The Norwegian Neonatal Healthcare Atlas, 2009-2014

An analysis of admissions and treatments of infants at units for sick neonates in Norway in the period 2009-2014

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Foreword, Northern Norway RHA

It is with great pleasure that I introduce a new publication on helseatlas.no: The Norwegian Neonatal Healthcare Atlas, see www.helseatlas.no. This is the second part of the national assignment that the Ministry of Health and Care Services gave the Northern Norway Regional Health Authority (RHA) and the Centre for Clinical Documentation and Evaluation (SKDE) in January 2015.

The atlas was created in cooperation between the Centre for Clinical Documentation and Evaluation (SKDE) in Tromsø and the Norwegian Neonatal Network. Senior Consultant Atle Moen at Oslo University Hospital's Department of Neonatal Intensive Care has been an important contributor to this work.

The Norwegian Neonatal Healthcare Atlas is the first atlas to be based on data from a discipline-specific quality register. It is a pleasure to see quality register data being used and presented in this manner. The great support for the Norwegian Neonatal Network and the professional commitment behind the publication of this atlas demonstrates the expert community's dedication to the promotion of quality in clinical work. The fact that the quality register, in cooperation with the expert community, has wanted to analyse national variation in the use of health services and quality data through a healthcare atlas also bears witness to a desire to promote good prioritisation of resources to these youngest patients. SKDE's competence and infrastructure ensure the legitimacy of the work done and results presented.

The regional health authorities that are responsible for providing good, adequate and equitable specialist health services to the population need to have access to knowledge about the content of and distribution of the health services provided. Healthcare atlases are important instruments in this respect, and I am looking forward to new editions with great anticipation.

Bodø 13 December 2016

Lars Vorland
Managing Director
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Foreword, Norwegian Neonatal Network

The Norwegian Neonatal Network (NNK) was established as a national medical quality register in 2004 and was one of the first national medical quality registers to be established in Norway. Its history began in the late 1980s, when driving forces at Rikshospitalet hospital had flexible and user-controlled software solutions developed to register discipline-specific clinical activities and collect data for use in quality management, improvement and research. With time, this solution was developed into the Norwegian Neonatal Program (*Neonatalprogrammet*), a system for collecting neonatal medicine data.

In spring 2001, it became public knowledge that women at risk of giving birth prematurely had to be transported to e.g. Sweden and Denmark for monitoring and delivery due to inadequate hospital capacity in Norway. As a result, the Storting decided in 2003 to allocate NOK 1.5 million to establishing a Norwegian perinatal medicine database, based on the Norwegian Neonatal Program, to improve the quality of neonatal healthcare in Norway. This database is currently being used by all Norwegian neonatal units, and all data are collected in the national database. The register is allowed to collect data about the health and health problems of neonates without obtaining consent, which is an important precondition for the high registration rate. The register has become an active participant in the Norwegian neonatal medicine community with a focus on monitoring of results, quality improvement and research.

The annual register reports form an important basis for the quality work of neonatal units all over Norway. Institution-based reports are of crucial importance to the internal quality assurance work in the individual units.

The Neonatal Healthcare Atlas describes data from the neonate register from a population-based perspective. This is a new and exciting approach. The population-based perspective offers new insight that begs for an objective assessment. We are not talking about right and wrong, but about how to, as far as possible, provide equitable health services. We have cooperated well with the SKDE in the process of preparing this healthcare atlas. The Norwegian Neonatal Network has taken due account of all protection of privacy considerations throughout the process and in connection with the release of statistics to the healthcare atlas.

Happy reading!

Oslo, 13 December 2016

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Chapter 1

Summary

Neonatal medicine is a discipline that includes intensive care treatment of infants with life-threatening conditions and less intensive supportive treatment or assessment of less seriously ill infants. Most infants admitted to neonatal units come from labour and delivery units directly after birth or from maternity units. Since, for obvious reasons, the patients are unable to give direct descriptions of their symptoms, a lot of the treatment provided to neonates is based on risk assessments and the precautionary principle.

This report covers all neonates (34,738 infants) who were admitted to units for sick neonates in the period from 2009 to 2014. Norway was relatively late in introducing special units for sick neonates. The first neonatal unit was established at Rikshospitalet in the late 1960s. In the 1970s, many county hospitals still did not have separate children's wards or neonatal units, and the most recently founded unit was not established until 1988.

The Norwegian Neonatal Network (NNK), which is the source of the data used in this healthcare atlas, was initiated and developed by the specialist community. At first, the objective was primarily to describe treatment activity and resource use, but the register developed into a quality register with extensive data on patient treatment and outcomes. The Norwegian Neonatal Network has excellent data quality and is practically complete. The register thus provides highly precise descriptions of the health services provided to sick neonates in Norway in the areas that we have analysed. This access to high-quality data that covers practically 100% of a population that has received treatment is unique.

There are no indications that there are significant geographical differences in morbidity among neonates in Norway. However, this review of all admissions to units for sick neonates shows geographical differences, some of them considerable, in the use of neonatal health services that cannot be explained by corresponding differences in morbidity. A newborn child who has to be admitted to a unit for sick neonates will usually have to be separated from its mother, which will be stressful and undesirable from the child's perspective. Admission can therefore only be justified in cases where it is necessary in order to provide necessary treatment and health services cannot be provided to the child without such separation.

The atlas shows a moderate, but clinically interesting, geographical variation in prematurity rates of 30%. The available material gives no basis for concluding as to whether this variation is unwarranted. It is documented that the admission and bed day rates are about twice as high in the hospital referral area with the highest rate compared with the one with the lowest rate, a difference that is interpreted as unwarranted and must be due to differences in admission practices.

The Neonatal Healthcare Atlas also describes differences in treatment preferences and assessments in relation to what is considered appropriate indications for using antibiotics and, not least, differing assessments of when ventilator treatment of infants is required. These differences in rates are also high enough to be characterised as unwarranted.

The atlas also shows a link between the potential overdiagnosis of sepsis (blood poisoning) and high use of antibiotics. There is reason to believe that the use of antibiotics in some hospital referral areas is higher than what is necessary to ensure good healthcare without risking undesirable incidents.

In summary, there is unwarranted variation in all the areas examined. The scope of these differences partly depends on how premature a child is, but there seems to be general variation across the whole range, except for admissions of infants born before 34 weeks, where there is little variation.

Both the extent of variation and the potential overuse of health services give grounds to question whether sick neonates have equitable provision of health services and whether this variation affects quality and patient safety. Neonatal medicine is a discipline that often uses risk assessments in addition to purely clinical assessments to make treatment decisions on an uncertain basis. Such necessary, but nevertheless subjective, assessments are probably a contributory cause of the geographical variation identified. The work to reduce variation and ensure more nationally equitable healthcare for neonates should primarily be carried out by the specialist community itself in professional arenas. Discussions and initiation of studies on the basis of register data are necessary to be better able to determine what the correct level of treatment should be.

Chapter 2

Introduction

2.1 Background

In 1938, the English paediatrician James Alison Glover published a study that showed considerable geographical differences in the rate of tonsillectomy among English schoolchildren, and that both variations in the practice of surgeons and socioeconomic circumstances contributed to these differences (Glover 1938).

Research on variation in the use of health services continued, particularly in the milieu around Professor John Wennberg and Dartmouth College in Vermont, USA. In the late 1960s, Professor Wennberg was responsible for the introduction of the public health insurance scheme Medicare in Vermont, and he was concerned about whether all the residents were receiving the health services they were entitled to. Together with Alan Gittelsohn he started mapping the resource input and the population's health service coverage based on what have subsequently been called 'hospital referral areas', in Norwegian 'boområder', as defined in this report. Wennberg found unexpectedly big variations between hospital referral areas in the use of almost all kinds of health resources, including personnel and expenses. He also found a very high variation between nearby hospital referral areas in the rates of surgical procedures such as appendectomy (four times), tonsillectomy (twelve times) and several other procedures. The remarkable thing was that there was great variation between neighbouring areas just a few blocks apart, and that it was not possible to explain these differences by differences in morbidity. When Wennberg and Gittelsohn tried to publish their results in medical journals, they were rejected repeatedly, because the editors simply could not believe that the results could be correct. Finally, the reputable journal Science published the article because they found the method credible and the conclusions worthy of attention. The work was published in 1973 under the title 'Small area variation in healthcare delivery' (Wennberg and Gittelsohn 1973).

In 1989, Wennberg's group published the article 'Variations in rates of hospitalization of children in three urban communities' in the New England Journal of Medicine' (Perrin et al. 1989), together with paediatrician Donald Berwick, who later founded the Institute for Health Improvement (IHI), among others. The article describes great variation in rates of hospitalisation between the three hospital referral areas of Rochester, New Haven and Boston, all associated with some of the most highly ranked teaching hospitals in the USA. The rate of hospitalisation for children in Boston was more than twice as high as for Rochester, and varied by a factor of more than six for certain diagnosis groups. However, the doctors at the paediatric departments in the three areas studied were completely unaware of the existence of any differences in practice.

In the 1990s, the group published The Dartmouth Atlas of Health Care.[1] The atlas describes the variation in the use of health services for all parts of the American health service across several hundred hospital referral areas in the USA, and it has had an impact on the subsequent American health policy debate. Internationally, the atlas has become the prototype for a growing number of national healthcare atlases that find a corresponding variation in the use of health services - regardless of how the health services are organised and funded.

Wennberg's research was met with both silence and criticism from parties involved in the health service, particularly from parts of the medical community. For many years, its findings challenge the idea of doctors' rational and evidence-based choices in patient treatment. Other research communities, including some in Europe, have focused on studies of variation in the use of specialist health services.

Like in other fields of research, results in small area variation research is also subject to debate on methodological approaches and how to control for differences in population composition (Rosenthal 2012). It is important to elucidate how results are interpreted and what implications the results are to have. Such debate contributes to the development of this field of research (IOM (Institute of Medicine) 2013).

2.2 Variation and responsibility to provide healthcare

The regional health authorities have a responsibility to provide *adequate* and *satisfactory* health services to the population in their respective regions. This responsibility to provide is the primary point of departure for this approach to understanding unwarranted variation in the use of health services. Great variation between the health regions in the use of health services could indicate that the responsibility to provide adequate and satisfactory health services is not fulfilled in a manner that ensures equitable treatment regardless of where patients live, and the variation could be interpreted as unwarranted.

2.3 What are the mechanisms that create variation?

In order to analyse and describe variation, Wennberg has defined three different categories of care with different degrees of variation (Wennberg (2010), see also Figure 2.1): necessary care, preference-sensitive care, and supply-sensitive care.

Necessary care

The first group comprises conditions with clear diagnostic criteria for which patients always seek healthcare, for which hospitalisation is the only treatment option, and for which known effective treatment exists. This group is characterised by the fact that the treatment rate reflects the actual prevalence of these conditions in the population. It was estimated that approx. 10–15% of all treatment provided by the specialist health service concerns patients that fall within this group. Examples include hip fractures and colon cancer. For neonates with a gestational age of less than 34 weeks, admission to a neonatal unit will fall under this category of care. However, this does not mean that all treatment provided to very preterm infants falls within the category necessary care.

[1] `http://www.dartmouthatlas.org`

Both antibiotics and ventilator treatment can be classified as necessary care for some infants, but as preference-sensitive care for others (see next paragraph). If major variation between hospital referral areas is found for conditions that fall under the category of necessary care, there is reason to consider whether there are differences in morbidity or whether there is an actual undercapacity. Alternatively, the variation could be due to patients not receiving necessary care or receiving the wrong treatment.

Preference-sensitive care

The second category is often described as preference-sensitive care. This describes care in cases where there are normally several treatment options and where the indications for and health benefit from a form of treatment may be unclear or controversial in the medical community. It is estimated that approx. 25% of all treatment provided by the specialist health service concerns this category. This is particularly the case in surgical disciplines, where the preferences and subjective judgement of the surgeon or department can influence the choice of treatment, sometimes even conflicting with good evidence-based practice. There will often be greater variation here than in the first category. Examples are well documented in the healthcare atlas 'Day Surgery in Norway 2011–2013' (Balteskard et al. 2015), which shows sometimes considerable variation between hospital referral areas in knee surgery, shoulder surgery, tonsillectomy and several other procedures that cannot be explained by underlying factors such as demographics and morbidity in the population.

Supply-sensitive care

Wennberg's third category of care is supply-sensitive care, which accounts for 50–60% of the specialist health service's activities. Variation in such services are estimated to be the most important cause of variation in the provision of health services. It is characterised by the availability of health services in the form of hospital beds, ICU capacity, medical specialists and diagnostic imaging capacity influencing the demand. When there is an increase in capacity, more patients will be treated until the capacity is filled, without this necessarily resulting in improved health either at an individual or at a population level.

2.4 Unwarranted variation

Terminology

The terminology used to refer to variation that is not due to an underlying difference in demographics or morbidity between hospital referral areas differed somewhat in the first two healthcare atlases. In the Child Healthcare Atlas, such variation was referred to as *unwarranted*, while the day surgery atlas also referred to it as *high* or *moderate*. Both atlases indicated that such variation could be due to over- and/or undertreatment. The Ministry of Health and Care Services' 2016 assignment document to the regional health authorities requested 'indicators to measure unwarranted variation', a request which resulted in a report submitted in November (SKDE 2016). Based on the available description of the reason for variation in health services and the Ministry's wording, the term *unwarranted* is used to describe variation that is not due to coincidence, patient preferences or differences in the composition of the patient group described. It is important to emphasise that, in this context, the term unwarranted is understood as being synonymous with 'undesirable', 'not ordered' and 'unjustified', and it indicates that the service described is not equitably distributed in accordance with the responsibility to provide health services. The term 'unwarranted variation' does not imply a norm for which rate can be deemed to represent the 'correct' level, but describes a variation that does not have any basis in differences in the patient composition (what is known as 'case mix') between hospital referral areas.

It is also important to emphasise that some types of health service variation are desirable, and such desirable variation can arise due to differences in needs or on the basis of the patients' own preferences. If there are equal treatment options, or if there is uncertainty or insufficient evidence to prove that one alternative is better than the other, great importance is to be attached to the patient's own choice. However, patient choice requires patients to be offered objective and balanced information about the different options, and health personnel's' personal preferences must not influence the decision. This is the requirement that underlies the measures covered by the term 'shared decision-making', where the patient is empowered to be capable of making independent, informed choices regarding his or her own treatment.

What is unwarranted variation?

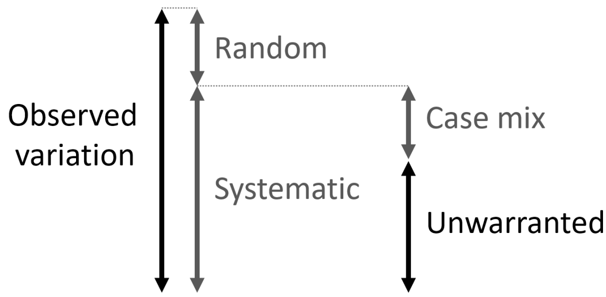

Figure 2.1: Illustration of the components of variation, based on Dishoeck et al. (2011).

As shown in Figure 2.1, observed variation is made up of two components, namely *random variation* and *systematic variation*. Random variation can be caused by fluctuations over time, and this component is most noticeable in connection with small figures. Systematic variation can be explained in full or in part by differences between hospital referral areas in terms of risk of illness or socio-economic or demographic variables. Such variation is often referred to as differences in case mix, or as warranted variation. Although we do not have a detailed overview of the distribution of all factors that can conceivably influence case mix between hospital referral areas, there are no indications that there are differences in risk of illness in neonates in Norway that could explain the extent of variation described in this atlas.

One example of decisions in neonatal medicine where there is general agreement that considerable importance should be attached to the opinion of the next of kin is treatment of infants born before the 25th week of pregnancy (gestational age less than 25 weeks). For these infants, the care pathway is complicated and the outcome uncertain. Norwegian neonatologists have long held differing opinions when it comes to how active the initial treatment of these infants should be, which gives all the more reason to emphasise the parents' opinion, see the discussion of the term 'shared decision-making' above.

There is little reason to believe that parental preferences differ between hospital referral areas if information is provided in an objective manner without healthcare professionals exerting strong influence. If such variation is nevertheless observed between hospital referral areas, that could give reason to assume that the variation is not influenced only by parental preference, but also by the preferences of the individual professional communities.

