PROJECT NEO GEO REPORT: 1

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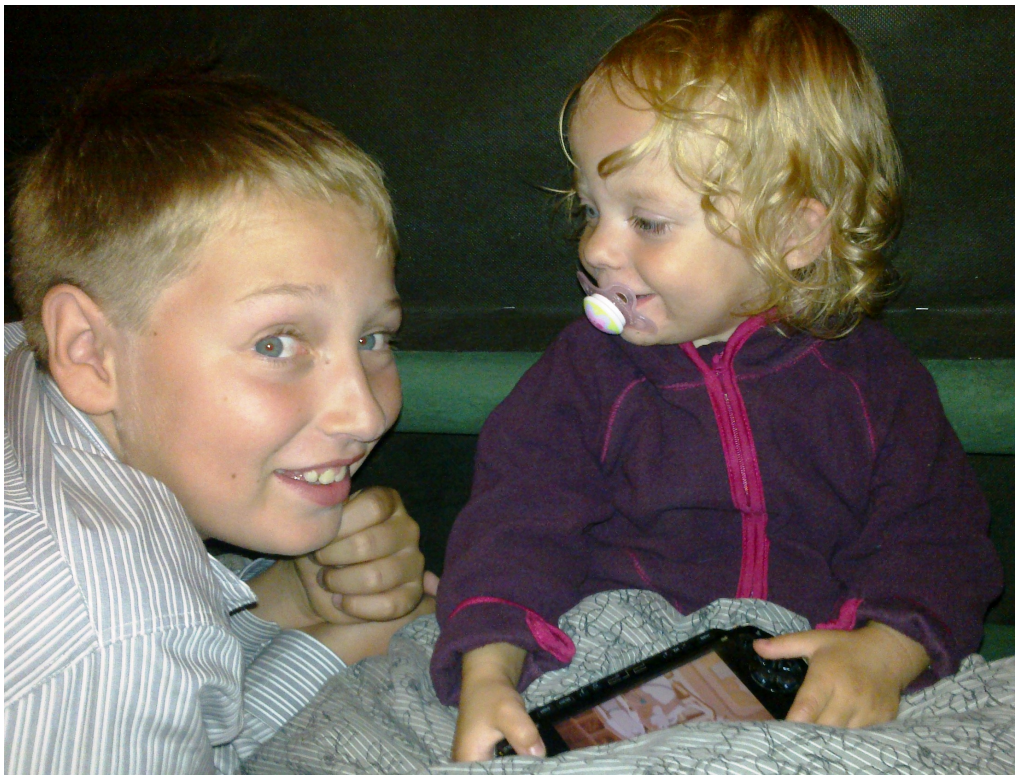
Trauma patients and distance to hospital:

A study towards a common tool for European wide harmonized policy making and knowledge sharing



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Foreword

One stormy and rainy autumn night in September 2009 a lot of thoughts flashed through my mind, as I was driving as fast as possible to the Newborn Intensive Care Unit at the hospital in Oslo. I had just got a short message saying; “it will be helicopter”. Would the baby and mother survive?

I was thinking back to the birth of my son, nine years earlier, trying to calm down, and thinking how it all turned out well, afterward. He was born 2-3 weeks on overtime, so he was very much expected. This time delivery was 14 weeks too early. I knew nothing about premature babies; their survival rates and how their health will be if they grow up.

I remembered the feeling of helplessness when my son was about to be delivered, standing beside and not being able to do anything, except trying to comfort and calm the mother to be. Delivery lasted for almost 24 hours, although we had been sent with ambulance all the long way to the hospital. Suddenly the delivery room was crowded with health personnel. Several attempts to get blood samples from the head of the fetus had been done, but they were not able to measure the oxygen levels from them. Then heart beat rhythm fell dramatically, and I was shuffled away to a remote small room, waiting for the results of an acute caesarian operation. The room was closed, with no windows, no people, no telephone, and it looked like a mixture of a storage room for cleaners and paper archive. Several hours later, one off the youngest nurses came in with a big baby. “The mother is all right”, she said, and I looked at the baby and cried of joy. The baby boy had a big black eye and his head started floating over the scales, he weighed almost 4.8 kilos. Now, almost twelve years later, he seems to become a healthy and bright young man. But that was not obvious right after his birth.

Like in more than half of the cases with premature births, there had been no early warnings or signs, at least not to our knowledge. When I thought back I was thinking that babies are much stronger than we think, and that the health personnel and equipment are much better today, than just one or two decades ago. But why had they closed down the local maternity hospital, where my son could have been born and the mother followed up, and why did it take hours before it became clear that the birth of our daughter was underway?

I arrived to the hospital shortly after the helicopter, as the helicopter could not go all the way due to the bad weather. A lot of checks were made by the health personnel, and we were told that delivery was now postponed by for 24 to 48 hours. All seemed to be fine with the mother and fetus they said. I should have listened to the midwife that, contradictory to the doctors, said that I should stay at the hospitals hotel. But my mind was occupied with getting clothes for a longer stay, and that my son back home was alright, until my parents could look after him. I missed the birth of our daughter with less than ten minutes, and I felt very guilty not having been there.

The coming days and weeks after the birth of Caroline a lot of questions arouse. Will she survive; will she be fine, and what signs should we look after? We had more questions than answers, and as we later discovered; there was no certain single answer, as the answers where often different, depending on whom we asked.

Although very different stories; the birth of and following up of Daniel and Caroline has a lot of parallels. They were both born under traumatic circumstances, far from

the local hospital, with little or no possibility for backing up from friends and family. Information given to us as parents, as the ones responsible for the long term following and resource persons, where scarce, contradictory and sometimes very hard to get. Why is it so?

This report aims at answering only a few of these questions, first and foremost through a literature study on the relationship between distance between trauma patients and the hospital, but also feasibility study on how to measure and monitor this in a European context.

This report is dedicated to my beloved daughter and son, Caroline and Daniel (front page picture}.

Vilni Verner Holst Bloch

Kongsvinger 2012-10-17

About the contributors

Vilni Verner Holst Bloch has a MSc in resource geography and landscape ecology. Vilni first started as a coordinator of activities within the field of geographical information systems (GIS) in Eigersund municipality in Norway. He was later on employee of Statistics Norway within environmental statistics. Vilni now works with a special focus on housing and population census within Statistics Norway.

He is president of the European Forum for GeoStatistics[1] (EFGS), and member of the European Foundation for the Care of Newborn Infants' Parents Advisory Board. He also has experiences in international reporting, cooperation and projects through presidency of EFGS. He is also founder of the private company NEOGEO[2].

Diana Makarenko-Piirsalu is an EU GIS expert, initiator and foundation member of the professional GIS umbrella organisation - Estonian Geoinformatics Society (ESTGIS). She was elected to become a Member of Management Board of ESTGIS, and contributing to an European GI umbrella organisation EUROGI activities.

She holds diploma in Geography, MSc in Landscape Ecology and Environmental Protection, and was awarded the highest scientific recognition of Estonia for her research.

At Statistics Estonia she was the initiator of implementing GIS in census conduction, and leading a GIS professional team. She contributes to the European Forum of Geostatistics activities and organised an international EFGS conference in 2010. She is a founder of the private company Geolytics OÜ[3] focusing on adding value to the society by implementing spatial analyses.

Magne Holst Bloch holds a Master degree in Interdisciplinary Social Science. His work resume, prior to higher education, consists predominantly of practical work and being a social-worker. He is also author of “Heureka”, a book on logical nuts[4].

As an agreement between NEOGEO and iFokus[5], to gain practical experience, he has worked on the literature study in this report.

1 http://www.efgs.info/

2 http://www.neogeo.no/

3 http://www.geolytics.ee

4 ISBN: 9788293082354

5 http://www.ifokus.as/

Preface

Silke Mader. Chairwoman of the Executive Board of EFCNI[6]. Silke founded EFCNI in 2008 together with experts and stakeholders. In 1997, her twins were born in 25 week of pregnancy, lacking totally the appropriate care. Unfortunately, one of them died a few days after birth, leaving the parents and the sibling. Silke's professional background lies in the elementary educational theory with main focus on linguistic support of migration children and remedial educational theory.

During her time in hospital and afterwards, she was faced with the non-existence of support of any kind, the absence of public awareness and the lack of information and education for parents during pregnancy. She felt that no parents should ever undergo such awful experience. Therefore, in 1999, she decided to actively participate in the Munich-based local parent group, which she headed from 2001 on. Two years later, she became Chairwoman of the German umbrella organisation "Das frühgeborene Kind" e. v. Together with experts, she developed declarations, guidelines and information material for parents with preterm children. As the situation throughout Europe is distressingly similar and preterm children urgently need a voice not only within Europe – but also worldwide, Silke decided to give up her job as a teacher and to assume her functions in the Foundation Board of EFCNI.

The European Foundation for the Care of Newborn Infants (EFCNI) published a benchmarking report in 2010[7], an EU Benchmarking Report that showed the prevalence and impact of premature births in European countries. Among the main points was that there are considerable differences in the level of care for premature infants between the European countries, and even that newborn and maternal health was not a prioritized area within the general healthcare system in many EU Member States. This, even though, effort in the early stages of life for these infants also is of great importance to their health as adults, and thus also impacts the general level of need for public healthcare services in society.

The report was later followed up with more concrete proposals for achieving better health care services for the premature born, presented in an EFCNI White paper[8]. The White Paper is intended as a reference for policy makers, politicians, healthcare professionals, parent's organizations and other stakeholders. In the annexes the 13 key findings are listed up.

This report aims at studying how geographical analysis may be part of a wider monitoring system for the care of pregnant women and babies born at risk, and so responds to several of the key findings in the EFCNI White paper.

