCristofaro, A. and Kerr, E.A. The quality of health care delivered to adults in the United States. *New England Journal of Medicine*, 348 (2003): 2635-2645.

Meredith, J. R. Building operations management theory through case and field research. *Journal of Operations Management*, 16 (1998): 441-454.

Meuwissen, J. H. J. M. Nederlandse verloskunde op een tweesprong. *Medisch Contact*, 17 (1979): 548-549.

Mohangoo, A. D., Buitendijk, S. E., Hukkelhoven, C. W., Ravelli, A. C., & Rijninks-Van Driel, G. C. Higher perinatal mortality in The Netherlands than in other European countries: the Peristat-II study. *Nederlands Tijdschrift voor Geneeskunde*, 152 (2008), 2718-2727.

NRC (2009), "Vrouw niet alleen laten bij de bevalling. Advies wil babysterfte halveren" *NCR Handelsblad*, December 30 2009

Oppenheimer, C. Organising midwifery led care in the Netherlands. *British Medical Journal*, 307 (1993): 1400-1402.

Organization for Economic Co-operation and Development (OECD). (2011). OECD health data 2010. Retrieved from <http://stats.oecd.org/index.aspx?queryid=24862>. Accessed on May 15, 2011.

Pieters, A. J. H. M., Akkermans, H., & Franx, A. E pluribus unum: using group model building with many interdependent organizations to create integrated health-care networks. In *Organization Development in Healthcare: Conversations on Research and Strategies*, 321-344. Bingley: Emerald, 2010.

Pieters, A. J. H. M., Van Oirschot, C., & Akkermans, H. No cure for all evils. Dutch obstetric care and limits to the applicability of the focused factory concept in health care. *International Journal of Operations & Production Management*, 30 (2010): 1112-1139.

QuickStats. Rates of cesarean deliveries – selected countries. *Birth*, 35 (2005): 336-337.

Repenning, N. P. A simulation-based approach to understanding the dynamics of innovation implementation. *Organization Science*, 13 (2002): 109-127.

Reuwer, P. J. H. M. Bel de ambulance maar. Reportage thuisbevallen in Nederland. *De Volkskrant*, May 30 2008.

Reuwer, P. J. H. M., Bruinse, H. W., & Franx, A. Pro-active support of labour. London: Cambridge University Press, 2009.

Rijnders, M., Baston, H., Schonbeck, Y., Pal, K. V. D., Prins, M., Green, J., & Buitendijk, S. Perinatal Factors Related to Negative or Positive Recall of Birth Experience in Women 3 Years Postpartum in the Netherlands. *Birth*, 35 (2008): 107-116.

Sakala, C., & Corry, M. P. Evidence-Based Maternity Care: What it is and What it can Achieve. New York: Milbank Memorial Fund, 2008.

Schein, E. H. The Clinical Perspective in Fieldwork. Newbury Park: Sage Publications, 1987.

Schutte, J. M., Schuitemaker, N. W. E., Van Roosmalen, J., & Steegers, E. A. P. Substandard care in maternal mortality due to hypertensive disease in pregnancy in the Netherlands. *BJOG An International Journal of Obstetrics and Gynaecology*, 115 (2008): 732-736.

Schwaninger, M., & Grösser, S. System dynamics as model-based theory building. *Systems Research and Behavioral Science*, 25 (2008): 447-465.

Skinner, W. The focused factory. *Harvard Business Review*, 52 (1974): 113-121.

Slobbe, L. C. J., Smit, J. M., Groen, J., Poos, M. J. J. C., & Kommer, G. J. Trends in Cost of Illness in the Netherlands 1999-2010. Bilthoven: RIVM, 2011.

Steegers, E. A. No Plasma volume expansion and delaying delivery in pre-eclampsia. *BJOG: An International Journal of Obstetrics & Gynaecology*, 112 (2005): 1337-1338.

Sterman, J. D. Systems thinking and modeling for a complex world. Management. Boston: Irwin McGraw-Hill, 2000.

Sterman, J. D. All models are wrong: reflections on becoming a systems scientist. *System Dynamics Review*, 18 (2002): 501-531.

Structuurnota Gezondheidszorg. Structuurnota Gezondheidszorg. The Hague: Staatsuitgeverij, 1974.

Van der Velden, L. F. J., Bennema-Broos, M., & Hingstman, L. Monitor arbeidsmarkt obstetrici/gynaecologen, behoefteeraming 2001-2015. Utrecht: NIVEL, 2001.

Visser, G. H. A., & Steegers, E. A. P. Beter Baren. Nieuwe keuzen nodig in de zorg voor zwangeren. *Medisch Contact*, 63 (2008): 96-100.

Voss, C., Tsiriktsis, N., & Frohlich, M. Case research in operations management. *International Journal of Operations & Production Management*, 22 (2002): 195-219.

Wagner, M. Born in the USA. How a broken maternity system must be fixed to put women and children first. Berkeley: University of California Press, 2006.

Wiegers, T. A. The quality of maternity care services as experienced by women in the Netherlands. *BMC Pregnancy and Childbirth*, 9 (2009): 1-8.

Wiegers, T. A., & Hukkelhoven, C. W. P. M. The role of hospital midwives in the Netherlands. *BMC pregnancy and childbirth*, 10 (2010).

Young, D. Home birth in the United States: Action and reaction. *Birth*, 35 (2008): 263-265.

Zwart, J. J., Donkers, M. D., Richters, A., Ory, F., Bloemenkamp, K. W. M., Duvekot, J. J., & Van Roosmalen, J. Ethnic disparity in severe acute maternal morbidity: a nationwide cohort study in the Netherlands. *European Journal of Public Health*, 21 (2011): 229-234.

Zwart, J. J., Richters, J. M., Ory, F., De Vries, J. I. P., Bloemenkamp, K. W. M., & Van Roosmalen, J. Severe maternal morbidity during pregnancy, delivery and puerperium in the Netherlands: a nationwide population-based study of 371 000 pregnancies. *BJOG An International Journal of Obstetrics and Gynaecology*, 115 (2008): 842-850.