It is thus necessary to determine how much coincidence and case mix contributes to variation in order to form an impression of the extent of unwarranted variation. In this atlas, we generally deem case mix not to be a significant contributor, while the importance of random variation must be assessed, particularly in relation to the size of the samples.

In a *population perspective,* variation is compared between geographical areas, regardless of where the area's population accessed health services. The use of health services may vary with sex and age, however. Adjustment for sex and age is not considered necessary in a neonatal medicine atlas, since all the patients are the same age and there is no difference between hospital referral areas in the sex ratio at birth. There are different methodological and statistical approaches to measuring variation, from calculating variance and confidence intervals as an expression of the variation in use of health services to more intricate and tailored measurements of variation (Ibáñez et al. 2009). In its healthcare atlases (Balteskard et al. 2015; Moen et al. 2015), SKDE has analysed use of health services by means of the ratios between observed usage rates to arrive at a measurement of variation. These ratios were also assessed in relation to treatment volumes, stability of rates over time and clinical assessments.

In this atlas, the years 2009–2014 are considered together. This approach provides a relatively big data material, but masks any differences in stability and development over time. Regardless of the method used, describing the variation in these figures will necessarily involve a certain element of discretionary judgement.

Variation and prioritisation

Even if the term unwarranted variation is defined as described above, it can also be seen in relation to the objectives and priorities of the public health service. There is broad political consensus in Norway that we are to have a publicly funded health service that guarantees equitable healthcare for everyone. Unwarranted variation between hospital referral areas represents a challenge to this objective.

Unwarranted variation in the use of health services represents a lack of equitable distribution of health resources, and thus a failure to prioritise based on severity and need. The term health resources must be understood to encompass more than money, for example medical technology equipment (MR machines), professional staff (neonatologists, neonatal nurses) and hospital bed capacity with access to intensive care beds.

If variation is due to overuse that does not lead to a health gain, then resources are being used on the wrong patients. This could displace or delay the treatment of patients that could have benefited more from treatment. Simply increasing the supply of resources in a situation with high unexplained variation maintains potential overuse at the same time as one is trying to increase treatment capacity. The result could be that overtreatment increases because the fundamental reasons underlying the incorrect prioritisation are not being addressed. If variation is due to underuse, that means that patients do not receive the services that should, objectively speaking, have been provided. If that is the case, reallocation of resources may be a better way of reducing variation, not least because increasing capacity requires long-term investments in expertise. It takes between five and ten years to train doctors and nurses for specialist functions in e.g. neonatal medicine.

It is therefore important to map unwarranted variation in the health service in order to be able to make rational and evidence-based prioritisation decisions both at the micro- and macrolevel, and to ensure that the population has equitable access to health services.

Variation, quality of treatment and patient safety

Variation that is caused by over- or underuse of health services represents a threat to quality of treatment and to patient safety. Any contact with the health service carries with it a certain risk of illness, complications or injuries, regardless of the original reason for the contact. Admission to an intensive care unit entails exposing neonates to hospital bacteria that are not part of a normal bacterial flora, and, at worst, this could make the child sicker than it was before being admitted. Hospital admission is also associated with a risk of other patient injuries. If the patient might do more or less equally well without the treatment in question, that means that undesirable patient injuries could result in a poorer outcome for the group as a whole than if no treatment had been provided.

There is broad debate in the international medical community about whether overdiagnosis and overtreatment in parts of the health sector are lowering the quality of the health services provided, and whether the outcomes are poorer than they would have been with a less aggressive approach.[2] The British Medical Journal has since 2002 published a number of research articles and editorials under the heading ‘Too much medicine’. Medical examination and treatment will always carry a risk of patient injuries, and this risk increases if too many patients are examined and treated. It may be safer and better to refrain from assessment and treatment if one is uncertain about whether it will result in a significant improvement of the patient’s health.

2.5 Assessment of variation in this atlas

Generally speaking the proportion of the total variation that is due to random variation will be smaller the higher the number of births, the bigger the number of patients in the patient sample, the more hospital referral areas and the smaller the differences between the number of births in the different hospital referral areas. In this analysis, we consistently look at the same hospital referral areas, which means that the number of hospital referral areas and the number of births are kept constant, while the size of the patient samples varies. The scope of random variation will therefore represent a general challenge when making comparisons between hospital referral areas with many and few births, particularly when looking at samples with a small number of treatments or admissions.

This analysis covers all admissions to neonatal units in Norway over a six-year period. It is challenging to determine how much variation is natural and expected and how much is unexpected and considered unwarranted. We look at the total service provision, but also at sub-samples comprising a relatively low number of patients. It is therefore not possible to stipulate a universal or general rule for how much variation is permitted before it is considered unwarranted. Generally speaking, the ratio between high and low rates (less variation) that can be accepted as expressing an unwarranted level of variation is lower than for smaller patient samples.

The different figures provide different information about the variation, such as the number of patients or bed days or treatment days on which the rates are based and the average number of

[2] http://www.bmj.com/too-much-medicine

bed days or treatment days per patient. Seen together, these data say something about how the variation manifests itself. The interpretations are based on looking at all the available information in conjunction. The variable average number of bed days or treatment days per patient in particular must be assessed in conjunction with the patient and day rates from which it is generated. A short average treatment period may signify success in concluding treatment quickly. It could also be due to a low threshold for initiating treatment. A hospital referral area where many patients undergo antibiotic treatment will initiate treatment of more patients without infections than an area with a low treatment rate. As a consequence, areas with high patient rates may have short average treatment periods as a result of treatment being discontinued early because a high number of treated patients are found not to suffer from infections, without this reflecting higher efficiency or resulting in better treatment. The same could apply to admissions, where a high patient rate with a high number of relatively healthy patients admitted will also lead to more rapid discharge, resulting in a short average treatment period per patient.

Chapter 3

Neonatal medicine

Neonatal medicine is a young medical speciality. In the 19th and early 20th century, obstetricians and midwives were responsible for the medical treatment of neonates. There was not much effective treatment available for preterm infants and infants with health problems related to oxygen deprivation during birth, congenital malformations and, above all, infections. Infant mortality was high, but decreased as the 20th century progressed, primarily due to improved hygiene, the population's improved state of nutrition and better antenatal and obstetric care. In addition, the introduction of antibiotics to treat infections in both mothers and children also led to a marked drop in infant mortality from about 1950.

The first attempts at creating an environment with conditions adapted for neonates and premature infants were made by Stéphane Tarnier in Paris in the mid-19th century, and it was modelled on the incubators used for chicken eggs. His work was continued by another Frenchman, Pierre Budin, who in 1907 published one of the first known works on the nutrition and care of premature infants. In 1896 one of Dr Budin's students, Martin Couney, organised an exhibition of infants in incubators during the Berlin World's Fair to which paying visitors were admitted. There was a nurse at each incubator to take care of the child. The parents would come and take their child home when it was big enough to manage with ordinary care.

Incubators were only introduced in hospitals after World War II, when small neonatal units were established in the USA by pioneers and innovators who began to see neonates as independent patients. They tried to create a physical environment and develop methods for treating premature infants that would enable them to resolve the challenges of stable temperature and nutrition. In the 1940s, one of the early pioneers, William Silverman, managed to keep a baby born twelve weeks prematurely alive for several weeks before it died. He wrote about this experience in an article where he describes the practical and ethical challenges involved and the criticism he faced (Silverman 1992).

More neonatal units were established in the USA in the 1950s. It had been discovered that oxygen could be used to improve the survival rate of premature infants, and they were placed in incubators with high concentrations of oxygen. Soon, an epidemic of blindness among children born prematurely became apparent. It took a while before the link between the high concentration of oxygen in the air the infants breathed and the development of what was called incubator blindness, or retinopathy of prematurity, was understood. One example is the musician Stevie Wonder, who was born moderately prematurely in 1950 and became blind after being exposed to high levels of oxygen in the incubator.

The development of neonatal medicine as a separate discipline and field of research really started

Figure 3.1: Babies in incubators. From the 1909 World's Fair in Seattle. Source: Unknown

to gather speed when President Kennedy and his wife had a son in 1963 who was born eight weeks prematurely and died a few days after birth from infant respiratory distress syndrome. Some years earlier, American paediatrician Mary Ellen Avery had identified the cause of premature infants developing severe pulmonary failure as a lack of a surface-active agent in the lungs called surfactant. Surfactant allows the lungs to expand without the child having to generate a higher negative pressure in the chest cavity than the chest muscles are capable of producing. The death of the president's son attracted much attention both in the USA and in the rest of the world, and resulted in a considerable increase in resources and improvements both in clinical neonatal medicine and in research on diseases in neonates and premature infants.

Norway was relatively late getting started with special units for sick neonates (Bratlid and Nordermoen 2010). The first neonatal unit was established at Rikshospitalet hospital in the late 1960s. In the 1970s, many Norwegian county hospitals still did not have separate children's wards or neonatal units. Buskerud county hospital, for example, did not get a dedicated children's department with a neonatal section until 1980.

Well-functioning neonatal units were established at all Norwegian county hospitals in the 1980s and 1990s, and the medical treatment of sick neonates improved greatly. Two important milestones in this medical progress was the introduction of surfactant administered directly into the lungs of immature infants and the practice of giving the mother antenatal steroids before a premature birth, which also helps to mature the baby's lungs. These two treatments have reduced morbidity and mortality in premature infants and made it possible to treat infants born as early as in week 22 or 23 of pregnancy. The treatment available for children with congenital malformations has also developed considerably over the past 30 years. Today, it is possible to treat children with e.g. complicated congenital heart defects for which no treatment existed as recently as in the 1990s.

3.1 Which infants are admitted to neonatal units, and what treatment do they receive?

Neonatal medicine is a discipline that includes intensive care treatment of infants with life-threatening conditions and less intensive supportive treatment or assessment of less seriously ill infants. Examples of less intensive treatment include antibiotics, a flow or air delivered to the nose to help them to breathe (CPAP), nutritional help and time to mature reflexes that keep breathing and blood circulation stable.

Most infants admitted to neonatal units come from labour and delivery units directly after birth or from maternity units. Since, for obvious reasons, the patients are unable to give direct descriptions of their symptoms, a lot of the treatment provided to neonates is based on risk assessments and the precautionary principle.

Reasons for admission include prematurity, jaundice, infections, respiratory problems, various forms of organ failure, cerebral abnormalities and injuries, congenital abnormalities including congenital heart defects, perinatal asphyxia (oxygen deprivation during birth that affects brain function), metabolic conditions and rare syndromes.

Neonatal units are among the hospital units with the longest average stays, typically between 11 and 13 days. However, the length of stays varies greatly, from infants who are admitted for a day for observation to infants who stay for three or four months or even longer after being born extremely prematurely in week 23. The majority of admissions are relatively short admissions of infants born near term, but the majority of bed days are accounted for by preterm or seriously ill infants.

A division of work between different types of neonatal units has been implemented in most, but not all, hospital referral areas. Most infants born before 26 weeks or 28 weeks (this varies between hospital referral areas) are born at university hospitals with regional functions. In the Western Norway Regional Health Authority, both Stavanger and Haukeland University Hospital treat infants born before the 26th week of pregnancy. In the Central Norway Regional Health Authority, the children's department in Ålesund treats infants born as early as in the 23rd week of pregnancy. In South-Eastern Norway Regional Health Authority, however, all births before 26 weeks have been centralised to Oslo University Hospital (OUS), and for most departments, this also applies to births after between 26 and 28 weeks. The work of preparing guidelines for the expertise and staffing of neonatal units in accordance with the guidelines set out in Norway's national healthcare and hospital plan is currently under way under the auspices of the Norwegian Directorate of Health.

Some national functions have been centralised to St. Olavs hospital and OUS Rikshospitalet, primarily the treatment of congenital abnormalities other than heart defects. OUS Rikshospitalet also fills the national function for surgical treatment of all children with congenital heart defects and the treatment of children with certain other extremely rare conditions.

Nevertheless, most treatment days for these patient groups take place at the neonatal unit in their local hospital referral areas, but at a less intensive level. Once the most intensive care has been provided by the unit with the regional function, the child and its parents are normally moved back to the unit responsible for their local hospital referral area, and further supportive treatment is provided at the local neonatal unit.

3.2 Neonatal medicine in Norway in 2016

Norwegian neonatal medicine is advanced in an international context, both in terms of treatment methods and results. Advanced intensive medical treatment is provided at units with regional or national functions, and infants with complex congenital heart defects or abnormalities in other organs are treated by Norwegian surgeons, who achieve some of the world's best results.

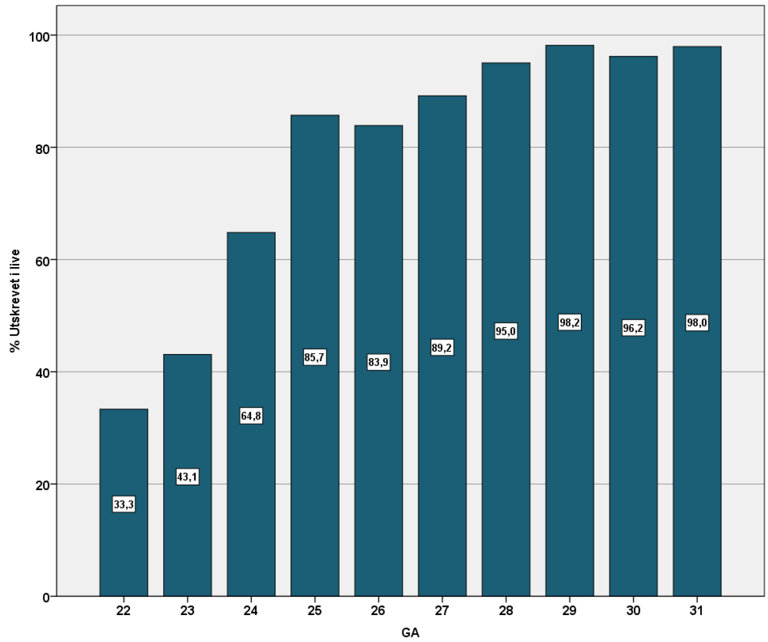

Figure 3.2: Survival in per cent of live births broken down by gestational age/duration of pregnancy regardless of the hospital where the birth took place, Norway, 2012–2015. Source: Norwegian Neonatal Network.

Even in cases when the duration of pregnancy is almost as low as the biological age of viability in week 22, the survival rate was 33% for all births and 43% for infants born in the 23rd week of pregnancy in the period 2012–2015 (Rønnestad, Stensvold, et al. 2016). For 2015, statistics from the Norwegian Neonatal Network show that 72% of all infants born in week 23 of pregnancy who were admitted to a neonatal unit survived infancy. The survival rate increases significantly with each additional week of pregnancy, and from the 25th week, we see survival rates of more than 80%. Not all survive without late effects, but severe functional impairment to the extent that it can later be questioned whether treatment was meaningful is relatively rare.

Sweden and Norway have some of the world's best treatment results for preterm infants measured in survival. The many factors contributing to this situation include good antenatal care, good foetal medicine follow-up and the high level of expertise among Norwegian obstetricians and neonatologist.

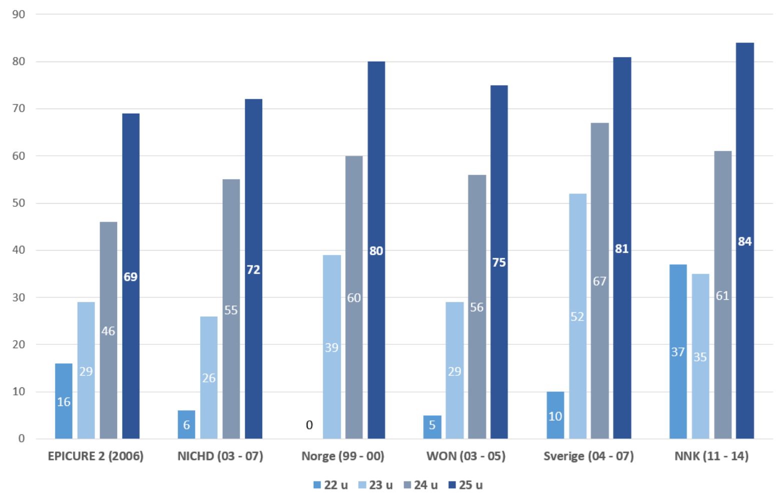

Figure 3.3: Survival rates for Norwegian preterm infants compared with figures from studies conducted in the UK (Epicure), USA (NICHD), figures from a big international register, a Norwegian study from 1999–2000 and up-to-date figures from the Norwegian Neonatal Network for the period 2011–14.