6 http://www.efcni.org/

7 EFCNI (2009-2011). EU benchmarking report 2009/2010. Too little, too late? Why EU should do more for preterm infants.

8 EFCNI (2011). Caring for Tomorrow - EFCNI White Paper on Maternal and Newborn Health and Aftercare Services

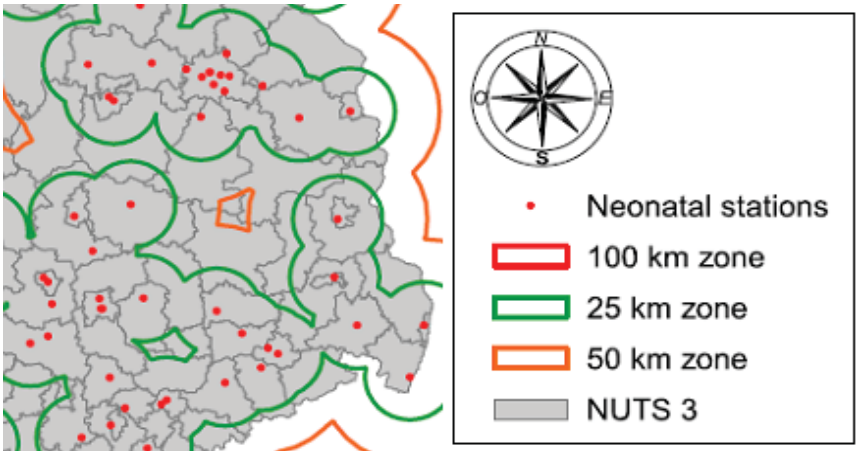
Introduction – The vision

Prematurity is the single, major cause associated with infant mortality and morbidity. There exists no European wide, targeted policy for neonatal health and premature infants. The vision of the NEOGEO project is to develop a system of policy tools to enhance care for newborn infants.

Neonatal stations form the core of medical care for newborn infants. A European geographic database of neonatal stations, with core information on hospital services, is necessary to monitor regional differences in care of new born infants. NEOGEO will be a first step with case studies towards a framework for a European Neonatal Geo-database and information system.

Putting neonatal stations on the map, combined with information on essential health care variables and geographical population distribution, makes it possible to answer basic questions on health services. NEOGEO will e. g. give an answer to how large a part of the population is covered with services for babies with extremely low birth weight within a 100 km radius?

Figure 1: Coverage and clustering of neonatal stations. Parts of Germany.

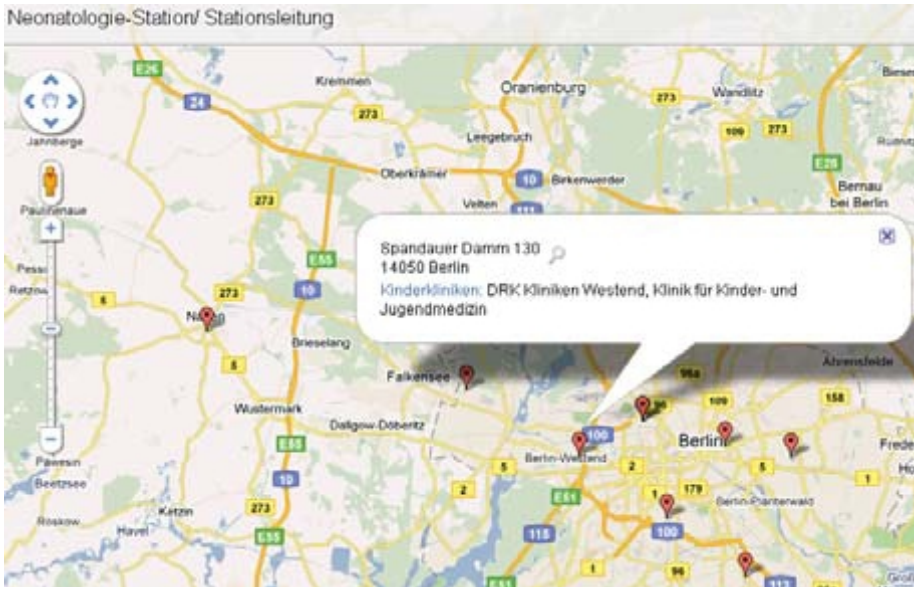


Source/Data: http://www.deutsches-krankenhaus-verzeichnis.de/ and http://www.gvsig.org/

Better regional planning and cooperation

Localization of neonatal stations will enable analysis of care for newborn infants independent of administrative regions and across borders. NEOGEO will e. g. make it possible to find geographic areas with insufficient coverage of neonatal stations, or regions were cross border cooperation between neonatal stations should be emphasized. This approach will make it possible to find answers reflecting the real distribution of population and neonatal station in Europe instead of relaying on artificial borders as the administrative units. Moreover, the study results can be aggregated on the administrative level as well. Furthermore it would give more effective service to those who need quick and professional help.

Figure 2: Example: Neonatal stations on the map using Google maps.



Source: http://www.deutsches-krankenhaus-verzeichnis.de/ and http://www.batchgeo.com/

Building a core health care data set

The NEOGEO project will be based on cooperation and dialogue with parents` organizations and health professionals across Europe. Through workshops with EFCNI and partners, a core set of variables will be developed. The core data set should be a European harmonized data set, enabling comparisons at all regional levels and between neonatal stations.

NEOGEOs vision

- Improving care for newborns.
- Benchmarking across borders
- Displaying inequalities
- Sharing knowledge
- Monitoring quality
- Healthcare reporting

Abstract

The purpose of this literature study was to investigate what research has been done in the area of neonatal health care services as viewed in a geographic/spatial perspective. And further, to look at their findings and what requires further research. Several studies have been done on the relation between distance to hospital, travel time and the quality of care for preterm infants. A handful of them will be accounted for in this literature study.

Since this is a review of existing literature, the methodology consisted of searching the internet for academic literature on the subject, and choosing among this literature based on relevance. We found that geographic aspects of the neonatal healthcare services have been investigated in many countries around the world.

In general these articles showed many of the same tendencies. Distance between mothers home and the ward where she delivered and/or received prenatal care was negatively correlated to the health outcome for the infant. This effect may also be influenced by mothers` socioeconomic status or ethnic origin in such a way that increasing distance disproportionally affected these groups.

On the other hand, the size of the ward where the babies were delivered is positively correlated to the health outcome for the child. In fact, not only the size of the ward, but the overall size of the hospital may affect health outcome in the same way. But fewer and bigger wards would mean increasing average distance and travel time between these wards and mothers home.

Another tendency is lack of adequate planning in national neonatal healthcare services, whether this regards transfers between hospitals or the distribution of these healthcare services in general. This might be caused by the lack of data linked with real location as detailed spatial distribution of population and hospitals have not been available for many countries.

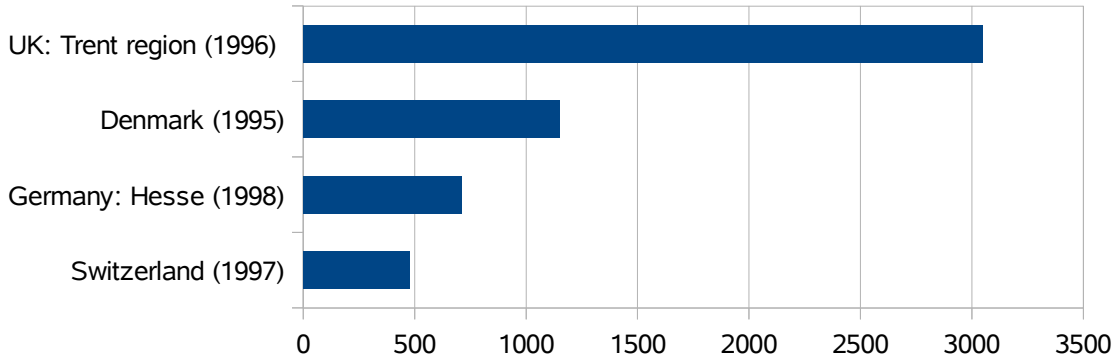
The large disparities between European countries in the way neonatal healthcare services are organized, shows that there is no consensus on basic premises for how to provide such services in an adequate way.

These findings suggest that what is needed is a mapping and analysis of the way such services are provided in European countries. A spatial analysis may provide valuable insights that can lead to better decisions. This may be combined with a survey among patients and employees at the relevant health facilities. For example, one may find that along the border between two countries it would be in the best interest for both parties to cooperate on neonatal care, due to geographic and/or infrastructural factors. Or the analysis may show that the distribution of these services within a country could be organized in a more effective way. Hence, understanding of spatial factors may maximize the utility of devoted resources, and especially if one aims at more equity in such healthcare services.

The literature study

A European study[9] showed that between European countries there are considerable diversity in the governments` approach to providing services of intensive care to premature babies and pregnant women. This regards health policies, the level of supply of services and the properties of the neonatal and maternity health care units. This difference in the models applied, serves as an opportunity to investigate the efficacy of different models. Since these countries are similar in their medical level and level of economic development, this comparison is a relevant one.

Figure 3: Mean number of births per maternity unit in selected countries.



Source: Zeitlina et al 2004.

The researchers` review of the relevant literature and studies in this area shows that on the one hand the different regions investigated had all rapidly applied new technology, but on the other hand there was no model for the supply of neonatal and maternity health care services that was generally accepted as the ideal and then widely applied.

One example of the vast differences between countries is shown in figure 1. In Switzerland the average sized maternity unit had a volume of roughly 500 births per unit in 1997, while in the region of Trent in the UK[10], the same number was about 3000 in 1996.

Another example is that in Eastern Denmark there were 3.4 maternity units per 10 000 births, while in the state of Hesse in Central-Germany, there were 13.8 (figure 4, next page). This indicate that if one were to find some general principles for the right model, in any given region, taking into account demographic and other variables, patient health outcome could be improved with a widespread application of such models.

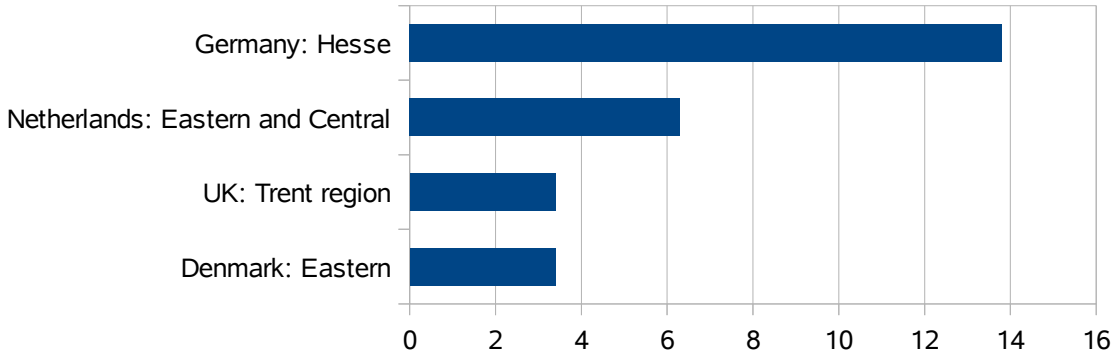
This suggests the need for a comparative analysis of the health outcome for neonatal and pregnant women under these different models. To undertake such a study one would need reliable data on a regional and national level on very preterm babies`

9 Zeitlina, Jennifer, Emile Papiernikb and Ge´rard Bre´arta (2004). *Regionalization of perinatal care in Europe*. Seminars in Neonatology (2004) 9, 99–110

10 The Trent Region is located along the mid-eastern coast of England and includes the cities of Nottingham and Sheffield, among others.

place of birth, different levels of care, size of NICUs, travel time and distance between health care units and patients and mortality rate.

Figure 4: Mean number of maternity units per 10 000 births (2000).

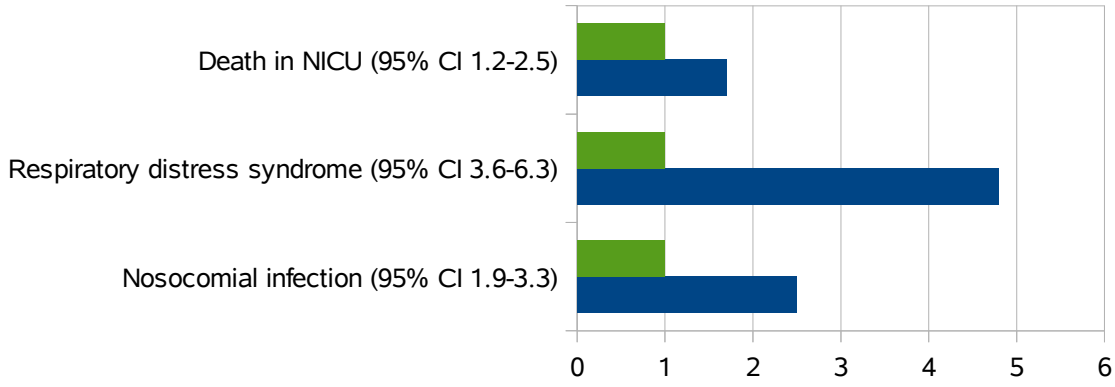


Source: Zeitlina et al 2004.

Canada

A Canadian study compared mortality rates among premature infants born outside tertiary care centers (outborn) with those who were born inside tertiary care centers (inborn)[11]. The researchers found that among premature infants who were delivered to Neonatal Intensive Care Units (NICUs), outborn infants had significantly higher perinatal risk factors. When adjusting for these risk factors and admission illness severity and applying logistic regression analysis, outborn infants still had higher mortality (adjusted OR 1.7, 95% CI 1.2-2.5). The investigation covered singleton infants (n=3769) who were born at or before 32 weeks` gestation and admitted to 17 NICUs in Canada during 1996-1997. The findings of the study was based on NICUs covering 75% of the population in Canada and can therefore be generalized to all of Canada`s NICUs, and perhaps even elsewhere.

Figure 5: Outcome for inborn and outborn neonatal infants after transfer to NICU (Adjusted Odds Ratios). Inborn is the reference group, in green.



Source: Chien et al 2001.

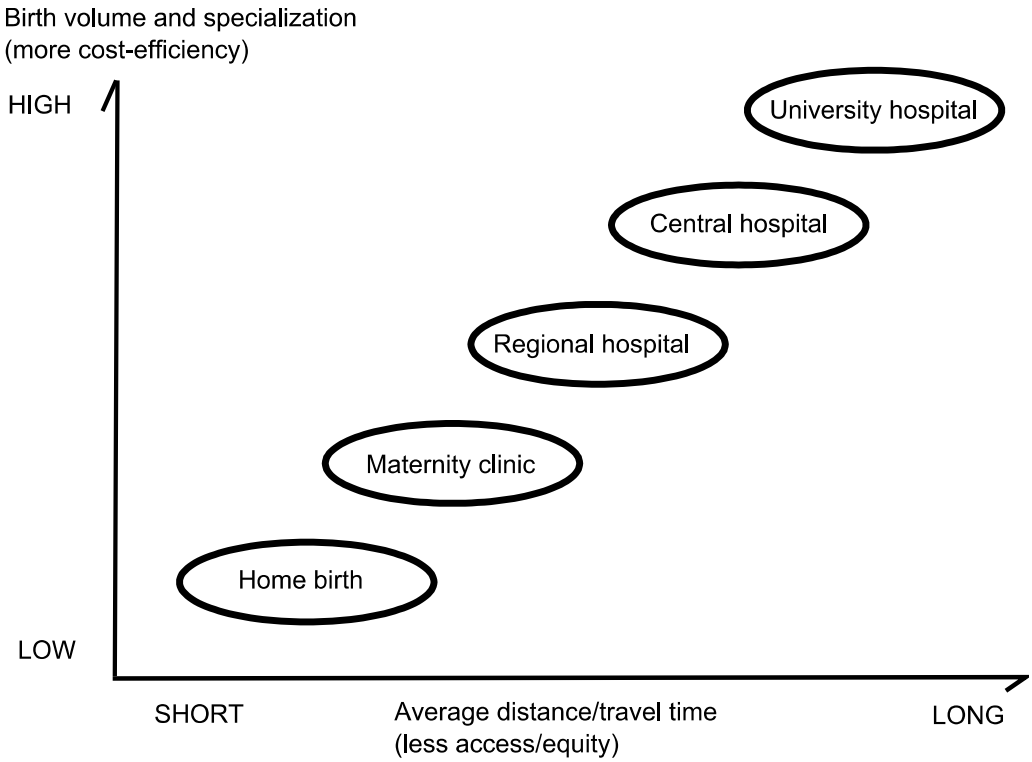
The researchers concluded that their study supported in-utero transfer of high-risk pregnancies to higher competence, tertiary level health care facilities. Updated protocols for the transfer of these high-risk pregnancies, with more frequent use of prenatal transfers could hence improve outcomes for infants and mothers, and reduce costs/liberate resources for society at large. A reasonable update of such protocols must be build on a comprehensive understanding of the spatial factors involved.

11*Chien, Li-Yin, Robin Whyte, Khalid Aziz, Paul Thiessen, Derek Matthew and Shoo K. Lee (2001). Improved Outcome of Preterm Infants When Delivered in Tertiary Care Centers. OBSTETRICS & GYNECOLOGY VOL. 98, NO. 2, AUGUST 2001*

Finland

Julia Venesmaa (2011)[12] studied the organization of maternity-care facilities in Finland in an equity-efficiency trade-off context. The equity-issue concerns the degree to which the population has similar access to maternity health care. The efficiency-issue is cost-efficiency, i. e. to get the maximal level of healthcare-services for the invested resources (maximize utility). Since widely geographically distributed healthcare-services increases equity and larger birth hospital units (more than 1 000 annual births) increases cost-efficiency, both these factors must be taken into account when organizing a national maternity health care system.

Figure 6: The relationship between equity in access and cost-efficiency in neonatal healthcare services.



Source: Venesmaa 2011.

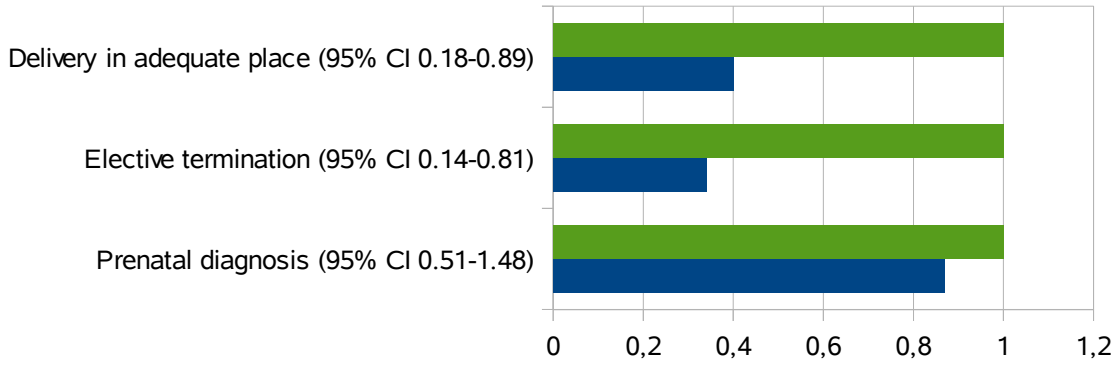
Studies show that increasing distance between mothers and hospitals increases the risk of out-of-hospital births and she argues that birth hospitals must be accessible within two hours for most of the population. But since larger units have larger resources, it is safer both for the infant and the mother to give birth in high-volume birth hospital units. The latter point is especially true for the mortality-rate of very low birth weight infants. With these two factors included in a trade-off analysis, and then applied to a location model for Finland`s birth hospitals, she seeks to find the optimal balance between equity of access in the population and cost-efficiency in healthcare. The results of her analysis are rather astonishing. According to Venesmaa, the optimal number of birth units in Finland is 10, as opposed to the existing 31 units.