Chapter 4

Norwegian Neonatal Network

The Norwegian Neonatal Network (NNK), which is the source of the data used in this healthcare atlas, was initiated and developed by the specialist community. At first, the objective was primarily to describe treatment activity and resource use, but the register developed into a quality register with extensive data on patient treatment and outcomes. The register was approved as a national medical quality register as early as in 2004. All Norwegian neonatal units have reported to the register since 2009, except for Vestfold Hospital, which only joined the network in 2012. The legal basis for NKK is the Medical Birth Registry Regulations (authorising the collection of data without obtaining consent), and OUS acts as data processor for the Norwegian Institute of Public Health, which is the data controller.

NKK is governed by an advisory board comprising representatives of the neonatal medicine community, the Norwegian Institute of Public Health as the data controller and the register/OUS as the data processor.

The concept for NNK's activity is that treatment activities and outcomes are registered daily in the Norwegian Neonatal Program (Neo). Neo is a computer program developed for neonatal units, and exists as local databases at all Norwegian neonatal units. Encrypted data are exported from these local databases to NNK's national database at OUS Rikshospitalet. Checks have shown that NNK contains complete data from the whole national population of sick neonates - both preterm and term infants. Such a complete register is unusual in an international context. In addition, Norway has a unique personal identity number system that makes it possible to generate data for long-term follow up by linking data from NNK with data from other public registers. Quality registers for neonatal medicine exist in several other countries, including Sweden, Canada, Japan and Australia/New Zealand, but the Norwegian register stands out due to its level of detail and the almost complete coverage for all neonatal units in Norway. This allows for a comprehensive description of scope and outcomes for all neonates treated in Norway.

NNK publishes annual reports that provide institution-based descriptions of the activities at each unit and compare units. These reports are subject to public review at the register's annual conference. The results are then used in the individual units' improvement efforts.

Over the past three or four years, scientific articles based on register data have been published, and several doctoral degree projects based on the register are under way. The incidence of infections in Norwegian neonatal units (Fjalstad et al. 2016), the use of inotropic drugs in the treatment of patients in need of intensive care (Burns et al. 2016), and changes in nutritional practices and the use of insulin to treat high blood sugar levels in extremely preterm infants (Stensvold, Strømmen, et al. 2015) have all been described. An article describing one-year survival and complications relating to the treatment of extremely preterm infants in Norway has been accepted for publication by the American Journal *Pediatrics* (Stensvold, Klingenberg, et al. 2017).

The data for neonates admitted to Norwegian neonatal units used in this atlas can be considered complete for the period 2009–2014, except for the data for Vestfold, which are complete from 2012 and have been estimated for previous years.

The data presented per treatment location make it possible for each unit to compare its performance with that of other units at the same level. In terms of internal quality work in the individual units, this type of reporting also provides an opportunity to observe changes in their own practices over time and, if relevant, take corrective action if changes are observed that are deemed undesirable. Many units have used and continue to use the data presented in the annual reports in this manner.

Admission and treatment rates presented for the whole population of a hospital referral area provide a different picture of the distribution and use of health services, because the challenges associated with differences in patient composition largely become irrelevant. When individual units are compared, differences between their patient groups can result in considerable variation that is not undesirable, but simply a natural consequences of centralisation and the division of functions. For example, the number of patients and number of days of antibiotic treatment at the neonatal unit at OUS will be considerably higher than for any of the other Norwegian units, because OUS treats all extremely preterm infants in the South-Eastern Norway health region for the first weeks of their lives, regardless of where they live.

Data quality

It has become established procedure in all the units to register on admission certain background information about infants (such as weight, length and head circumference), the pregnancy (such as its duration) and the birth (such as whether the child was born vaginally or by caesarean section). Such information is compulsory in order to register the patient in the Norwegian Neonatal Program.

Diagnosis codes for different degrees of prematurity are generated automatically on the basis of the gestational age (duration of pregnancy) entered in the Norwegian Neonatal Program. Procedure codes, for example phototherapy for jaundice or ventilator treatment, are entered automatically on the day when the boxes for such activities are ticked during the daily registration. In this way, all activity is registered on a daily basis, and not as a summary at the end of the stay. This ensures that the registered data are complete and of high quality.

As a result of this, the registration of codes and duration of treatment is of high quality and, for the variables analysed in this atlas, is deemed to be a good and accurate registration of the work carried out at Norwegian neonatal units.

Chapter 5

Data sources, sample and definitions

5.1 Data sources

Norwegian Neonatal Network (NNK)

The Norwegian Neonatal Network (NNK) collects, analyses and reports treatment activity data for all sick or preterm infants admitted to Norwegian neonatal units. The register is described in more detail in chapter 4.

NNK has provided aggregate data for the period 2009–2014 for the defined hospital referral areas,[1] broken down by gestational age group, for use in the analyses in this report. Hospital referral areas are defined on the basis of the mother's address.

Medical Birth Registry of Norway (MBRN)

The Medical Birth Registry of Norway (MBRN) is a national health register containing information about all births in Norway. The objective of the registry is to help to clarify the causes and consequences of health problems related to pregnancy and birth, as well as to monitor the incidence of congenital abnormalities.

All maternity units in Norway must notify the MBRN of births. The notification form contains the names and personal ID numbers of the infants and its parents, and information about the mother's health before and during pregnancy and any complications in connection with the pregnancy or birth. Such information could include medication used by the mother during pregnancy, procedures/interventions during birth, complications during birth, postnatal complications in the mother, whether it was a live birth, any conditions the child have been diagnosed with or signs of congenital abnormalities.

For use in the analyses in this report, the MBRN has supplied aggregate data for the number of births (live births and stillbirths) for the period 2009–2014 in the defined hospital referral areas, broken down by five gestational age groups that describe the duration of the pregnancy at the time of birth (22 weeks-27 weeks and 6 days, 28 weeks-31 weeks and 6 days, 32 weeks-33 weeks and 6 days, 34 weeks-36 weeks and 6 days, and 37 weeks).

[1] NNK lacks data for residents of Vestfold hospital referral area for the years 2009–2011. The analyses are therefore based on the assumption that the number of admissions and length of stays/days of treatment for the three-year period 2009–2011 are identical to the figures for the three-year period 2012–2014.

5.2 Sample

The analyses in this report deal with all patients admitted to neonatal units in Norway in the period 2009–2014 at an age of less than five days, as registered in the Norwegian Neonatal Network (NNK). Stays in several hospitals with direct transfers from one unit to another without the patient being discharged to home in between stays are be registered as one admission. All admissions are counted per hospital referral area. Some units in some areas have had a practice whereby admissions are registered without the child being physically moved from the maternity ward. Registered admissions that did not involve physically moving the patient are not included.

The following six areas have been selected for analysis:

1. Admissions
2. Infections and antibiotic treatment
3. Mechanical ventilation (ventilator treatment)
4. Use of intensive care
5. Phototherapy (light treatment for jaundice)
6. Hypoglycaemia (treatment for low blood sugar)

In the analyses, rates are calculated per 1,000 neonates, and the data for the number of births in each gestational age group come from the Medical Birth Registry of Norway (MBRN). For all the six areas selected for analysis, the patient rates and bed day or treatment day rates are calculated to show the proportion of total births within each of the gestational age groups.

5.3 Definitions

Concepts that are not related to the sampling, but that are important in the presentation and discussion of results, are presented here and in a separate factsheet available in the atlas.

Hospital referral areas

Population areas/hospital referral areas are defined by municipality (for OUS and Akershus, by city district/postal code) on the basis of the mother's address and the health trusts' area of responsibility/catchment area. In this context, hospital referral areas are the same as hospitals or health trusts' catchment areas, i.e. the area where a health trust or hospital is responsible for providing emergency care to the population.

Three of Oslo's city districts (Grorud, Stovner and Alna) belong to the catchment area of Akershus University Hospital (Ahus). Since the Norwegian Neonatal Network has no information about city districts, the three districts in question are coded on the basis of the mother's postal code. The postal codes that correspond to these city districts were identified using data provided by Statistics Norway. Several postal codes cover addresses from more than one city district. In such cases, the postal code is assigned to the district where the majority of people in the postal code area in question belong. This is a somewhat crude and imprecise categorisation, but it is deemed to be sufficiently accurate to link most neonatal unit treatment of patients from the three districts to the correct hospital referral area.

Since these patient groups are relatively small and some areas have a small population, some of the hospital referral areas have been merged with a neighbouring area. This applies to Finnmark and UNN (UNN/Finnmark), Nord-Trøndelag and St.Olav (Trøndelag), and Førde and Bergen (Bergen/Førde). The neonatal unit at Nordlandssykehuset hospital also covers the population of Helgeland, and these areas have been merged (Nordland).

The hospital referral areas are defined in Appendix B, page 85. Short versions of the names of the hospital referral areas are used in the report, in the fact sheets and in the atlas. Table 5.1 shows the hospital referral areas and the short names.

Table 5.1: Hospital referral areas with short names

Hospital referral area	short name
Finnmark health trust og UNN health trust	UNN/Finnmark
Helgeland health trust og Nordlandsykehuset health trust	Nordland
Helse Nord-Trøndelag health trust og St. Olavs hospital health trust	Trøndelag
Helse Møre og Romsdal health trust	Møre og Romsdal
Helse Førde health trust og Helse Bergen health trust	Bergen/Førde
Helse Fonna health trust	Fonna
Helse Stavanger health trust	Stavanger
Østfold health trust	Østfold
Akershus health trust	AHUS
Oslo universitetssykehus health trust	OUS
Innlandet health trust	Innlandet
Vestre Viken health trust	Vestre Viken
Vestfold health trust	Vestfold
Telemark health trust	Telemark
Sørlandet health trust	Sørlandet

Patients

By number of patients is meant the number of neonates that have been admitted to a neonatal unit.

Rate

Rates are used to make hospital referral areas with different population sizes comparable, so that what is compared is use of health services per birth rather than absolute admission or bed day figures. The atlas uses rates per 1,000 births. The rates are calculated for each hospital referral area for the period 2009–2014.

Patient rate/admission rate

By patient rate or admission rate is meant the number of patients admitted to neonatal units, i.e. the number of patients admitted per 1,000 births. The patient rate/admission rate shows what proportion of the infants born in each hospital referral area were admitted to a neonatal unit during the relevant period.

Day rate

By day rate is meant a rate for the number of days the patient has spent in a neonatal unit or the number of days that the patient has undergone a certain type of treatment at a neonatal unit. The day rate is expressed as the number of bed days or the number of treatment days per 1,000 births for each hospital referral area during the period.

Length of stay or treatment period per patient

By length of stay or treatment period per patient is meant the average number of bed days or treatment days per patient (admitted to a neonatal unit).

Ratio and variation

By ratio is meant the relationship between the highest and lowest rates. The ratio is used as a measure of variation. Because the element of random variation depends on the size of the patient sample, the interpretation of the ratio will also depend on the size of the patient sample. The smaller the sample, the greater the chance that the result is due to coincidence.

$$\text{Ratio (FT)} = \frac{\text{Rate for the hospital referral area with the highest rate}}{\text{Rate for the hospital referral area with the lowest rate}}$$

The analyses and assessments of variations also use ratios calculated by looking at the second highest rate in relation to the second lowest rate (FT_2) and the third highest rate in relation to the third lowest rate (FT_3). FT, FT_2 and FT_3 are given in Table C.1 on page 90.

Hospital referral area ratios and variation profiles

The hospital referral area ratio is the rate of each hospital referral area in relation to the national rate. It is used to make variation profiles that illustrate the variation, see Figure 5.1. The hospital referral area ratio is calculated as follows:

$$\text{Hospital referral area ratio}_i = \frac{\text{Rate of hospital referral area } i}{\text{National rate}}$$

If the rate of a given hospital referral area is equal to the national rate, the hospital referral area ratio for the area in question will equal one. If the hospital referral area ratios show considerable dispersion, i.e. if many hospital referral areas have a ratio that is considerably different from one, this would give reason to say that there is great variation. The greater the difference between hospital referral area ratios, the greater the variation (see Figure 5.1).

Figure 5.1 illustrates some theoretical variation profiles linked to Wennberg's categories of care. It is nevertheless not the case that variation will always be low for all groups of necessary care. Correspondingly, variation is not always moderate and high for preference-sensitive and supply-sensitive care.

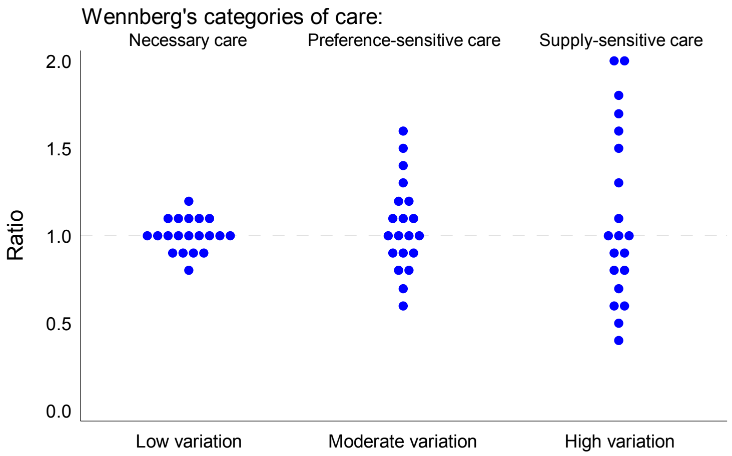

Figure 5.1: Illustration of variation profiles and variation assessments, all other factors being equal.

Gestational age (GA)

By gestational age (GA) is meant the period from the first day of the last menstrual period measured in whole weeks and days. Infants born before 37 weeks are defined as preterm infants, and infants born from 37 weeks and 0 days are considered to be born at term. Gestational age is sometimes referred to as length of pregnancy. The following gestational ages and notations are used in the analyses:

All: All births regardless of gestational age

Term infants: Gestational age more than 36 weeks and 6 days (GA > 36.6)

Preterm infants: Gestational age less than 37 weeks (GA < 37.0)

Late preterm infants: Gestational age 34 weeks to 36 weeks and 6 days (GA 34.0–36.6)

Early preterm infants: Gestational age less than 34 weeks (GA < 34.0)

Moderately preterm infants: Gestational age 28 weeks to 36 weeks and 6 days (GA 28.0–36.6)

Extremely preterm infants: Gestational age less than 28 weeks (GA < 28.0)

The sum of a baby's gestational age and the number of days since birth is also called postmenstrual age (PMA). In this report, the term postmenstrual age is only used to describe the median age of discharge from neonatal units.

Missing data

NNK lacks data for residents of Vestfold hospital referral area for the years 2009–2011. The analyses are therefore based on the assumption that the number of admissions and bed days/treatment days for the three-year period 2009–2011 are identical to the figures for the three-year period 2012–2014.

5.4 Adjustment for incidence of prematurity

As described above, the observed variation will comprise a component caused by random variation, a case mix-related component and a component caused by differences in medical practices and services (unwarranted variation). For neonates, the case mix component will mainly be due to differences in morbidity among preterm infants or differences in the incidence of prematurity.

Smith et al. showed that in the UK, population-based survival and the need for neonatal medical treatment in infants born before the 34th week of pregnancy vary with socio-economic status. This is related solely to a difference in the prematurity rate, which increases as socio-economic status drops. There is no difference in the infants' survival or morbidity when the figures are adjusted for the difference in the prematurity rate (Smith et al. 2009).

When assessing the variation in the use of neonatal medical treatment, the case mix component will therefore first and foremost be related to variation in the incidence of premature births. If it varies between hospital referral areas, that will make it more difficult to estimate the case mix component of the observed variation.

In order to assess the size of the case mix component, and thereby also the size of the unwarranted variation, it is therefore necessary to establish the extent to which the incidence of prematurity, i.e. the prematurity rate, varies between different hospital referral areas.

The Medical Birth Registry of Norway reports annual prematurity rates. In recent years, Norway's prematurity rate has been about 6%. The prematurity rate for each county can vary a lot from year to year. The average prematurity rate for a longer period must therefore be considered in order to determine whether there is an actual variation in premature births between different hospital referral areas.