12 *Venesmaa, Julia (2011). Organising a maternity care unit network. Thesis submitted in partial fulfillment of the requirements for the degree of Licentiate of Science in Technology. Aalto University School of Science and Technology. Faculty of Information and Natural Sciences. Department of Industrial Engineering and Management*

France

A study conducted in France[13] examined the relationship between several variables. The independent variables were distance between mothers and nearest maternity ward, and maternal origin. The dependent variables were self elected termination of pregnancy, prenatal diagnosis, the frequency to which pregnancies with fetuses with malformations that requested neonatal surgery was delivered in an adequate facility, and their mortality rate. The study included fetuses with three different types of malformations, but no chromosomal anomalies (n=706). Regarding distance three categories were selected, less than 11 km, between 11 and 50 km and more than 50 km. One distinction was made regarding origin of mothers, Western European and non-Western European mothers. The distinction between adequate and non-adequate facility for delivery was made between either a Level-III maternity ward with surgery center for neonatal infants or not.

Figure 7: Comparison between mothers of Western European and Non-Western European origin.



Source: Pasquier et al 2006. (Adjusted Odds Ratios). Western European origin is the reference group, in green.

Multivariate analysis showed that the distance variable affected frequency of prenatal diagnosis. Compared to those who lived less than 11 km from nearest adequate health facility, the 11-50 km group had significantly lower prenatal diagnosis probability (adjusted OR 0.49, 95% CI 0.25-0.94), and the more than 50 km group lower still (adjusted OR 0.39, 95% CI 0.20-0.74). This effect was not influenced by origin of mother. However, the frequency to which the infants were delivered in an adequate birth facility was influenced by mothers` origin, with less probability for an adequate birth facility for the non-Western European women (adjusted OR 0.40, 95% CI 0.18-0.89). Non-Western European mothers also chose to terminate their pregnancy less often (adjusted OR 0.34, 95% CI 0.14-0.81). The tendency that non-Western European women less often delivered at an adequate ward would work in favor of the Western European women regarding differences in mortality rate of the infants, even though there was no such difference found among those who delivered at an adequate ward. When delivery occurred at an adequate ward the neonatal mortality rate was significantly lower (adjusted OR 0.22, 95% CI 0.07-0.72).

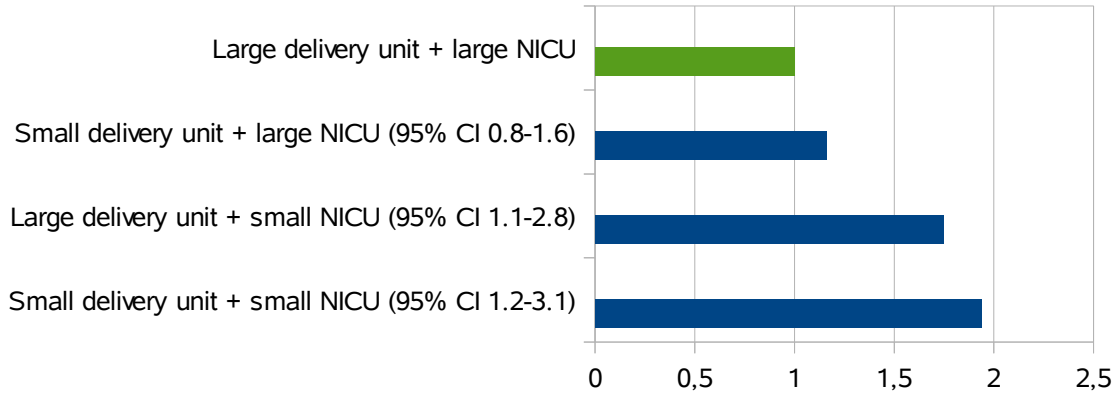
13 *Pasquier J.-C., M. Morelle, S. Bagouet, S. Moret, Z.-C. Luo, M. Rabilloud, P. Gaucherand and E. Robert-Gnansia (2006). Effects of residential distance to hospitals with neonatal surgery care on prenatal management and outcome of pregnancies with severe fetal malformations. Ultrasound Obstet Gynecol 2007; 29: 271–275 Published online in Wiley InterScience (www.interscience.wiley.com). DOI: 10.1002/uog.3942*.

As we can see, the distance variable has the same effect on mothers of Western European and non-Western European origin when it comes to prenatal diagnosis. But there are still differences between the two groups in the rate of delivery at adequate wards.

Germany

A German study investigated the impact of NICUs` volume of patients on patient health outcome[14]. They realized that there was little research done in this area compared to that on the level of care. Their hypothesis was that larger units would have lower neonatal mortality rate. 36 admissions or more per year were considered as large units and less than 36 admissions as small units. The study was based on very low-birth-weight births (less than 1500 g) in the Lower Saxony[15] area born in the period of 1991 to1999 (n=7745). Only the number of low-birth-weight births at 24-30 weeks were included in the analysis (n=4379). Procedures were followed to ensure data validation before performing uni-variate data analysis and logistic regression modeling.

Figure 8: Mortality rate for infants born at combinations of delivery units and NICUs.



Source: Bartels et al 2005. (Adjusted Odds Ratios). Large delivery unit + large NICU is the reference group, in green.

The neonatal mortality rate among infants admitted to large and small NICUs were 10.2% and 12.2% respectively. Thus, there was a 2 percentage point difference, or roughly a 20% higher mortality in smaller NICUs. Not only the size of the NICUs were important, but also the overall size of the delivery hospital.

As shown in figure 8 the difference was far greater when comparing infants born in small NICUs at small delivery hospitals (1000 or less births per year) with large NICUs at large delivery hospitals (more than 1000 births per year). The mortality in the first group was almost twice as high (OR 1.94, 95% CI 1.20-3.14) as in the other. When stratification was made according to gestational age the impact was the largest for infants born at less than 29 weeks.

Their study suggests that larger perinatal centers are beneficial for the health outcome for the infants. However, applying this principle would decrease the number of birth units and therefore also geographic coverage, and as other studies in this paper show, distance to birth units is also an important factor. Hence, we have a trade-off relation between size and accessibility.

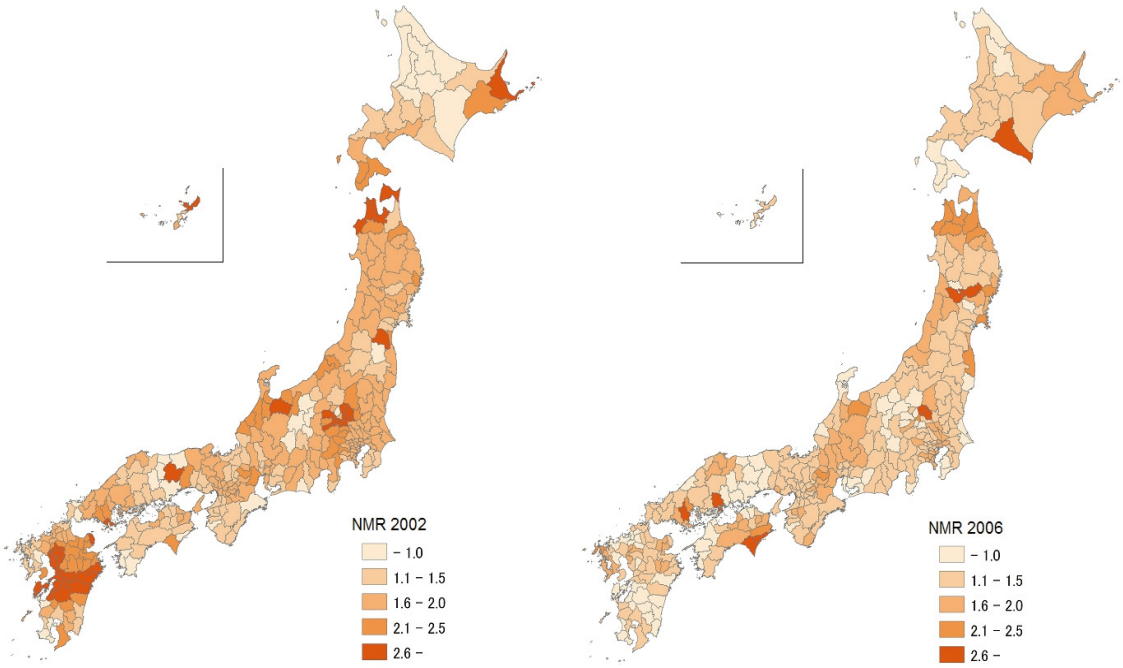
14 Bartels, Dorothee B., David Wypij, Paul Wenzlaff, Olaf Dammann and Christian F. Poets (2005). Hospital Volume and Neonatal Mortality Among Very Low Birth Weight Infants. *Pediatrics* 2006;117;2206 DOI: 10.1542/peds.2005-1624.

15 Region situated in the north-western part of Germany. A population of roughly 7, 9 mill as of 2010.

Japan

A 2010-study from Tokyo, Japan, used GIS to measure travel time to the nearest perinatal care center from population centroid in different municipalities[16]. A comparison was made between areas that had reduced travel time and areas that had not. It was examined with a Difference-In-Difference Estimation weather reduced travel time affected neonatal mortality rate (NMR).

Figure 9: Reduction in NMR from 2002 to 2006. Japan.



Source: Aoshima et.al 2010.

In 2002 the median travel time was 66.99 minutes, and by 2006 this was reduced to 39.09 minutes, which means there was a 41.6% reduction in median travel time in this period. In the same period they observed a decrease in the mean NMR from 1.72 (per 1,000 childbirths) to 1.33.

Among the areas with more than 60 minutes or more median travel time in 2002, those that reduced travel time during the four year period also achieved significantly reduced NMR, and thus contributed the most to the decrease in NMR. In addition the researchers found that an increase in the number of obstetricians per 10 000 childbirths would reduce NMR. But given the time it would take to accomplish this, they said that decreasing travel time should take priority as a means of decreasing the NMR and improving the perinatal care system in general.

The researchers made reference to the fact that the relation between effectiveness and uneven distribution of resources dedicated to neonatal and pediatric care has been discussed in other countries. The Japanese researcher's conclusion was that by reconsidering geographic placement of perinatal care centers one could enhance efficacy of devoted resources and reduce NMR.

16Aoshima Kohei, Hiroyuki Kawaguchi and Kazuo Kawahara (2010). Neonatal mortality rate reduction by improving geographic accessibility to perinatal care centers in Japan. *J Med Dent Sci* 2011 ; 58 : 29

United Kingdom

British researchers evaluated in their article, the way in which neonatal transfer was conducted in the UK[17]. They felt that the health services of neonatal intensive care in the UK were the result of an unplanned evolution. The main tendency was described as a not very well planned organization of health care units of different size, level of services etc. Along with other factors this resulted in a larger than necessary amount of perinatal transfers between health care facilities.

As in the case of the study from Finland[18], this is a trade-off situation. If a transport service in a given region covers too large an area the transport may be considerably delayed, but if it covers too small an area it will not be cost effective. The size of an area is a function of both its geographic area and the size of its population basis. Hence, both these factors must be taken into account when planning for a "balanced" neonatal transport service. However, there is still a problem of varying workloads. Using the Trent Region[19] as an example, with approximately 4.7 million inhabitants and 63 000 childbirths in 1997, the median number of acute transfers where one per day, but the range was from 0 to 5. But this also points in the direction of the importance of a carefully planned network for the neonatal transfer service.

Examination of models for transportation of neonatal infants within Europe reveals that there is no "one size fits all" solution to how such networks should be organized. Rather, they should be tailor made to each specific region, taking into account geography, demography and other variables.

Six years prior, other researchers[20] suggested changes in the system of neonatal transfer in the UK, but the authors thought that little had been done.

17 Fenton A. C., A. Leslie, C. H. Skeoch (2003). *Optimizing neonatal transfer.* Downloaded from fn.bmj.com on November 29, 2011 - Published by group.bmj.com

18 Julia Venesmaa (2011). *ORGANISING A MATERNITY CARE SERVICE NETWORK*. Thesis submitted in partial fulfillment of the requirements for the degree of Licentiate of Science in Technology. AALTO UNIVERSITY SCHOOL OF SCIENCE AND TECHNOLOGY. Faculty of Information and Natural Sciences. Department of Industrial Engineering and Management

19 The Trent Region is located along the mid-eastern coast of England and includes the cities of Nottingham and Sheffield, among others.

20 Field D, D. Milligan, C. H. Skeoch, et al. (1997). *Neonatal transport: time to change?* Arch Dis Child Fetal Neonatal Ed 1997;76: F1–2.

United States of America

An earlier study from the United States[21] investigated effects of the down-prioritization of rural areas regarding access to obstetric care. By defining rural hospitals as smaller than certain levels of quantity (among others, less than 50 beds and more than 15 miles from a city of a population 30 000 or more) and a rural area as the area served by these hospitals (the sum of zip code areas closer to these hospitals than other hospitals, by public roads), they could calculate distances based on data they received from Washington State Department of Transportation.

They found a negative association between diminishing numbers of obstetrical providers and preterm birth outcomes. Since the level of prenatal care is important for perinatal outcome, for both the infant and the mother, it implies that higher level of available prenatal care reduces the needed level of perinatal care in a population.

Their conclusion was that if this represented a causal relationship, it was neither medically nor cost-efficiently sound, from the perspective of both government and taxpayers, to decrease access to obstetrical providers in rural areas.

Regional differences in neonatal intensive care in the United States were investigated to see whether more neonatal intensive care beds or neonatologists was positively correlated with lower neonatal mortality rate[22]. The researchers linked birth and death records for 246 neonatal intensive care regions. They found a relation between the number of neonatologists per birth and infant mortality. However, the relation between the number of neonatal intensive care beds and neonatal mortality rate was not consistent.

Most interesting was perhaps their conclusion that resources where not effectively geographically distributed. While a few regions had less resources than needed, i. e. neonatologists, many regions probably had more resources available than what was needed to reduce high-risk newborn mortality. In other words, a geographical redistribution of the number of available neonatologists per birth could save lives, without further resources invested.

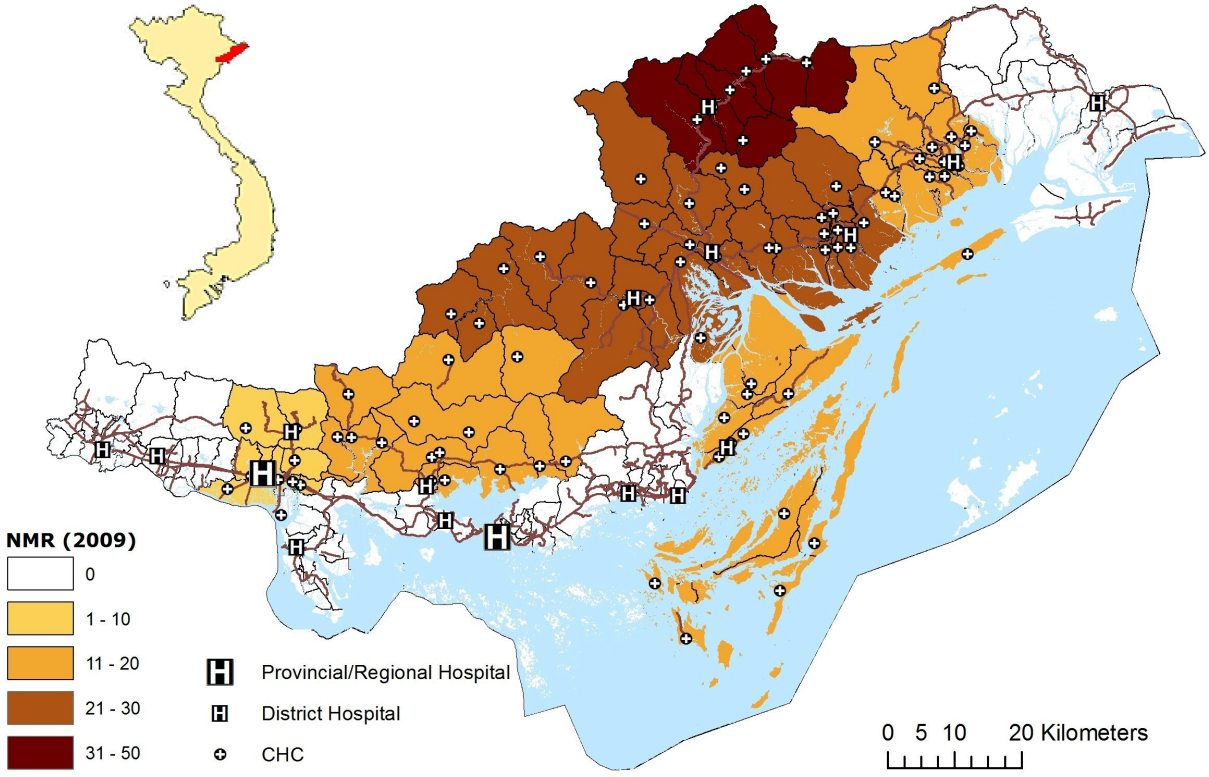
21 Nesbitt, Thomas S., Frederick A. Connell, L. Gary Hart and Roger A. Rosenblatt (1990). Access to Obstetric Care in Rural Areas: Effect on Birth Outcomes. *Am J Public Health* 1990; 80:814-818.

22 Goodman David C., Elliott S. Fisher, George A. Little, Therese A. Stukel, Chiang-Hua Chang and Kenneth S. Schoendorf (2002). *The Relation Between The Availability Of Neonatal Intensive Care And Neonatal Mortality. N Engl J Med*, Vol. 346, No. 20 · May 16, 2002 · www.nejm.org

Vietnam

A recent study showed that neonatal mortality was correlated to the distance between patients and the nearest health facility[23]. The researchers emphasized the importance of spatial dimensions, and the fact that this had not been adequately investigated in relation to the goal of reducing neonatal mortality. This, even though, high quality delivery care is generally considered to be a main factor in the survival of neonatal infants. The study investigated the relation between the distance from mother's home to the nearest health facility, and how this distance influenced the utilization of perinatal health care.

Figure 10: NeoKIP study area in Quang Ninh province in northern Vietnam.



Source: Målqvist et al 2010.

The area investigated was eight districts within the province of Quang Ninh[24], in the period from July 2008 to December 2009. All neonatal deaths (n=197) and a random reference sample (n=686) of all the 11 708 registered births were studied. GIS coordinates for health facilities and mothers` homes were obtained to calculate straight line distances, and in addition, all the mothers were interviewed. Regarding distance, the mothers who belonged to the 4th and 5th quintile (more than or equal to 1 257 meters), had almost twice the risk of experiencing neonatal mortality (OR 1.96, 95% CI 1.40-2.75) than that of the three lower quin-tiles, after adjusting for mothers age at delivery and marital status in a multivariate logistic regression model. Differences between socioeconomic groups were also found, and when stratifying for socioeconomic factors such as mothers` level of education and the quality of their homes, the effect of distance was increased.

23 Målqvist, Mats, Nazmul Sohel, Tran T Do, Leif Eriksson and Lars-Åke Persson (2010). *Distance decay in delivery care utilization associated with neonatal mortality. A case referent study in northern Vietnam*. BMC Public Health 2010, 10:762

http://www.biomedcentral.com/1471-2458/10/762

24 The province of Quang Ninh is located along the north-eastern cost of Vietnam and had a population of roughly 1.1 million as of 2008.

The negative association found was due both to distance decay at birth and in the utilization of health care in the prenatal period. Among the conclusions was that geographic considerations must be made when planning measures for improved neonatal survival rate. This was even more important for socioeconomically disadvantaged groups. In conducting the study the use of a GIS (Geographic Information System) was central.

Zambia

Although the Zambian level of health care is different from the level enjoyed by European citizens, a 2010 study showed the importance of distance to healthcare facilities and the relevance of a GIS in researching such matters[25]. The study concerned mothers who gave birth in rural areas of Zambia.