The patient sample is based on data obtained from the Medical Birth Registry of Norway showing premature births by hospital referral area for the period 2009–2014.

All preterm infants (GA < 37)

Fonna hospital referral area has the highest prematurity rate, at 74 per 1,000 births. The prematurity rate in Fonna is 30% higher than in the hospital referral area of UNN/Finnmark, which has the lowest prematurity rate at 57 per 1,000 births.

Infants born at a gestational age of 34 weeks to 36 weeks and 6 days (GA 34.0–36.6)

For late preterm births, UNN/Finnmark hospital referral area has the lowest prematurity rate at 39 per 1,000 births. The prematurity rate of Innlandet hospital referral area is 30% higher, at 52 per 1,000 births.

Infants born at a gestational age of less than 34 weeks (GA < 34)

For patients with a gestational age of less than 34 weeks the prematurity rate varies from 17 per 1,000 births in Møre og Romsdal to 25 per 1,000 births in Telemark. This means that for this group, the prematurity rate of Telemark is 47% higher than that of Møre og Romsdal.

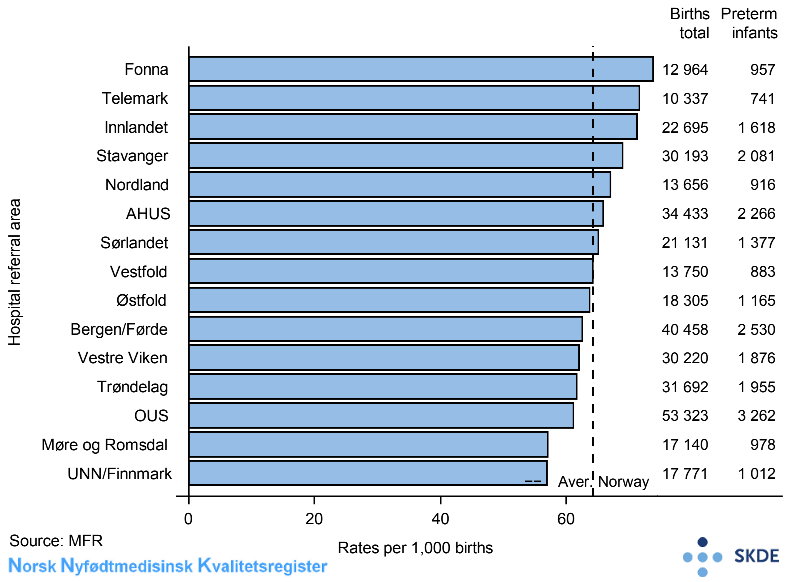

Figure 5.2: Prematurity rate, all premature births, rates per 1,000 births per hospital referral area, in total for the period 2009–2014.

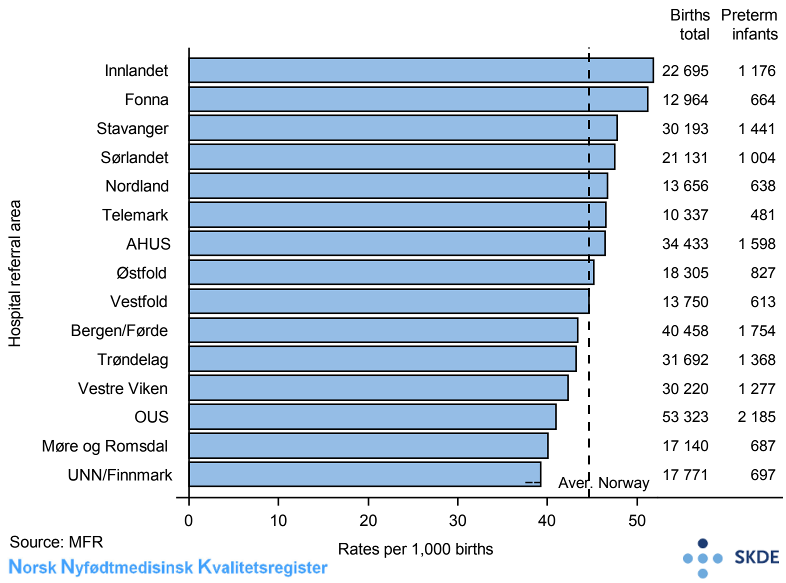

Figure 5.3: Prematurity rate, gestational age 34 weeks to 36 weeks and 6 days (GA 34.0–36.6), rates per 1,000 births per hospital referral area, in total for the period 2009–2014.

The prematurity rates for infants with a gestational age of less than 37 weeks vary by 30% between hospital referral areas. This is a somewhat surprising finding, but the variation is so great that it will have an effect on systematic variation through case mix if it is not taken into account. Therefore, all rates in this atlas are calculated on the basis of the number of births in the relevant gestational age group.

Prematurity rates vary by 30–50% between hospital referral areas for all premature births, except for extremely preterm births (gestational age less than 28 weeks), for which the variation between hospital referral areas is 100%. The number of births in this group is small (1,516 births during the period), so there could be a considerable element of random variation.

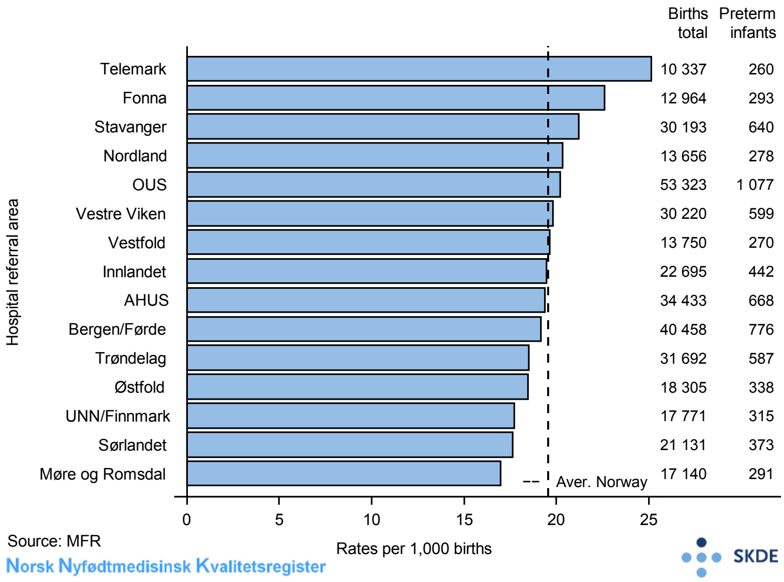

Figure 5.4: Prematurity rate, gestational age less than 34 weeks 6 days (GA < 34.0), rates per 1,000 births per hospital referral area, in total for the period 2009–2014.

Table 5.2: Prematurity rates, ratios (FT) and births in different gestational age groups

GA	Rate Norway	Births	FT	Highest rate - Lowest rate	
>36.6	930	342,249	1.0	940 – 914	Møre og Romsdal – Fonna
<37.0	64	23,617	1.3	74 – 57	Fonna – UNN/Finnmark
34.0–36.6	44	16,410	1.3	52 – 39	Innlandet – UNN/Finnmark
<34.0	20	7,207	1.5	25 – 17	Telemark – Møre og Romsdal
28.0–36.6	60	22,101	1.3	68 – 53	Fonna – UNN/Finnmark
<28.0	4.1	1,516	2.0	5.9 – 3.0	Fonna – Møre og Romsdal

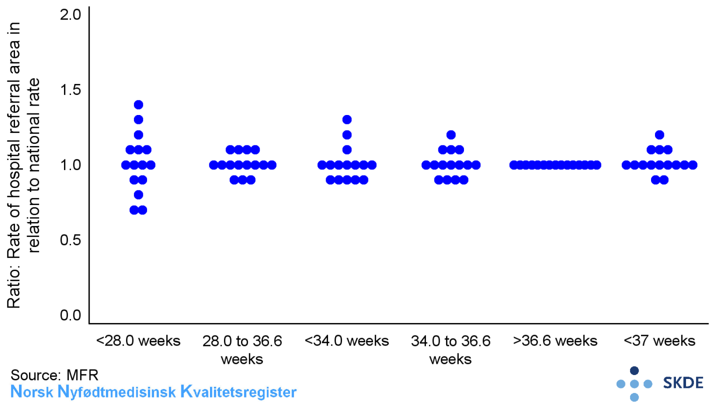

Figure 5.5: Variation profiles, prematurity rates.

Chapter 6

Results

6.1 Admissions

Admissions to neonatal units before the age of five days almost always means that the child is admitted directly from the hospital's delivery and maternity unit. Some are admitted from home after falling ill during the first few days after leaving the maternity unit, while a small number of infants are admitted after home births.

Many children are born in hospitals without a neonatal unit. Births that have been deemed to involve an increased risk of complications or illness in the child or women who are at risk of delivering prematurely before the 35th or 36th week of pregnancy are routinely moved to a maternity unit at a hospital with a neonatal unit.

Nevertheless, infants may fall ill unexpectedly or complications could arise during birth that result in the child needing emergency medical treatment. All maternity units are equipped and competent to make assessments and initiate necessary emergency care measures should such a situation arise. This will be done in cooperation between the midwives, gynaecologists and anaesthesiologists at the hospital in question. Infants who are considered potentially ill are not treated in maternity units anywhere in Norway, but are moved to a hospital with a special neonatal unit by a suitable form of transport.

What distinguishes admissions to neonatal units from most other hospital admissions is that the child was usually already in hospital. This means that the travel distance from the home is not relevant as an explanation for any variation in admission practices.

Admissions to neonatal units will usually be based on medical factors. Infants who weigh less than 2 kg or are born before the 34th week of pregnancy can usually not be treated in a maternity unit throughout their stay. However, there will be differences between hospitals in terms of how they deal with e.g. moderately preterm infants born between weeks 34 and 36, or infants who need ultraviolet light treatment for jaundice. In many hospitals, there will be close cooperation between the maternity ward where the child is admitted and nurses and doctors from the neonatal unit who give advice and supervise the baby so that it does not have to be moved to the neonatal unit. Such a practice requires systematic training and maintenance of the maternity unit staff's skills.

The most important argument against transferring infants from the maternity unit to the neonatal unit is not a wish to limit the use of resources, but a wish to avoid physically separating the mother and child during what is a vulnerable period for both of them. Most Norwegian neonatal units are still quite cramped, built to accommodate a child of 50 cm and a nurse. There are few undisturbed areas with room for the parents to stay with the child in the way that is possible in a maternity unit. Physical separation constitutes a breach of the child's statutory right to have at least one of his/her parents present round the clock, and is often very stressful and difficult for the new parents.

Admission to neonatal units will often be based on a risk assessment of symptoms that could have several different reasons. A typical case is a child whose breathing is a bit rapid during the first 24 hours and where the mother's waters broke 26 hours before the child was born. Such a child will often, but not always, be admitted to a neonatal unit for observation and will often, but not always, be treated with antibiotics to be on the safe side, as these symptoms could be consistent with an early-stage infection. Blood tests are of limited value. In most such cases, it will turn out in a few days that the child has no infection, and the child will be returned to the maternity unit or discharged and sent home with the parents.

An admission that starts before day 5 can involve stays at several departments. Most neonatal units outside regional hospitals have a lower limit for how preterm infants they receive, and it is normally drawn at between 26 and 30 weeks. Infants born before this time are delivered at one of five hospitals; Oslo University Hospital, Stavanger University Hospital, the University Hospital of Northern Norway, Haukeland University Hospital or St. Olavs Hospital. During the period we are looking at in this healthcare atlas, Nordlandssykehuset hospital in Bodø and Sykehuset Møre og Romsdal hospital in Ålesund have also treated infants born as early as in the 23rd week of pregnancy.

Children with serious congenital abnormalities, serious complications related to premature birth and children with a health situation that is very demanding in terms of resources are usually treated at regional hospital level. The neonatal unit at Rikshospitalet hospital holds a unique position among Norwegian neonatal units, since it is responsible for the national function for treatment of children with complex congenital heart defects and certain other complicated abnormalities. St. Olavs Hospital also receives children with congenital gastrointestinal or urinary tract abnormalities.

Infants who are born at a regional hospital are nearly always transferred to their local hospital before being discharged home. In many cases, the most demanding part of the admission in terms of resources will take place at regional hospital level, while most of the treatment days will be at the neonatal unit at the child's local hospital. The regional and local treatment levels cooperate closely.

All admissions and the total number of days spent in neonatal units are registered in the Norwegian Neonatal Network for infants who were younger than five days on admission. Stays in several hospitals with direct transfers from one unit to another without the patient being discharged to the home in between stays will be registered as one admission. Some units at some hospitals have had a practice whereby admissions are registered without the child being physically moved from the maternity ward. Registered admissions that did not involve physically moving the patient are not included in this analysis.

6.1.1 All admissions

On average, 5,800 infants are admitted to neonatal units in Norway each year. Approximately 60% of them (3,500) are born in week 37 or later (not preterm), approximately 22% (1,250) are born between weeks 34 and 37 (late preterm), and approximately 18% (1,050) are born before the 34th week of pregnancy.

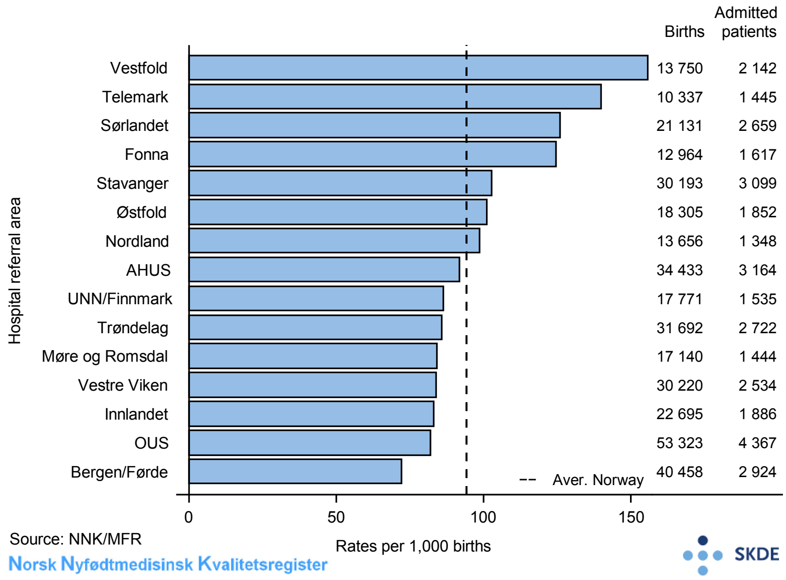

Figure 6.1: Patients, admissions, all gestational ages, rates per 1,000 births per hospital referral area, in total for the period 2009–2014.

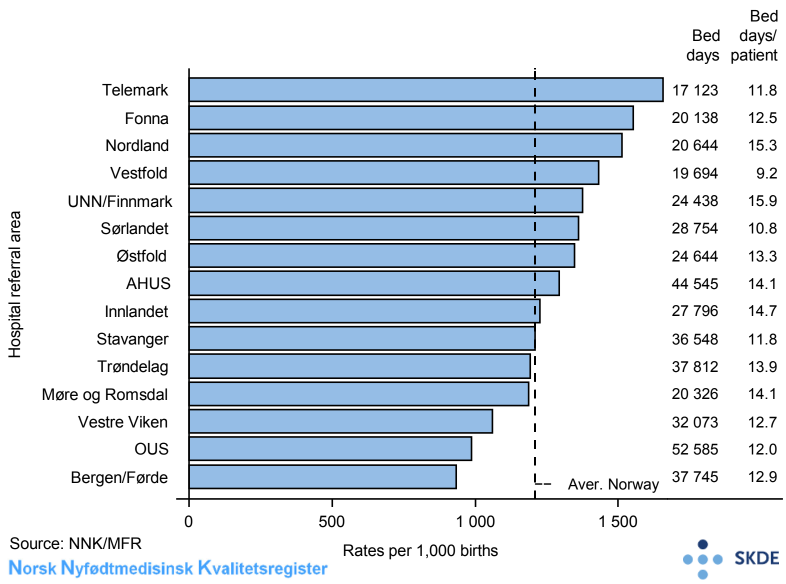

Figure 6.2: Length of stay, admissions, all gestational ages, rates per 1,000 births per hospital referral area, in total for the period 2009–2014.