By using a GIS they linked data from different sources and measured distances between patients and health care centers. Combining data from the Demographic and Health Survey 2007 with information on health care facilities from the Zambian Health Facility Census 2005, they calculated straight-line distances. Furthermore, it was distinguished between comprehensive, basic and limited/substandard level of services at the health care facilities. The effect of distance was measured by controlling for the effects of other presumed important variables using multivariate multilevel logistic regression analysis. Since only about a third of all births in rural Zambia take place at a health facility, and the rest at home, the impact of distance is especially important. Among the births included in the study (n=3 682), as distance to nearest health facility doubled, the chance of delivery at a facility decreased by 29% (95% CI, 14%-40%). Independently, with one step increase in the level of care at the nearest facility, the probability of delivery of the child taking place there increased by 26% (95% CI, 7%-48%).

According to this study the distance-variable was at least as important as household poverty, lack of education or lack of female autonomy, when it comes to explaining why most deliveries in rural areas of Zambia occur at home without supervision of professional care. The researchers recommended further use of GIS in future research, policy and planning.

25 Gabrysch, Sabine, Simon Cousens, Jonathan Cox, Oona M. R. Campbell (2010). *The Influence of Distance and Level of Care on Delivery Place in Rural Zambia: A Study of Linked National Data in a Geographic Information System*. *PLoS Medicine* | www.plosmedicine.org January 2011 | Volume 8 | Issue 1 | e1000394

The feasibility study

The feasibility study aims at sorting out whether it is possible to make a European wide geodata based system for monitoring and sharing knowledge within the field of the care of newborn infants.

In the first sub chapter the availability and quality of necessary data and data models are assessed. Then, in the next sub chapter, Estonia is used as an example of how to make analysis and presentations based upon best available data.

European wide data sets and models

To set up a geographic information system one need a set of data that are harmonized and fits the intended purpose. In this case the main ingredients are; population data, hospital data, regional units and road networks. These data sets will be assessed by their quality and availability.

Eurostat has made a handbook for quality reports[26], which points out some issues that should be assessed;

1) Relevance
2) Accuracy
3) Timeliness and Punctuality
4) Accessibility and Clarity
5) Coherence and Comparability
6) Trade-offs between Output Quality Components
7) Assessment of User Needs and Perceptions
8) Performance, Cost and Respondent Burden
9) Confidentiality, Transparency and Security

Not all of these issues are equally important, nor within the frames of this project. E. g. for setting up a European wide monitoring system, with all its components, an own study should be made on user needs, costs, confidentiality etc. In this report issues 1-4 in the list above are emphasized.

Population data

To make a geographic analysis, e. g. on service areas of hospitals, one needs to know where the patients are located. Today, there exists no European wide population data set that covers all of Europe with high geographic accuracy. However, the ongoing Population and housing census 2011, will enable most European countries to make population on geographical grids with grid cell size of 1x1 km. This will in most cases be based upon aggregating population on address level. In these cases also population variables like sex and age might be used. The European Forum for GeoStatistics (EFGS)[27] is in a leading role through the ESSnet project Geostat 1A (2010-2012) and Geostat 1B (2012-2014) for making population data available on grids. Population on grids will most probably be part of mandatory reporting from national statistical institutes (NSIs) through the EU directive INSPIRE[28]. Most countries will deliver population statistics on grids free of charge. EFGS has called for a global action on this issue.

26 Eurostat (2009). ESS Handbook for Quality reports. http://epp.eurostat.ec.europa.eu/portal/page/portal/ver-1/quality/documents/EHQR_FINAL.pdf

27 http://www.efgs.info/

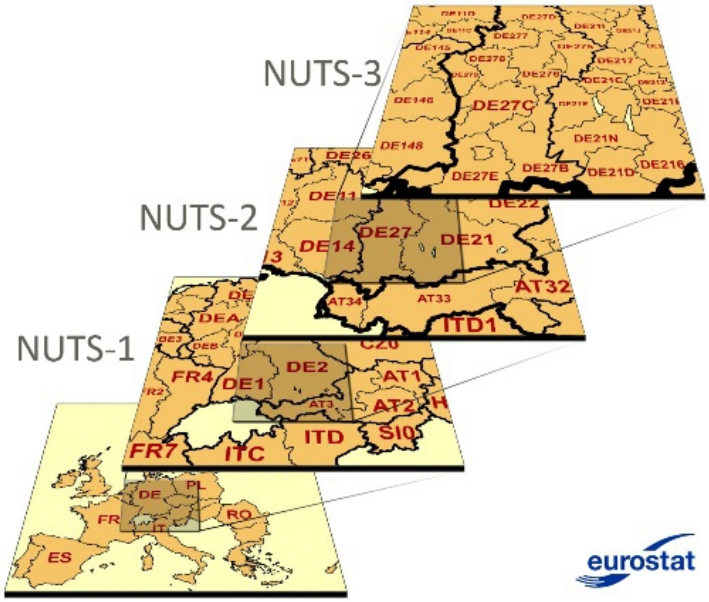
28 Directive 2007/2/EC of the European Parliament and of the Council of 14 March 2007 establishing an Infrastructure for Spatial Information in the European Community (INSPIRE) http://inspire.jrc.ec.europa.eu/

Regional units

To display information on maps one often uses regional units; like administrative units, post code areas, country borders etc. Most commonly used is the so called Nomenclature of territorial units for statistics (NUTS, see Figure 11). The NUTS classification[29] is a hierarchical system for dividing up the economic territory of the EU for the purpose of; the collection, development and harmonisation of EU regional statistics, and socio-economic analyses of the regions. The classification consists of the following three levels:

NUTS 1: major socio-economic regions
NUTS 2: basic regions for the application of regional policies
NUTS 3: small regions for specific diagnoses

Figure 11. Illustration of Nomenclature of territorial units for statistics (NUTS).



Source: Eurostat 2012.

A lot of statistics may be downloaded from Eurostat, having NUTS as their regional unit. Map data for NUTS are also available free of charge from Eurostat[30]. However, NUTS vary a lot in size and tend also to vary in size over time. NUTS are also rather coarse for sub-regional studies, and should be used with this in mind.

Post code areas are less used as regional units in official statistics. However, they are more often used in registers than NUTS, and generally consists of smaller areas than NUTS. Post codes are also often used in geocoding, for placing register records on a map. GeoNames[31] provides a free of charge download service for post codes with coordinates[32]. The GeoNames geographical database is available under a creative commons attribution license. It contains over 10 million geographical names

29 Source: Eurostat 2012. http://epp.eurostat.ec.europa.eu/portal/page/portal/nuts_nomenclature/introduction

30 NUTS map data: http://epp.eurostat.ec.europa.eu/portal/page/portal/gisco_Geographical_information_maps/popups/references/administrative_units_statistical_units_1

31 Geonames: http://www.geonames.org/

32 GeoNames post codes download service: http://www.geonames.org/postal-codes/

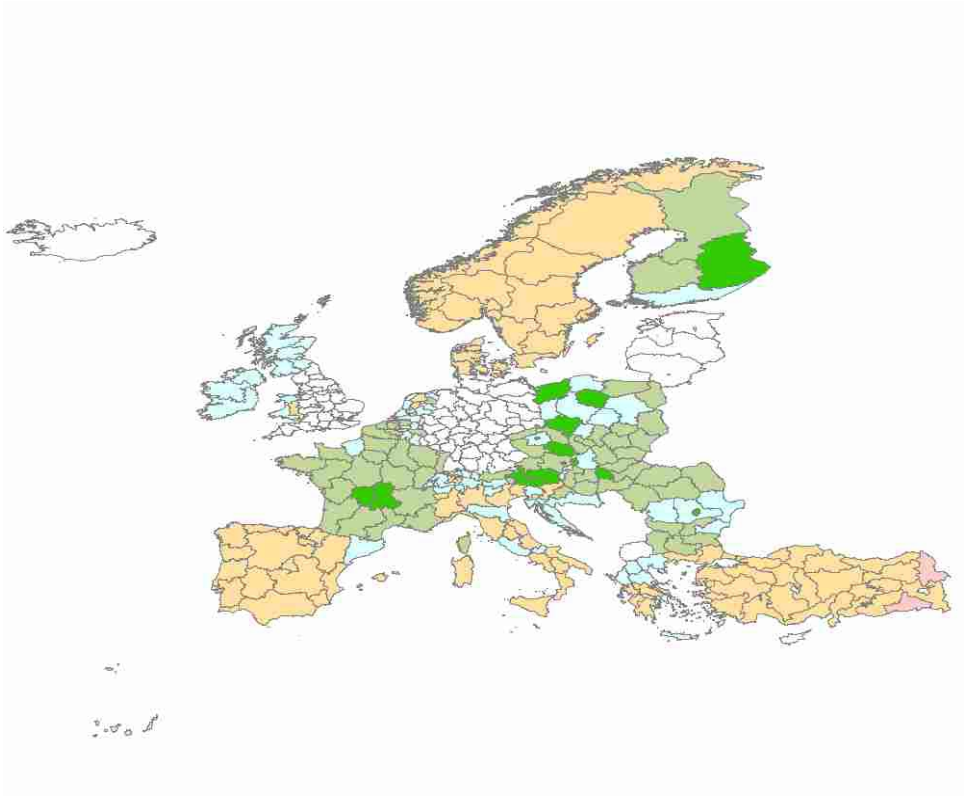
and consists of over 8 million unique features whereof 2.8 million populated places and 5.5 million alternate names. Post codes for all countries in Europe are supposed to have full coverage. Some of the mayor users are Microsoft, Nokia, BBC, Apple and The New York Times.

Hospital data

Besides population data, hospital data are the most essential for geographical studies on hospital and patients. There are several global and European sellers of hospital data. However, it seems like none of them have full coverage for Europe, they lack geo-referencing, the data might not be up-to-date, the data might be biased by self reporting or not well harmonised.

Figure 12 might illustrate part of this problem, showing statistics on number of hospital beds per 100 000 population by NUTS 2. Not all countries have been able to report this statistics, and the reference year behind each country varies quite much.

Figure 12. Hospital beds per 100 000 inhabitants. Europe.



Source: Eurostat 2012. (C) EuroGeographics for the administrative boundaries.

One therefore have to look into alternative sources or methods. Two potential sources might be GeoNames and OpenStreetMap[33] (OSM data), both being based upon voluntary contributors and disseminate data free of charge. Using search engine at GeoNames[34] and download service at GeoFabrik[35], one get about 1 700 hospitals and 8 000 hospitals in Europe respectively. These figures were checked against reliable lists for some countries. GeoNames for sure has an under-coverage of hospitals, and OSM data seem to have an over-coverage in some countries (due to inclusion of minor clinics of different characteristics).

33 OpenStreetMap: http://www.openstreetmap.org/

34 GeoNames search engine: http://www.geonames.org/advanced-search.html?

35 GeoFabrik : http://www.geofabrik.de/

Other approaches might include having address lists from international providers of health care products used at NICUs, or e.g. address lists from recognised and widely used magazines within the field of neonatology. However, there is a great risk in also these sources being biased, and one hence has to find alternative ways of improving these hospital data sets.

In principle one should use most authoritative sources, when available. One future source might be geodata made available through the INSPIRE directive on Buildings or Utility and Governmental Facilities. These data will however only cover parts of EU member states, EFTA countries and candidate countries. It is also possible some countries will take charge for their data sets, and that definitions used for “hospitals” are not harmonised for purposes of analysing geographic relationships between hospitals and population.

Hence, further work has to be done to have a European wide geo-database for hospitals in Europe. This should be done in several steps; wash of existing data, sending out post questionnaires and setting up a web based survey.

Road networks

A data set for road networks is essential for analyzing e. g. service areas of hospitals, location-allocation studies, and time and distance studies. According to EuroRoads[36], specifications for a harmonized EU road database will be finished by end of 2012. When this will have full coverage, and under which terms, are however still uncertain.

Several providers exists for road networks, often sellers of car navigation systems. Costs and geographic coverage varies, and attributes like speed-limits and turn-tables might differ from country to country. For the more rough analysis simpler data-sets might be used. OSM data has been used in the next chapter. The quality and harmonization of this data-set should be examined in more detail. Another option might be the data-set from CIESIN[37], the global road data-set called gROADS[38]. Also this need some more quality assessments, as this data set is very new. GROADS is quite rough, for use in scale 1:250 000, but might be sufficient for rougher geographic analyzes.

Airport data

To be able to analyze flight time and distances a European wide geo-database for airports and heliports is needed. EUROCONTROL[39] seems to have a full coverage for this topic, for download free of charge, the so called European AIS Database – EAD[40]. This geo-database contains more than 3 600 records. Some checks on conversion between file formats and transformation between different projections and datums should be done.

36 Euroroads : http://www.euroroads.org/php/vision.php

37 The Center for International Earth Science Information Network (CIESIN): http://www.ciesin.columbia.edu/

38 http://www.ciesin.columbia.edu/confluence/display/roads/Global+Roads+Data

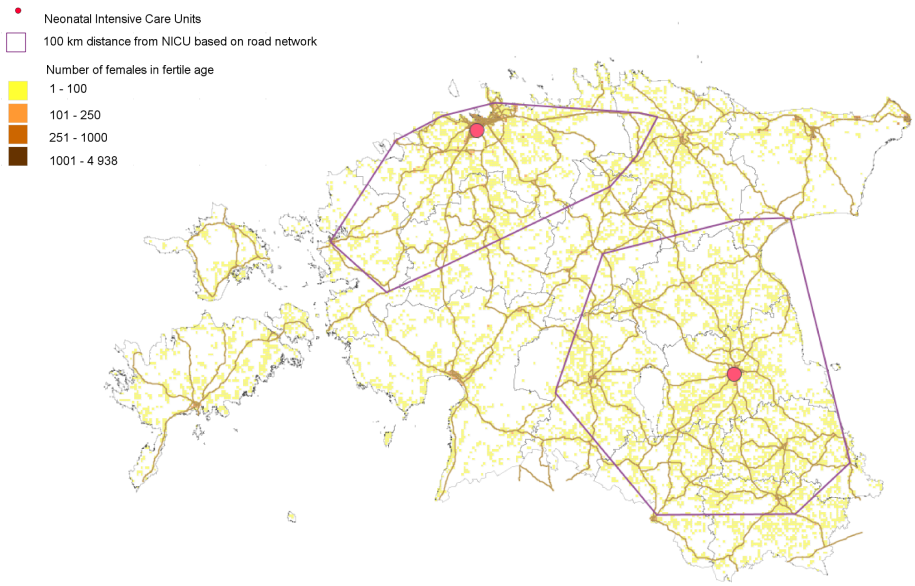
39 EUROCONTROL, The European Organisation for the Safety of Air Navigation: http://www.ead.eurocontrol.int/

40 European AIS Database - EAD: http://www.ead.eurocontrol.int/eadcms/eadsite/index.php.html

The Estonian case study

The maps illustrate different opportunities for analyzing and visualizing spatial relationships among the neonatal stations and the population distribution on 1 km2. The maps are effective sources for visualization of study results for further decision making and policy development.

Figure 13. NICUs and 100 km road distance. Estonia 2001.



Source: Statistics Estonia and OpenStreetMap

Based on the map in figure 13, only 66% of females in fertile age are living 100 km travel distance from neonatal stations in Estonia. Thus, for 34 % of females in fertile age the travel time to the Neonatal stations are more than 1,2-1,5 hr. Particularly for people living on islands, the service might be not effective.

The map in figure 14, illustrate the spatial analyzes for finding the most effective locations for two new neonatal stations based on the centroids of local administrative units used as potential new locations. The analysis takes into account the Euclidean distances between the living locations of females in fertile age and centroids of local governments. The higher weight is assigned to these locations there more females are living. Thus, the centroids of local governments are selected which are accessible for higher number females.

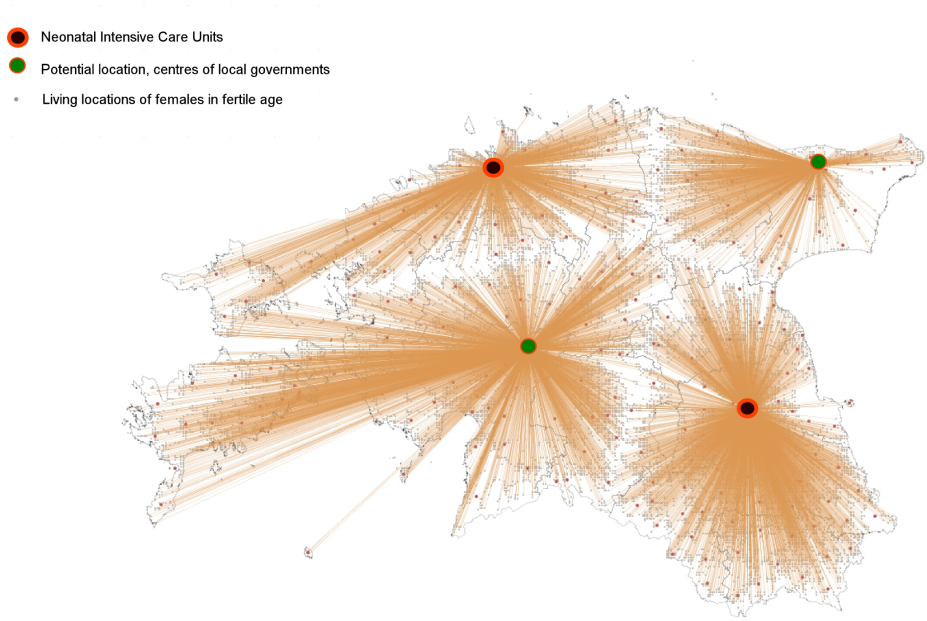
This analysis should be treated as one example of a spatial location – allocation analysis, not as a suggestion for new neonatal station location at current state of study. The latter needs more detailed analysis.

Figure 15 illustrate the proximity analysis opportunities for data which are linked with location. 10 km, 25 km and 100 km buffer areas are conducted to answer simple questions: How many females in fertile age are living in a radius of respective distances from existing or potential neonatal stations?

Knowing how many females are living in a certain radius of health care service providers is essential information for effective planning of health care services. The information based on administrative units are not detailed enough for spatial planning purposes.

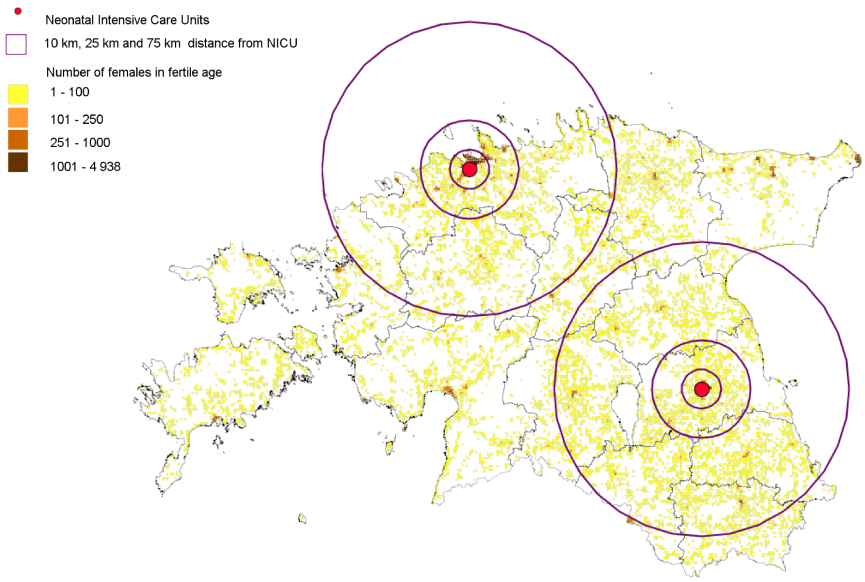
The data source used for this illustrative spatial analyzes maps is Census 2001 results from Statistics Estonia and as such do not reflect the current status of demographics. During the last decade the people migration mainly towards the main cities in Estonia has taken place. Therefore, for a sound analysis reflecting the current status of people distribution the need exists to conduct the analysis based on 2011 Census data. These will be disseminated during the coming months.