The admission rate in neonatal units for all neonates regardless of length of pregnancy varies from 72 admissions per 1,000 births in Bergen/Førde hospital referral area to 156 admissions per 1,000 births in Vestfold. This means that more than twice as many neonates are admitted in Vestfold hospital referral area as in Bergen/Førde. The average national admission rate is 94 admissions per 1,000 births. Out of the 15 hospital referral areas, 9 have admission rates lower than 100, which means that in these areas, fewer than 10% of neonates are admitted to a neonatal unit.

The bed day rate in Telemark hospital referral area, which has the highest rate at 1,656 bed days per 1,000 births, is 80% higher than the bed day rate in the Bergen/Førde area, which has the lowest rate at 933 bed days per 1,000 births. For the country as a whole, the bed day rate for the period was 1,209 days per 1,000 births.

6.1.2 Infants with a gestational age of 37 weeks or more (GA > 36.6)

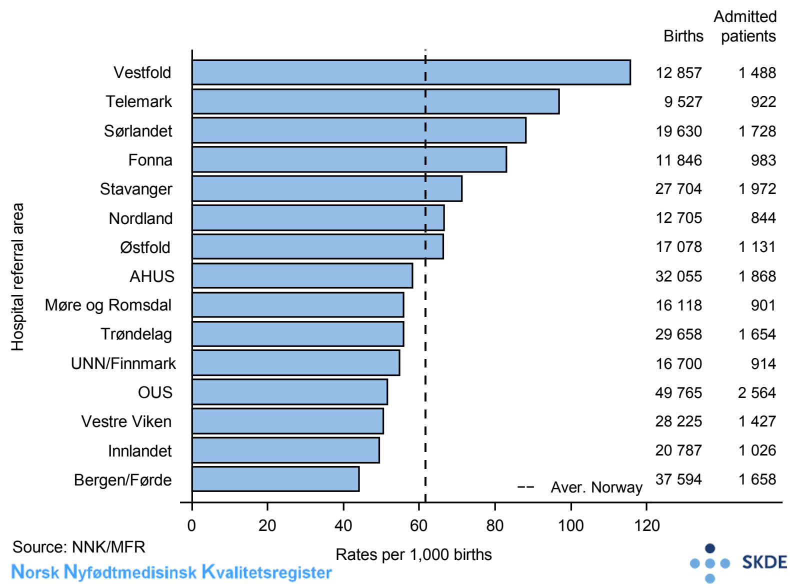

Figure 6.3: Patients, admissions, gestational age 37 weeks or more (GA > 36.6), rates per 1,000 births per hospital referral area, in total for the period 2009–2014.

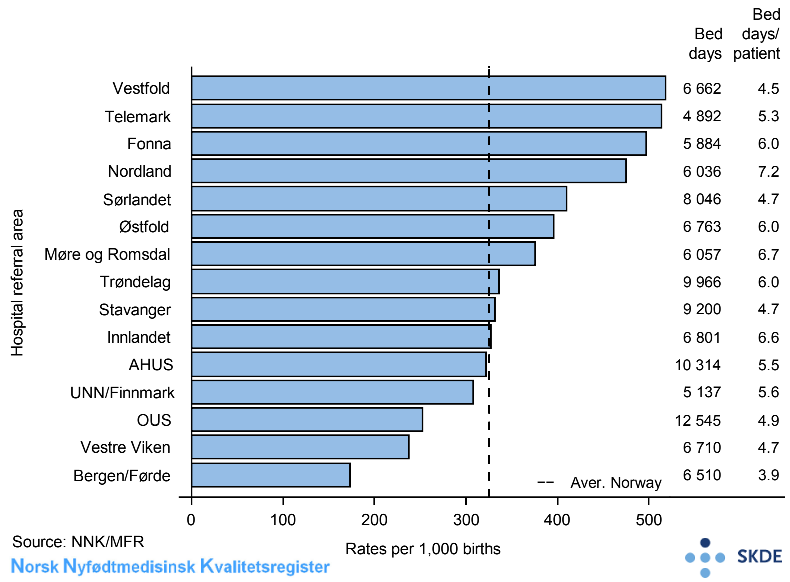

Figure 6.4: Length of stay, admissions, gestational age 37 weeks or more (GA > 36.6), rates per 1,000 births per hospital referral area, in total for the period 2009–2014.

The admission rate in neonatal units for term infants varies from 44 admissions per 1,000 births in Bergen/Førde hospital referral area to 116 admissions per 1,000 births in Vestfold. This means that 2.6 times as many infants are admitted in Vestfold hospital referral area as in Bergen/Førde. For the country as a whole, 62 term infants per 1,000 births are admitted to neonatal units.

The bed day rate for term infants varies greatly. Vestfold hospital referral area has a rate of 518 bed days per 1,000 births, which is three times that of the Bergen/Førde area, which has a rate of 173 bed days per 1,000 births. The average bed day rate for the country as a whole is 326 bed days per 1,000 births.

6.1.3 Infants born at a gestational age of 34 weeks to 36 weeks and 6 days (GA 34.0–36.6)

Vestfold hospital referral area had more than twice as many admissions of late preterm infants born at a gestational age of between 34 weeks and 36 weeks and 6 days (711 admissions per 1,000 births) as Bergen/Førde hospital referral area (348 admissions per 1,000 births). The admission rate for Norway as a whole is 453 admissions per 1,000 births, which means that 45% of all infants born at a gestational age of between 34 weeks and 36 weeks and 6 days are admitted.

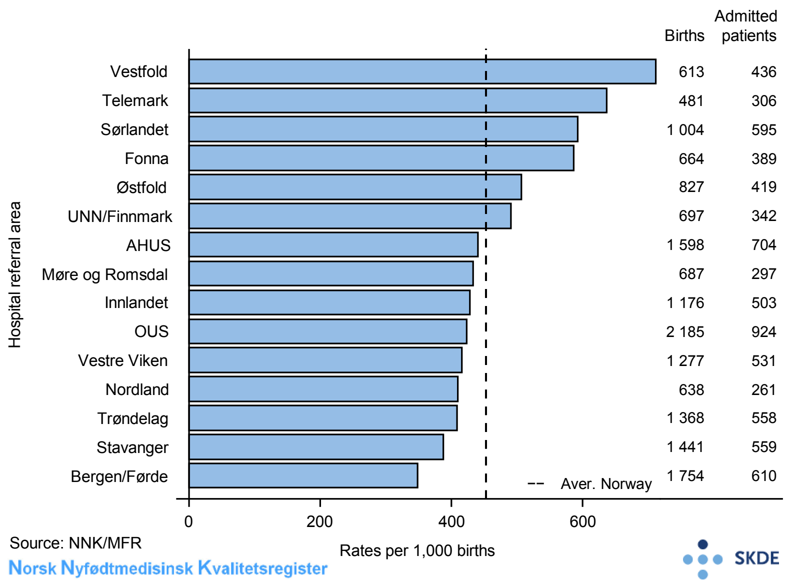

Figure 6.5: Patients, admissions, gestational age 34 weeks to 36 weeks and 6 days (GA 34.0–36.6), rates per 1,000 births per hospital referral area, in total for the period 2009–2014.

UNN/Finnmark hospital referral area has the highest bed day rate for late preterm infants, at 7,901 bed days per 1,000 births. The rate of UNN/Finnmark is more than twice that of Bergen/Førde hospital referral area, which has a bed day rate of 3,440 bed days per 1,000 births. The national average is 5,127 bed days per 1,000 births. The average length of stay varies from 9.2 days in Vestre Viken to 16.1 days in UNN/Finnmark.

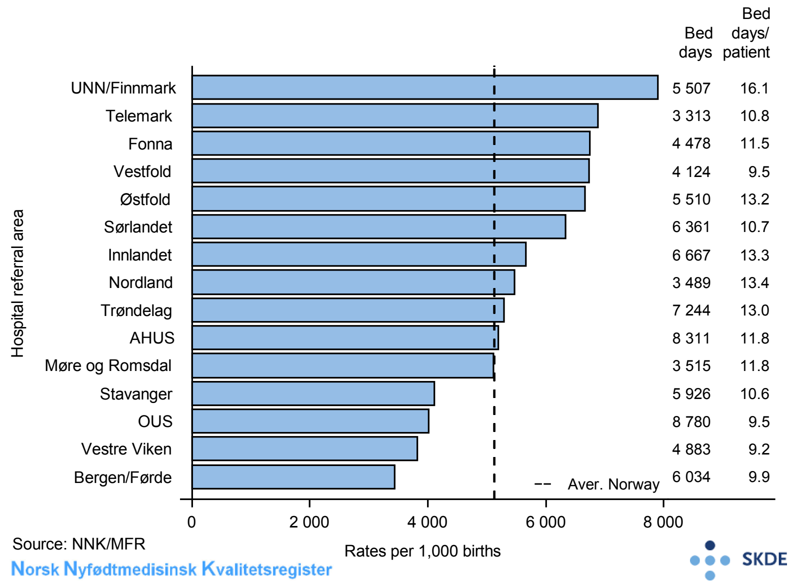

Figure 6.6: Length of stay, admissions, gestational age 34 weeks to 36 weeks and 6 days (GA 34.0–36.6), rates per 1,000 births per hospital referral area, in total for the period 2009–2014.

6.1.4 Infants born at a gestational age of less than 34 weeks (GA < 34.0)

Most infants born at a gestational age of under 34 weeks are admitted to a neonatal unit. Vestfold hospital referral area had the lowest rate, at 807 admissions per 1,000 births. Vestre Viken, which had the highest rate, had 962 admissions per 1,000 births, or 20% more admissions than Vestfold. For the country as a whole, 864 infants per 1,000 births were admitted to neonatal units.

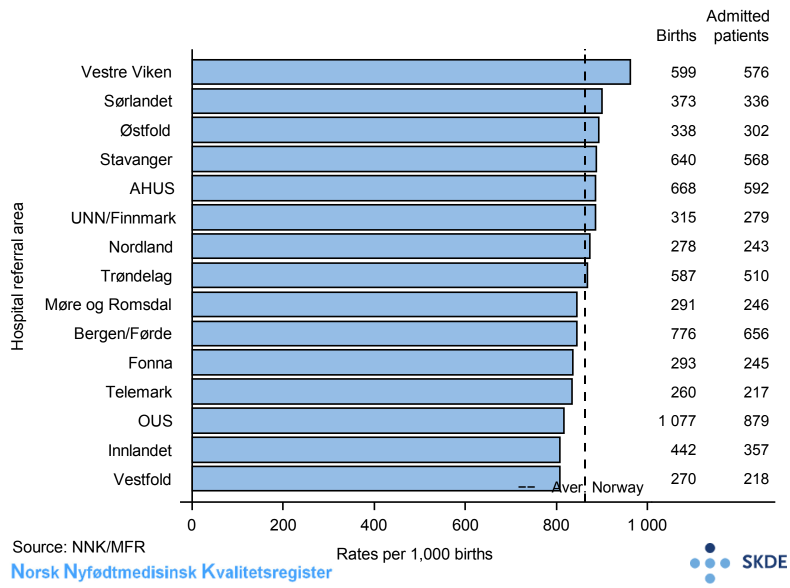

Figure 6.7: Patients, admissions, gestational age less than 34 weeks (GA < 34.0), rates per 1,000 births per hospital referral area, in total for the period 2009–2014.

For this group, the bed day rate was lowest in OUS hospital referral area, at 29,025 bed days per 1,000 births, and highest in UNN/Finnmark, at 43,790 bed days per 1,000 births. This means that the rate was 50% higher in UNN/Finnmark than in OUS. The average length of stay for the country as a whole is 38.4 days, and it varies from an average of 35.6 days for the hospital referral areas of OUS and Vestre Viken to 49.4 days in UNN/Finnmark.

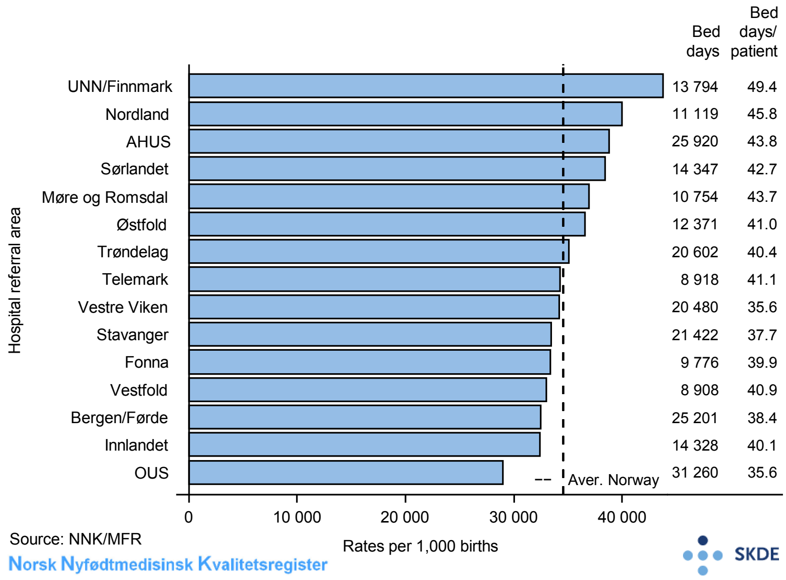

Figure 6.8: Patients, admissions, gestational age less than 34 weeks (GA < 34.0), rates per 1,000 births per hospital referral area, in total for the period 2009–2014.

6.1.5 Postmenstrual age on discharge home

Postmenstrual age (PMA) on discharge home is another way of measuring the length of hospital stays. Postmenstrual age is the sum of the gestational age plus age from birth stated as weeks and days. In Norway, the normal due date is defined as postmenstrual age 40 weeks and 2 days.

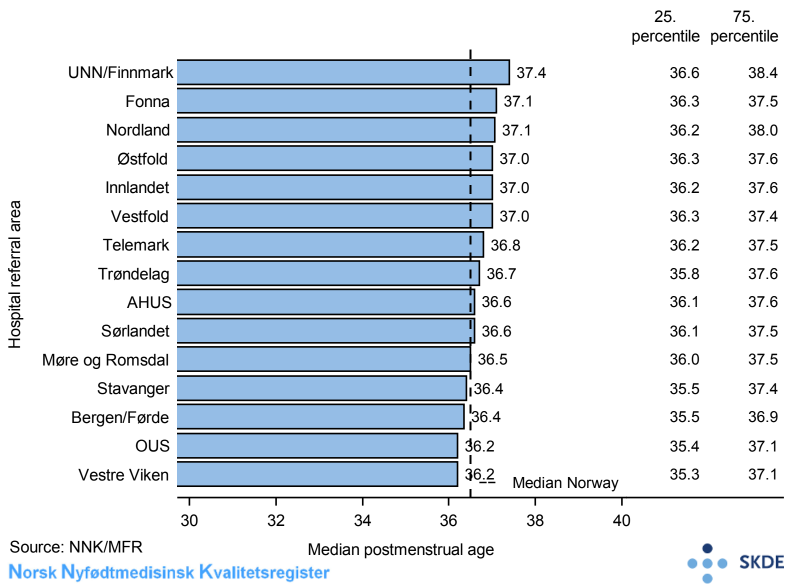

Figure 6.9: Postmenstrual age on discharge, gestational age 28 weeks to 36 weeks and 6 days (GA 34.0–36.6), rates per 1,000 births per hospital referral area, in total for the period 2009–2014.

For infants with a gestational age of between 28 weeks and 36 weeks and 6 days, the average postmenstrual age on discharge home varies from 36.2 weeks in the hospital referral areas of Vestre Viken and OUS to 37.4 weeks in UNN/Finnmark hospital referral area.

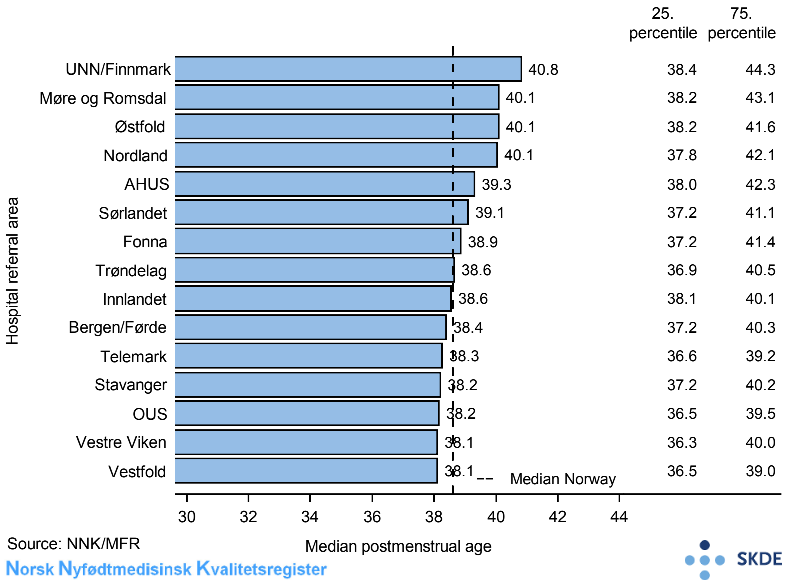

Figure 6.10: Postmenstrual age on discharge, gestational age less than 28 weeks (GA < 28.0), rates per 1,000 births per hospital referral area, in total for the period 2009–2014.

For infants with a gestational age of less than 28 weeks, PMA on discharge home varies from 38.1 weeks in Vestfold and Vestre Viken to 40.8 weeks in UNN/Finnmark hospital referral area.

6.1.6 Summary

There is considerable variation between hospital referral areas, both in admission rates and in bed day rates. The greatest variation is found for term infants. There are 2.6 times as many term infants being admitted in Vestfold hospital referral area as in the Bergen/Førde area, and the bed day rate is three times as high. There is less variation for late preterm infants, and little variation for the most preterm infants (gestational age less than 34 weeks). For a more in-depth discussion of the results, see Chapter 7.

6.2 Infections and antibiotic treatment

Suspected infection is the most common cause of term infants being admitted to neonatal units. Symptoms of infection in neonates are nonspecific, and it is often impossible to determine with a sufficient degree of certainty whether a child who breathes more rapidly than normal has an infection that requires treatment or is only experiencing passing symptoms as part of the process of adapting to life outside the mother's body. However, all neonatologists with some years' experience have seen patients go from clinically healthy to critically ill in a matter of hours and sometimes die from an infection. There is therefore broad agreement among neonatologists and is considered good clinical practice to start antibiotic treatment if neonates show symptoms that could be a sign of a beginning infection.

Sepsis can be diagnosed on the basis of either an overall clinical picture that give grounds for concluding that the condition is clinical sepsis or specific bacteria growing in a blood culture from the child. In 94% of cases, sepsis is diagnosed on the basis of the patient's clinical condition, while only 6% of sepsis diagnoses in term infants are made on the basis of bacteria detected in blood cultures (Fjalstad et al. 2016).

In 2006, the Norwegian Society of Pediatricians' interest group for neonatal medicine established a consensus on the use of the diagnosis clinical sepsis with the following criteria, all of which must be met:

1. Clinical signs of infection
2. Maximum CRP (blood test infection marker) level > 30
3. Minimum five days of antibiotic treatment
4. Other causes that could explain the clinical picture must be excluded.

Criteria 1 and 4 will be subject to the individual doctor's discretionary judgement. It is therefore conceivable that the use of the sepsis diagnosis can vary considerably despite these criteria being established.

Each year, approximately 2,300 neonates, which corresponds to 40% of all infants admitted to hospital and 3.8% of all neonates, undergo a short or long course of antibiotic treatment.

Generally speaking, the risk of infection increases as the length of pregnancy decreases, and infants born before the 30th week of pregnancy in particular are often routinely put on antibiotics after birth.

There is no epidemiological basis for claiming that the incidence of sepsis in neonates should vary between hospital referral areas.

The total use of antibiotics can also be reduced by discontinuing antibiotic treatment early for infants who display no clinical symptoms or if the laboratory findings do not support the early suspicion of infection. Norwegian guidelines recommend discontinuing treatment within 36–48 hours if the suspicion of sepsis is no longer supported by clinical criteria (Klingenberg and Nakstad 2015).

The patient sample consists of all infants admitted to Norwegian neonatal units who are registered in the Norwegian Neonatal Network by daily ticking of the relevant box as having been treated with antibiotics for at least one day.

6.2.1 Infants with a gestational age of 37 weeks or more (GA > 36.6)

More than twice as many neonates resident in Stavanger hospital referral area are treated with antibiotics compared with Bergen/Førde. While 15.9 infants per 1,000 births are treated with antibiotics in Bergen/Førde, 36.7 infants per 1,000 births receive such treatment in Stavanger. The incidence of infections in the national cohort 2009–2011, which is partly included in this sample, was 9.1 cases per 1,000 births (Fjalstad et al. 2016). This means that in Bergen/Førde hospital referral area, 1.75 times as many patients are started on antibiotics as the national incidence of infections would indicate, and in Stavanger hospital referral area 4 times more patients start antibiotic treatment than the national infection incidence would indicate.

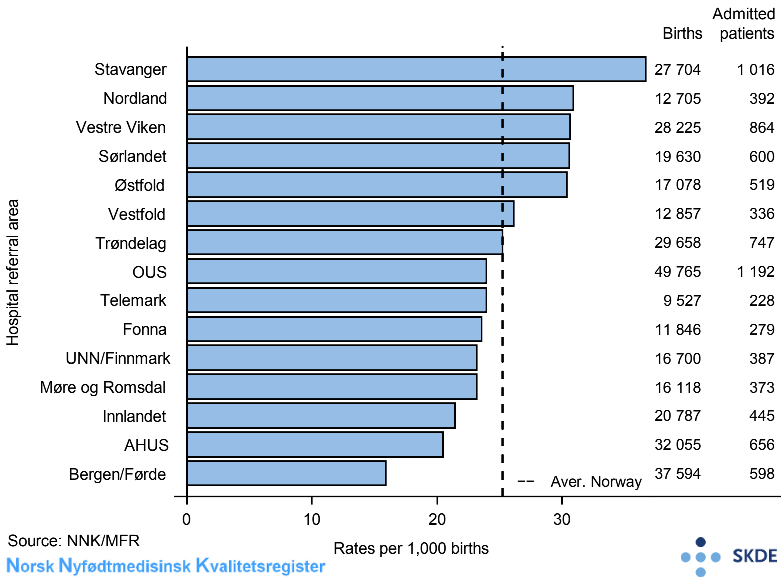

Figure 6.11: Antibiotic treatment, number of patients admitted, gestational age 37 weeks or more (GA > 36.6), rates per 1,000 births per hospital referral area, in total for the period 2009–2014.

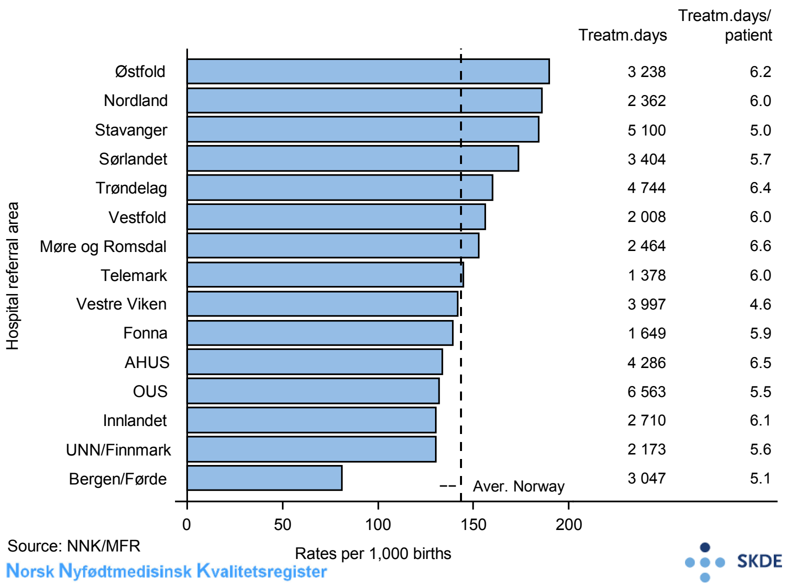

Figure 6.12: Antibiotic treatment, number of bed days, gestational age 37 weeks or more (GA > 36.6), rates per 1,000 births per hospital referral area, in total for the period 2009–2014.

Østfold hospital referral area had 190 treatment days for neonates per 1,000 births, while the corresponding figure for Bergen/Førde was 81. This is more than twice as many treatment days for neonates in Østfold as for neonates in Bergen/Førde hospital referral area. The average period of treatment per patient varies from 4.6 days in Vestre Viken hospital referral area to 6.6 in the Møre og Romsdal area.

6.2.2 Infants born at a gestational age of 34 weeks to 36 weeks and 6 days (GA 34.0–36.6)

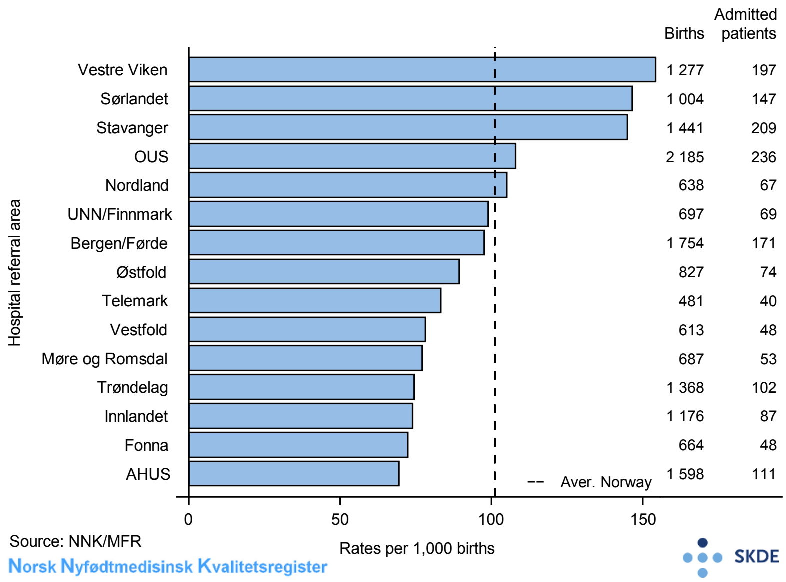

Figure 6.13: Antibiotic treatment, number of patients admitted, gestational age 34 weeks to 36 weeks and 6 days (GA 34.0–36.6), rates per 1,000 births per hospital referral area, in total for the period 2009–2014.

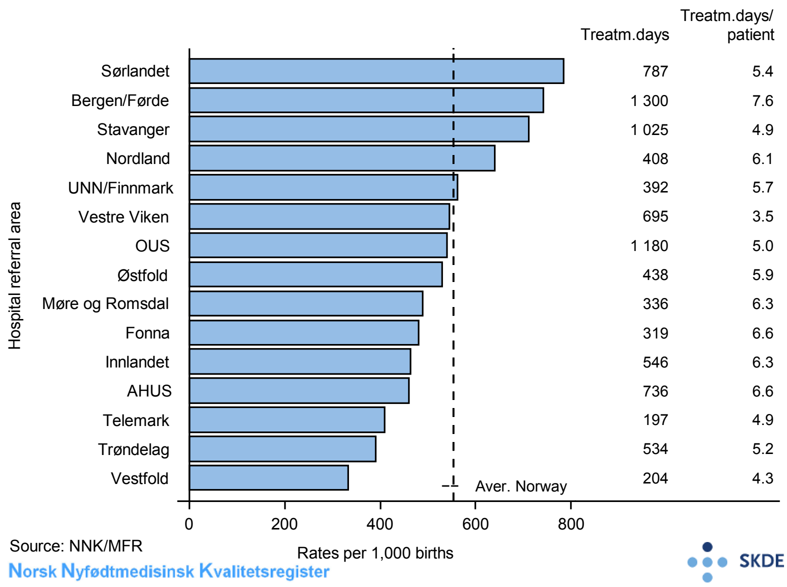

Figure 6.14: Antibiotic treatment, number of bed days, gestational age 34 weeks to 36 weeks and 6 days (GA 34.0–36.6), rates per 1,000 births per hospital referral area, in total for the period 2009–2014.

For late preterm infants (gestational age 34 weeks-36 weeks and 6 days), 2.2 times as many (154 per 1,000 births) were treated with antibiotics in Vestre Viken as in AHUS hospital referral area (69 per 1,000 births).

There is also great variation in terms of the duration of antibiotic treatment for late preterm infants. Vestfold hospital referral area has 333 treatment days per 1,000 births, while Sørlandet has more than twice as many at 784 treatment days per 1,000 births. The average number of treatment days per patient varies from 3.5 in Vestre Viken to 7.6 in Bergen/Førde.

6.2.3 Infants born at a gestational age of less than 34 weeks (GA < 34.0)

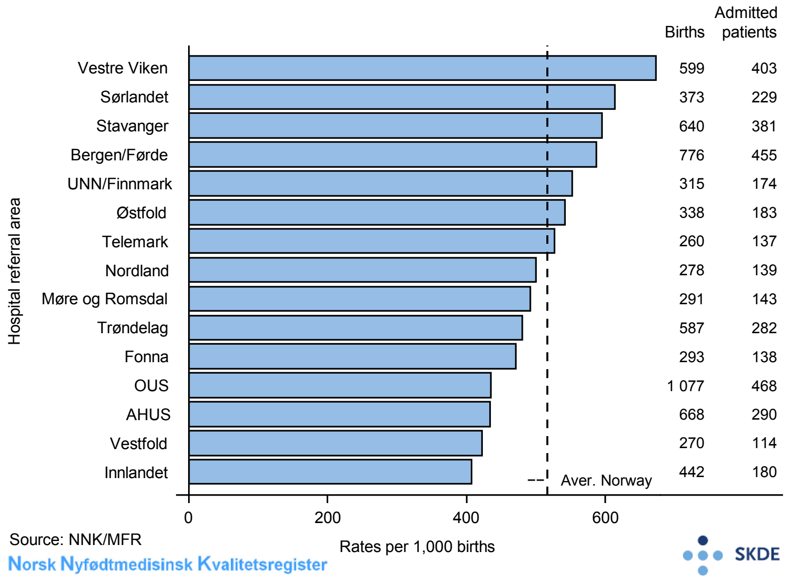

Figure 6.15: Antibiotic treatment, number of patients admitted, gestational age less than 34 weeks (GA < 34.0), rates per 1,000 births per hospital referral area, in total for the period 2009–2014.

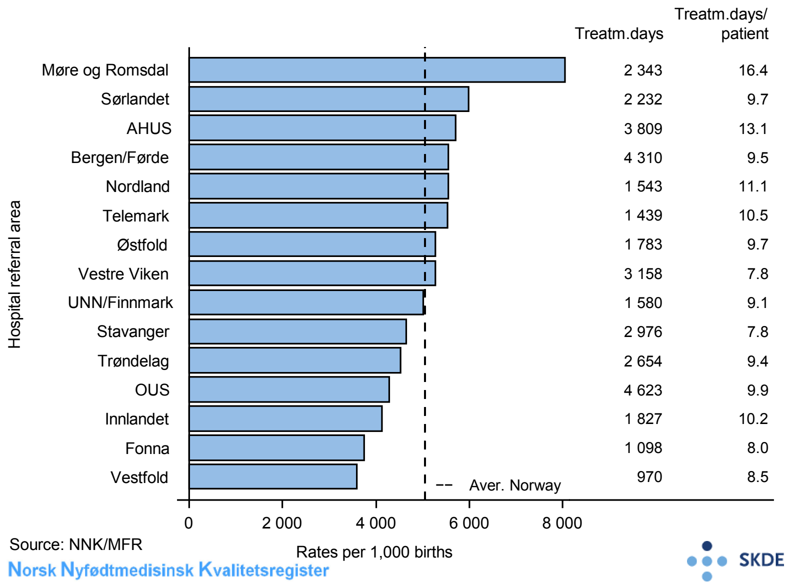

Figure 6.16: Antibiotic treatment, number of bed days, gestational age less than 34 weeks (GA < 34.0), rates per 1,000 births per hospital referral area, in total for the period 2009–2014.

There is less variation in the number of patients treated with antibiotics for the most preterm infants. In Innlandet hospital referral area, 407 per 1,000 births were treated with antibiotics. In Vestre Viken, 65% more infants from this gestational age group were treated with antibiotics, giving a rate of 673 per 1,000 births.