Figure 14. Location – allocation analysis of NICUs. Estonia 2001.



Source: Statistics Estonia and OpenStreetMap

Figure 15. NICUs and 10, 25 and 100 km flight distance. Estonia 2001.



Source: Statistics Estonia and OpenStreetMap

Conclusions and recommendations

As these studies show, the relation between distance to hospital care for mothers of premature infants, travel time, transfer between health care facilities with different level of services, neonatal mortality rate and general level of health for neonatal infants, have been investigated in different parts of the world. Europe, East-Asia, Africa and North-America are all covered in this paper. In addition to distance, other underlying variables such as infrastructural development and access to ambulance transportation, affect travel time. The distance- and travel time variables affected not only the level of care the infants received, but also the rate to which they received prenatal diagnosis. The general relation between distance and outcome seems clear, and this effect would be further enhanced by unsatisfying levels on these other variables.

We have also seen that there is great variety between the different countries` approach to neonatal healthcare. The study conducted on a European level illustrated this. They concluded that there is no “one size fit all”-model, but because of the many different variables, national and regional models must be tailor-made. However, this does not mean that one can’t find an ideal model for a given area. Rather, it calls for greater understanding of the pros-, and cons of alternative models for this area. Even though two countries may seem very different at a national level, there may be great similarity between regions within these countries, and hence the opportunity to learn from each others` experiences.

For a given level of resources invested in neonatal care, location of these resources in a rational relation to population-density, quality of infrastructure and level of transportation, would ensure maximal efficacy of these resources. For example, the American study suggested that a rearrangement of neonatologists between hospitals could reduce NMR, since some regions probably had more than needed and others had less. Another example is the investigation into the Finnish neonatal healthcare system, which according to the author, showed that a radically different distribution of these services would provide the optimum balance between equity and cost-efficiency.

Alternatively, if one were able to accomplish adequate level of neonatal healthcare with a lower use of resources, it would possibly liberate resources for other areas within the public healthcare system. Hence, a spatial analysis of these matters is central for policymakers and other stakeholders.

Further work

The single major cause of infant morbidity and mortality is prematurity. There is no European wide targeted policy for the health of premature infants. What is needed is a set of policy tools that will enable enhanced care for neonatal infants. With the use of a geographic and statistical analysis this can be accomplished. Today there exists no European wide harmonized way of knowledge sharing in this field.

NICUs and other health facilities that treat neonatal infants should be placed on the map, together with the relevant attribute variables. Taking into account population density, infrastructure, speed-limits in roads etc, one can perform a network-analysis or a buffer-analysis. A buffer-analysis may, for example, estimate the number of infants of extreme low birth weight that will be born outside a 100 km radius of a NICU, the following year. It may also show that along a border between two countries, there should be a bilateral perspective on neonatal healthcare, because the total level of utility can be increased through more cooperation, and thus be to the benefit of both parties. Another probable finding of such an analysis will be that one could distribute resources more effectively, such as moving one nursery position from one hospital to another.

Spatial analysis will not only give valuable insights into the prioritizing of resources, but will also enable better comparisons between different regions/nations in Europe. Benchmarking across borders can give feedback to politicians and decision makers, about what could reasonably be expected in terms of healthcare services, provided by a hospital that receives a given amount of resources.
On both a national and international level one would easily find inequalities in the neonatal healthcare services provided to the population. Perhaps most important in this context is differences within a country, as this may influence national health policies.

On an international level there should be build a common data system for the treatment of neonatal infants. This will enable the sharing, and further development, of knowledge in this area. This will also strengthen the possibility of monitoring the quality of, and reporting on neonatal healthcare. Considering the European study accounted for in this paper, which concluded that there was a vast diversity in the approach to neonatal healthcare in the European countries, one should also strive for building consensus on the best approach.

The most crucial point in establishing a harmonized European wide monitoring system for NICUs, seem to be the mapping of the hospitals. All in all, conducting this further work should improve the care for newborns and increase cost-efficiency and equity in the services they receive.

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Annexes

Thirteen key recommendations from EFCNI White paper

The thirteen key recommendations identified in this White Paper cover the following areas of activity on national and European level:

1. Recognize the issues of maternal, newborn care and aftercare as a public health priority, particularly the health of preterm infants and infants with illnesses
2. Acknowledge the potential long-term consequences of preterm birth and for newborns with illnesses that need to be tackled
3. Address health inequalities in maternal and newborn care within all European Member States
4. Conduct national audits on maternal, newborn care and aftercare services and establish a multidisciplinary task force for developing national best practice guidelines
5. Implement national policies and guidelines for high-quality pre-conceptional, maternal and newborn care and aftercare. These policies and guidelines should include the principles highlighted in this White Paper
6. Provide equal and early access to full and true information, education and counseling
7. Harmonize education and training of health care providers
8. Provide social and financial support to parents and families
9. Develop and implement strategies for public awareness and education
10. Harmonize cross-border maternal and newborn healthcare
11. Monitor outcomes and implement audit procedures in maternal, newborn and aftercare
12. Implement European wide standardized data-sets for pregnancy and preterm birth outcome
13. Invest in comprehensive research to tackle the challenge of preterm birth and its potential long-term consequences

Key findings from European benchmarking report

Key findings from EFCNI (2009-2011) report on benchmarking European countries.

There is currently no single source of up-to-date, comparable European data on the prevalence, mortality and morbidity associated with preterm births.

Official national sources of information about preterm birth do not appear to be available to decision-makers in a number of countries to support the development of neonatal policies

Data on preterm birth, including risk factors, management and outcomes of neonatal healthcare is not collected and analyzed consistently across EU member states - reliable statistics are scarce and, where they do exist, are often inconsistent

Even in the absence of rigorous data collection, available data suggest a clear trend of increasing prevalence of preterm births in all of the EU countries (with the exception of Sweden).

Existing data also highlight considerable inequalities in the preterm birth rates in European countries, with wide variations both between and within countries.

Data collection systems are often voluntary resulting in significant variation in the level of detail, the indicators used (e. g. different weekly categories v. weight), the definition of the indicators themselves and the definition of prematurity.

With regard to costs, there is an absence of reliable and comprehensive cost data in countries demonstrating the health-economic impact of prematurity (with the exception of Denmark).

Abbreviations and Definitions

Adjusted OR:
Adjusted odds ratio. The likelihood of one event occurring compared to the likelihood of another event occurring.

CI:
Confidence interval. The interval, within which, a quantitative value can be placed with an expressed amount of certainty. E. g., 95% CI 1.2-2.5, means that there is a 95% probability that the value is in this interval.

EFCNI:
European Foundation for the Care of Newborn Infants.

Gestational Age:
The duration of pregnancy, measured in weeks from inception.

GIS:
Geographic Information System.

Health Facility:
A general term for locations of different size and level of expertise that practice medicine. In this article it relates to healthcare services for premature babies and their mothers.

Level-III maternity ward:
Neonatal Intensive Care Units are usually divided in three categories after level of care. Level-III units have the highest standards of equipment and expertise.

Neonatologist:
Doctor who practices neonatology, a sub-discipline of pediatrics that provides healthcare for newborn infants, especially premature born and low-birth-weight infants.

NICU:
Neonatal Intensive Care Unit. Usually one distinguishes between three different levels of care, where a Level-III NICU provides the most sophisticated intensive care.

NMR:
Neonatal Mortality Rate. The rate, to which, death occurs in live-born neonatal infants. Usually it is distinguished between early NMR, during the first 7 days after birth, and late NMR, from day 8 to 28.

NUTS:
The Nomenclature of Units for Territorial Statistics (NUTS) is a geocode standard for referencing the subdivisions of countries for statistical purposes. The standard is developed and regulated by the European Union, and thus only covers the member states of the EU in detail. The Nomenclature of Territorial Units for Statistics is instrumental in European Union's Structural Fund delivery mechanisms.

Obstetrician:

Doctor specialized in obstetrics, the care for the reproductive tracts of women, and their children, during pregnancy, at birth and after delivery.
Perinatal:
Before birth, that is, during pregnancy.

Rural Area:
In this context, a geographic area that have lower than certain levels of access to neonatal care, and/or the level of care provided by the hospitals that serve these areas. For example distance, travel time, infrastructure, size of the health facility etc.

List of some geocoding systems

Geocoding is the process of finding associated geographic coordinates (often expressed as latitude and longitude) from other geographic data, such as street addresses, or zip codes (postal codes). With geographic coordinates the features can be mapped and entered into Geographic Information Systems, or the coordinates can be embedded into media such as digital photographs via geotagging.

Here are some of the most used geocoding systems used globally or in Europe:

ISO 6709 Standard Representation for Geographic Point Location by Coordinates

ISO 3166 country and subdivision codes

The ISO 3166-1 alpha-2 codes are used in the following standards:

- ISO 3166-2 — Country subdivision code
- ISO 3901 — International Standard Recording Code (ISRC)
- ISO 4217 — Currency code
- ISO 6166 — International Securities Identifying Number (ISIN)
- ISO 9362 — Bank Identifier Codes (BIC), also known as SWIFT codes
- ISO 13616 — International Bank Account Number (IBAN)

IATA airport codes, area /point codes, airports

ICAO airport codes, area /point codes, airports

ITU-R country codes

ITU-T country calling codes

ITU-T mobile calling codes

NUTS area code, partially administrative, worldwide: countries, Europe : country to community

Postal codes, area, worldwide, country-codes by UPU

UN M.49 region codes, area code, continents, countries (like ISO 3166-1 numeric)

SALB (Second Administrative Level Boundaries), by UN

UN/LOCODE, area, administrative, cities. United Nations Code for Trade and Transport Locations, implemented by the United Nations Economic Commission for Europe

UTM - The Universal Transverse Mercator (UTM) geographic coordinate system uses a 2-dimensional Cartesian coordinate system to give locations on the surface of the Earth

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