The number of treatment days for infants born at a gestational age of less than 34 weeks varies between hospital referral areas at a ratio of 2.2. Vestfold hospital referral area had 3,593 treatment days per 1,000 births, while the Møre og Romsdal area had more than twice as many, with 8,052 treatment days per 1,000 births. The average number of treatment days per patient also varies, from 7.8 in Vestre Viken and Stavanger to 16.4 in Møre og Romsdal.

6.2.4 Patients diagnosed with sepsis

The patient sample consists of infants with diagnoses in the code block P36.0-P36.9, sepsis with or without bacterial growth in blood culture.

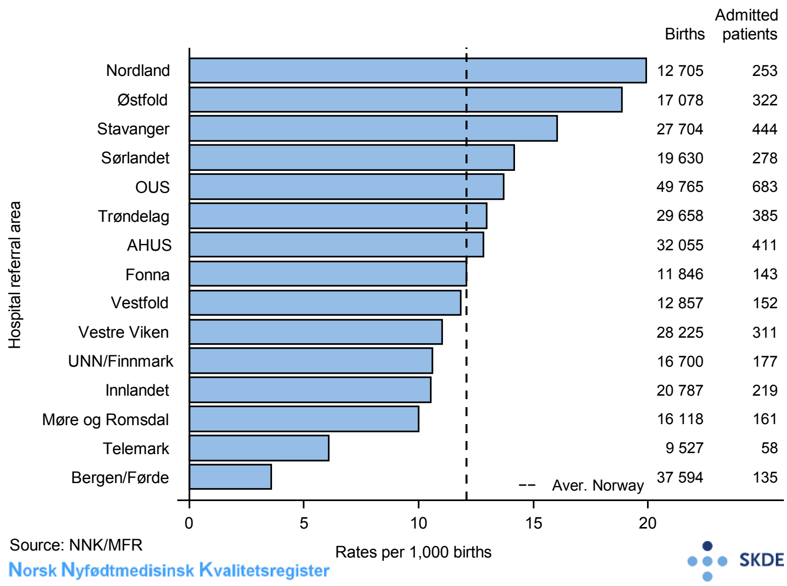

Figure 6.17: Number of patients diagnosed with sepsis, gestational age 37 weeks or more (GA < 36.6), rates per 1,000 births per hospital referral area, in total for the period 2009–2014.

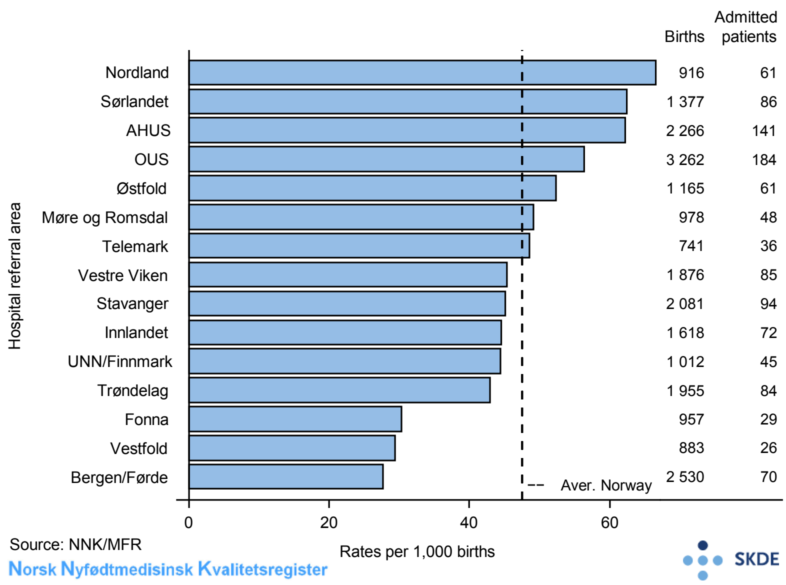

Figure 6.18: Number of patients diagnosed with sepsis, gestational age less than 37 weeks (GA < 37.0), rates per 1,000 births per hospital referral area, in total for the period 2009–2014.

The use of the diagnosis sepsis for term infants varies considerably between hospital referral areas. The diagnosis is used 5.5 times as often in Nordland hospital referral area as in the Bergen/Førde area. The use of the diagnosis sepsis correlates with the number of days of antibiotic treatment with a Pearson correlation coefficient of 0.83 ($p < 0.001$).

More than twice as many infants born at a gestational age of less than 37 weeks were diagnosed with sepsis in Nordland, where 67 cases per 1,000 births were diagnosed, than in Bergen/Førde, where 28 cases were diagnosed per 1,000 births.

6.2.5 Summary

In this healthcare atlas, we find variation between hospital referral areas in the use of antibiotics that cannot be explained by medical factors or differences in risk factors. This is particularly pronounced for term infants, but also applies to preterm infants. The variation applies both to start-up and duration of antibiotic treatment, and can be described as unwarranted.

There is also great variation in the use of the sepsis diagnosis for neonates, and this variation must be categorised as unwarranted, especially for term infants. Overdiagnosis of sepsis appears to be associated with high rates of start-up and duration of antibiotic treatment.

6.3 Ventilator treatment

Ventilator treatment is required when infants are unable to breathe on their own in a way that ensures adequate oxygen uptake and elimination of carbon dioxide due to serious lung diseases or neurological symptoms.

The majority of infants admitted to neonatal units do not need ventilator treatment. In the period 2009–2014, 8.9% of all patients admitted to neonatal units underwent ventilator treatment, and 5.6% of all treatment days during this period were associated with such treatment. Ventilator treatment is mainly carried out at regional hospitals. A small proportion of such treatment is carried out at local hospitals, primarily for preterm infants born after the 28th week of pregnancy, and sometimes for term infants. For most units, births before week 26–28 have been centralised at the regional level.

Most preterm infants born after the 28th week of pregnancy can be given breathing support either in the form of extra oxygen or using the method known as CPAP, whereby a constant air flow sufficient to prevent the lungs from collapsing is delivered through the child's nose. The child will then be breathing on its own without active help from a ventilator. Such non-invasive ventilation support is becoming increasingly successful also for infants born before week 28, but a higher percentage of them will need ventilator support for a short or longer period. The most prematurely born infants, those born before the 25th week of pregnancy, will often need several weeks of ventilator treatment.

In term infants, ventilator treatment is primarily used for infants who have suffered severe oxygen deprivation during birth (asphyxia), infants with persistent high blood pressure in the lungs after birth, infants who have breathed in amniotic fluid containing their own stool, and infants with various abnormalities or neurological disorders that cause them to not breathe on their own. However, some of these infants can do equally well with CPAP instead of ventilator treatment.

The sample consists of all infants who are registered in the Norwegian Neonatal Network by daily ticking of the relevant box as having received at least one day of ventilator treatment.

6.3.1 All ventilator treatment

The number of infants who receive ventilator treatment varies from 6.3 patients per 1,000 births in Vestre Viken to 11.1 patients per 1,000 births in Møre og Romsdal. The rate of Møre og Romsdal is 80% higher than that of Vestre Viken. Nation-wide, 8.4 infants per 1,000 births undergo ventilator treatment.

Møre og Romsdal hospital referral area also has the highest number of ventilator treatment days, with 117 treatment days per 1,000 births. The rate of Møre og Romsdal is more than twice that of Bergen/Førde hospital referral area, which has a rate of 41 treatment days per 1,000 births. The figure for Norway as a whole is 68 treatment days per 1,000 births.

The average treatment period per patient varies from 4.7 treatment days per 1,000 births in Bergen/Førde to 10.9 treatment days per 1,000 births in Vestre Viken.

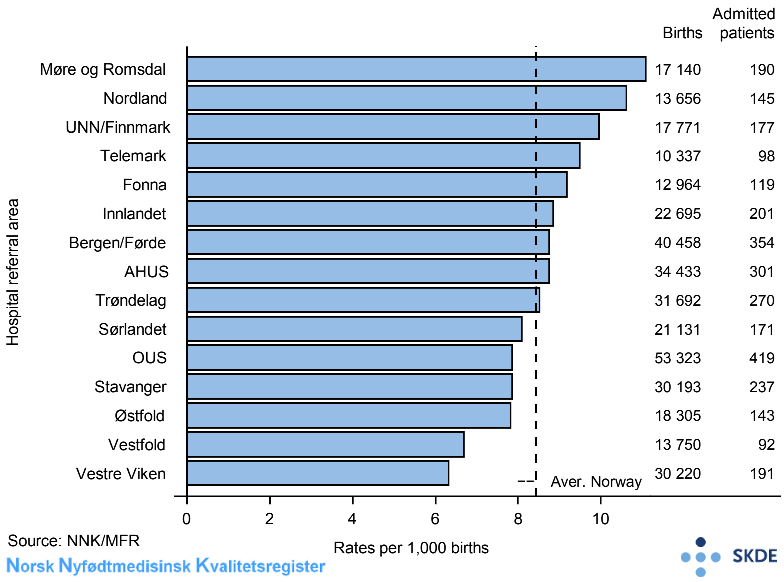

Figure 6.19: Ventilator treatment, number of patients admitted, all gestational ages, rates per 1,000 births per hospital referral area, in total for the period 2009–2014.

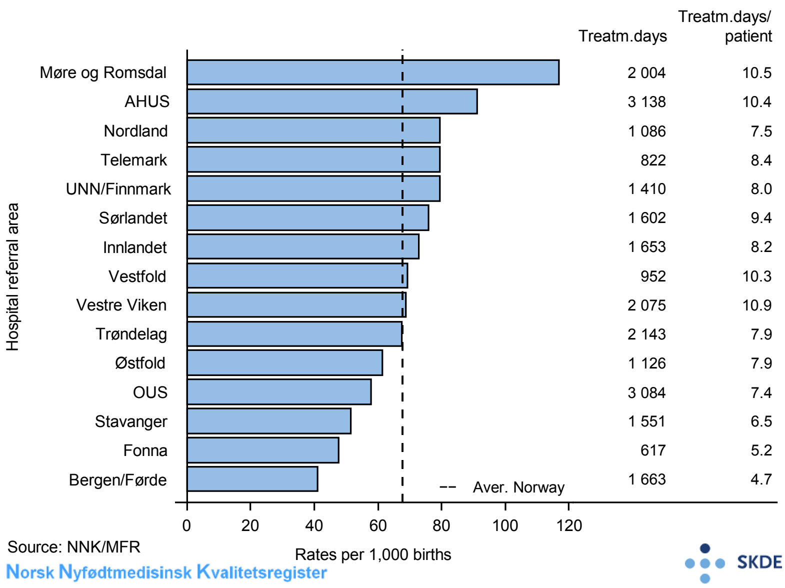

Figure 6.20: Ventilator treatment, number of bed days, all gestational ages, rates per 1,000 births per hospital referral area, in total for the period 2009–2014.

6.3.2 Infants with a gestational age of 37 weeks or more (GA > 36.6)

In Møre og Romsdal, which has a rate of 5 per 1,000 births, 2.7 times more term infants undergo ventilator treatment there than in Vestre Viken, where the rate is 1.8 per 1,000 births. For the country as a whole, the rate is 3.1 per 1,000 births.

Infants resident in Telemark have 3.4 times more ventilator treatment days than infants resident in Vestfold. Telemark has 25.5 treatment days per 1,000 births, while the corresponding rate for Vestfold is 7.5 treatment days per 1,000 births. The variation in treatment day rates between hospital referral areas is due to differences in patient rates in combination with different average periods of treatment. While each patient undergoes an average of 7.1 days of ventilator treatment

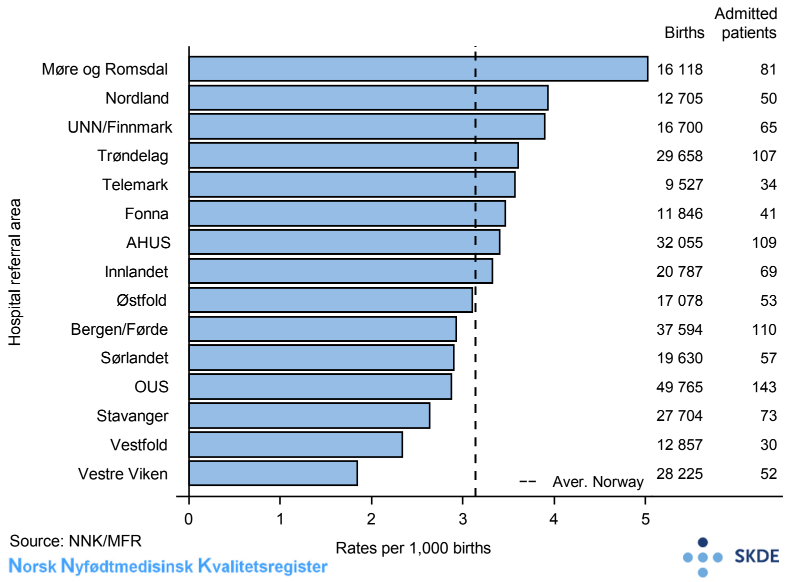

Figure 6.21: Ventilator treatment, number of patients admitted, gestational age 37 weeks or more (GA > 36.6), rates per 1,000 births per hospital referral area, in total for the period 2009–2014.

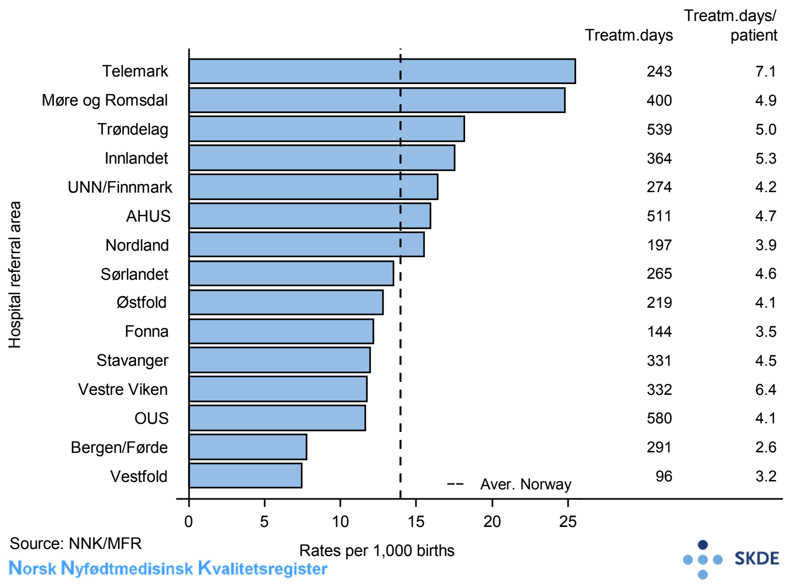

Figure 6.22: Ventilator treatment, number of bed days, gestational age 37 weeks or more (GA > 36.6), rates per 1,000 births per hospital referral area, in total for the period 2009–2014.

in Telemark, the average treatment period is 3.1 days in Vestfold.

6.3.3 Infants born at a gestational age of 28 weeks to 36 weeks and 6 days (GA 28.0–36.6)

For moderately preterm infants (gestational age between 28 weeks and 36 weeks and 6 days), the patient rate is 2.5 times higher in the population of UNN/Finnmark hospital referral area, at 77 patients per 1,000 births, than in the population of Vestre Viken, where 31.5 patients per 1,000 births undergo ventilator treatment.

As regards the number of days of ventilator treatment, Sørlandet hospital referral area has the

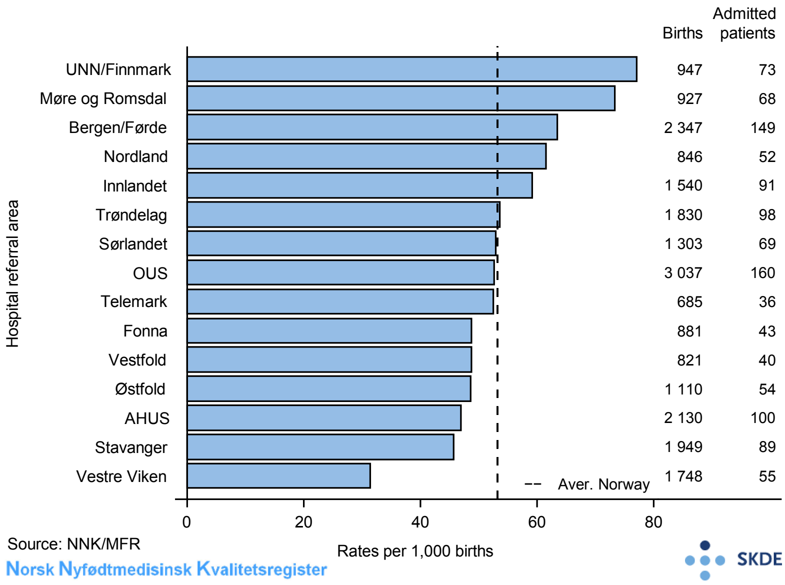

Figure 6.23: Ventilator treatment, number of patients admitted, gestational age 28 weeks to 36 weeks and 6 days (GA 28.0–36.6), rates per 1,000 births per hospital referral area, in total for the period 2009–2014.

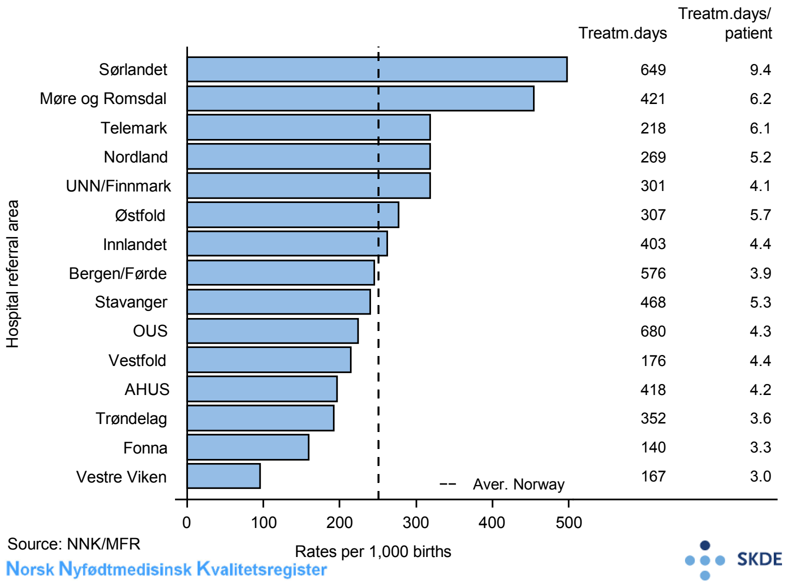

Figure 6.24: Ventilator treatment, number of bed days, gestational age 28 weeks to 36 weeks and 6 days (GA 28.0–36.6), rates per 1,000 births per hospital referral area, in total for the period 2009–2014.

highest rate for moderately preterm infants, at 498 treatment days per 1,000 births. The corresponding rate for Vestre Viken hospital referral area is 96 treatment days per 1,000 births, which means that the rate of Sørlandet is more than five times as high as that of Vestre Viken. The number of treatment days per patient varies from 3.0 days in Vestre Viken to 9.4 days in Sørlandet hospital referral area.

6.3.4 Infants born at a gestational age of less than 28 weeks (GA < 28)

Because ventilator treatment of extremely preterm babies (gestational age less than 28 weeks) mostly takes place at regional units and the number of patients treated in each hospital referral area is relatively low, we have chosen to present the results for ventilator use at regional level only for this group.

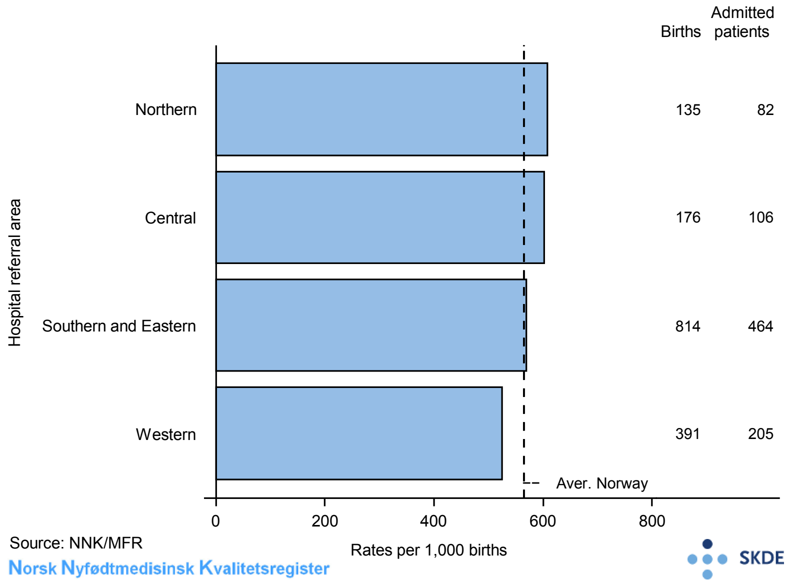

Figure 6.25: Ventilator treatment, number of patients admitted, gestational age less than 28 weeks (GA < 28), rates per 1,000 births per hospital referral area, in total for the period 2009–2014.

The use of ventilator treatment of extremely preterm infants varies from 607 patients per 1,000 births in the Northern Norway Regional Health Authority's catchment area to 524 patients per 1,000 births in the catchment area of the Western Norway Regional Health Authority. This means that the rate of Northern Norway RHA is 20% higher than that of Western Norway RHA.

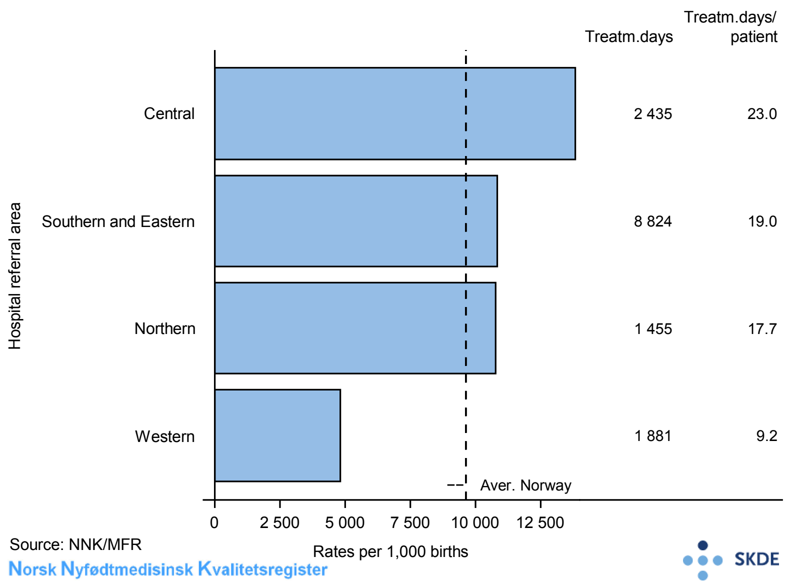

Figure 6.26: Ventilator treatment, number of bed days, gestational age less than 28 weeks (GA < 28), rates per 1,000 births per hospital referral area, in total for the period 2009–2014.

The number of ventilator treatment days for extremely preterm infants is highest for those resident in the catchment area of Central Norway RHA, which has a rate of 13,800 treatment days per 1,000 births. This means that the rate of this region is nearly three times as high as the rate for the population in Western Norway RHA's catchment area, which has 4,800 ventilator treatment days per 1,000 births.

The average ventilator treatment period varies from 9.2 treatment days per patient in Western Norway RHA's catchment area to 23.0 treatment days per patient in Central Norway RHA's catchment area.

6.3.5 Summary

There is considerable variation in the number of patients who undergo ventilator treatment as well as in the number of treatment days for patients of all gestational ages. For infants born after the 28th week of pregnancy, this variation cannot be explained by medical differences and case mix. For a more in-depth discussion of the results, see Chapter 7.

6.4 Hypoglycaemia and phototherapy

6.4.1 Hypoglycaemia - treatment for low blood sugar

Low blood sugar (hypoglycaemia) in neonates is a condition that can cause babies to be moved from a maternity unit to a neonatal unit. In some cases, hypoglycaemia can be caused by serious illness, but these conditions are rare. It is more common for hypoglycaemia to arise as a consequence of prematurity, low birth weight, low body temperature and delayed milk production in the mother that does not give the baby sufficient nutrition to maintain a stable blood sugar level. Healthy neonates are born with glycogen stores that can be converted into sugar in the liver, so that they will normally manage with little additional nutrition during their first 24 hours. In preterm infants or infants with a lower birth weight than normal, these glycogen stores may be insufficient to keep their blood sugar level stable until the mother starts to produce milk. This places them at risk of developing low blood sugar, which could, among other things, affect the energy supply to the bran and cause brain damage. However, most cases of low blood sugar are detected quickly because the infant shows symptoms, and if they are given glucose, either in the form of milk in the stomach or intravenous glucose, transitory low blood sugar will not cause complications.

The patient sample consists of patients registered in the Norwegian Neonatal Network's database with the diagnosis 'P70.4 Other neonatal hypoglycaemia'.

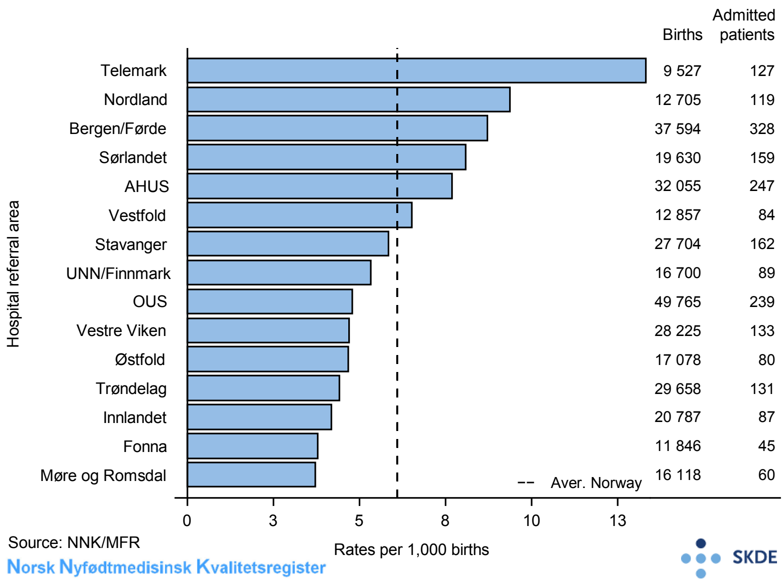

Figure 6.27: Hypoglycaemia, admissions, gestational age 37 weeks or more (GA > 36.6), rates per 1,000 births per hospital referral area, in total for the period 2009–2014.

For term infants (gestational age 37 weeks or more), the patient rate for admissions to neonatal units with a diagnosis of low blood sugar varies from 3.7 patients per 1,000 births in Møre og Romsdal to 13.3 patients per 1,000 births in Telemark. This means that more than three times as many infants are admitted to neonatal units with this diagnosis in Telemark hospital referral area as in Møre og Romsdal.

There is also considerable variation in the number of late preterm infants (gestational age 34 weeks to 36 weeks and 6 days) transferred from maternity to neonatal units with the diagnosis hypoglycaemia. The patient rate for this group varies from 32 patients per 1,000 births in Møre

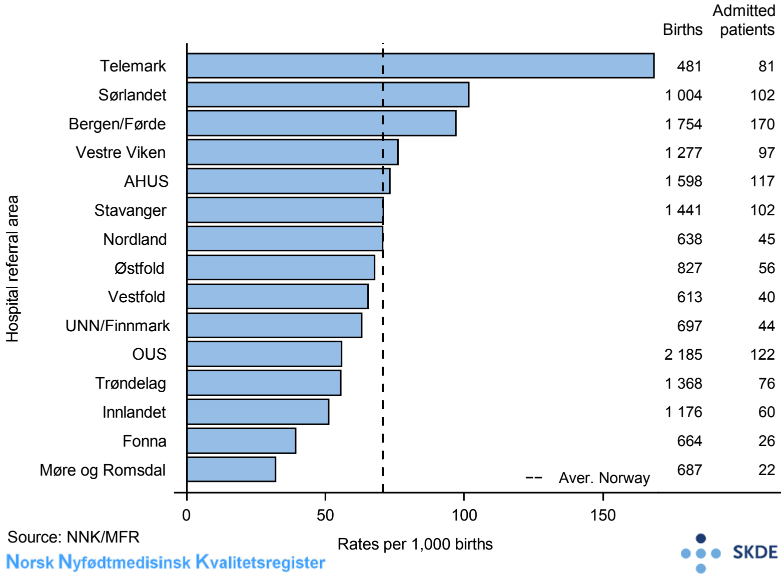

Figure 6.28: Hypoglycaemia, admissions, gestational age 34 weeks to 36 weeks and 6 days (GA 34.0–36.6), rates per 1,000 births per hospital referral area, in total for the period 2009–2014.

og Romsdal to 168 patients per 1,000 births in Telemark. In other words, more than five times as many neonates are transferred with a diagnosis of low blood sugar in Telemark as in Møre og Romsdal hospital referral area.

6.4.2 Phototherapy - light treatment for jaundice (hyperbilirubinemia)

Bilirubin is released when red blood cells from the foetal stage are broken down to be replaced by mature cells. In most cases, jaundice is a normal physiological condition caused by a temporarily reduction of the child's capacity to convert fat-soluble bilirubin into water-soluble bilirubin that can be excreted via the biliary tract into the intestine. This is a transient and harmless condition in most infants, but in some cases where the mother and baby have different blood types or in cases involving rare blood or metabolic disorders, the levels of bilirubin can become very high and bilirubin can enter the infant's brain and cause brain damage. Such brain damage can cause a very severe and debilitating form of cerebral palsy.

Bilirubin is broken down more quickly when the child's skin is exposed to ultraviolet light, and there are national guidelines for when infants should receive phototherapy to prevent their bilirubin levels from rising to a level that could damage the brain. These guidelines are set out in a common nomogram that is used by all Norwegian maternity and neonatal units, and about which there is professional consensus. These guidelines have relatively big margins of safety in relation to the level considered to be associated with a risk of brain damage, and this means that most babies who undergo phototherapy would never have developed brain damage. However, there is broad international agreement that such overtreatment is necessary in order to ensure that no infants develop such brain damage. In the past ten years, two or three infants have developed symptoms of brain damage after treatment was started up too late, but none of them have developed chronic bilirubin-induced cerebral palsy (Bratlid, Nakstad, et al. 2011).

Between four and five per cent of all neonates develop jaundice that requires phototherapy due to a high level of bilirubin circulating in the bloodstream (Tønne et al. 2010). In most cases where there are no other risk factors at play, phototherapy can be administered to babies while they are physically located in the maternity unit, with the assistance and assessment of a paediatrician. Whether the babies are physically moved from the maternity unit to the neonatal unit therefore largely depends on local procedures and guidelines.

The sample consists of patients registered in the Norwegian Neonatal Network by daily ticking of the relevant box as having received at least one day of phototherapy.

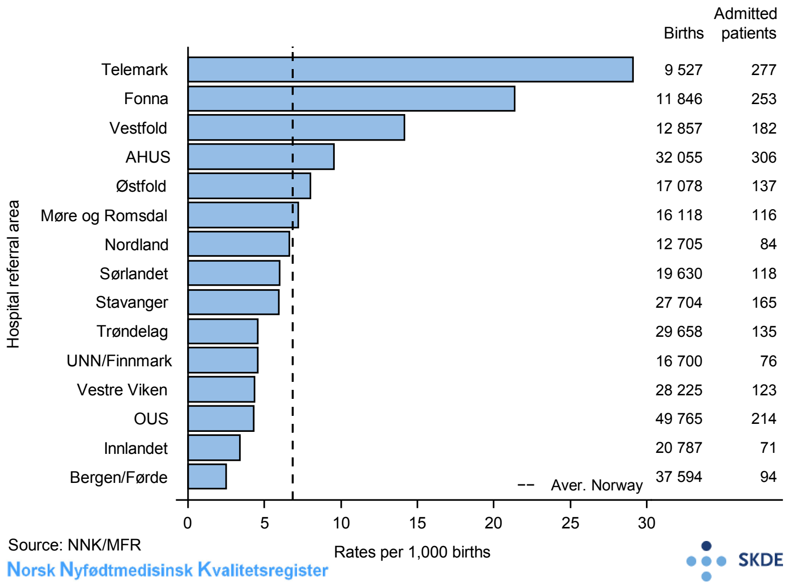

Figure 6.29: Phototherapy, admissions, gestational age 37 weeks or more (GA > 36.6), rates per 1,000 births per hospital referral area, in total for the period 2009–2014.

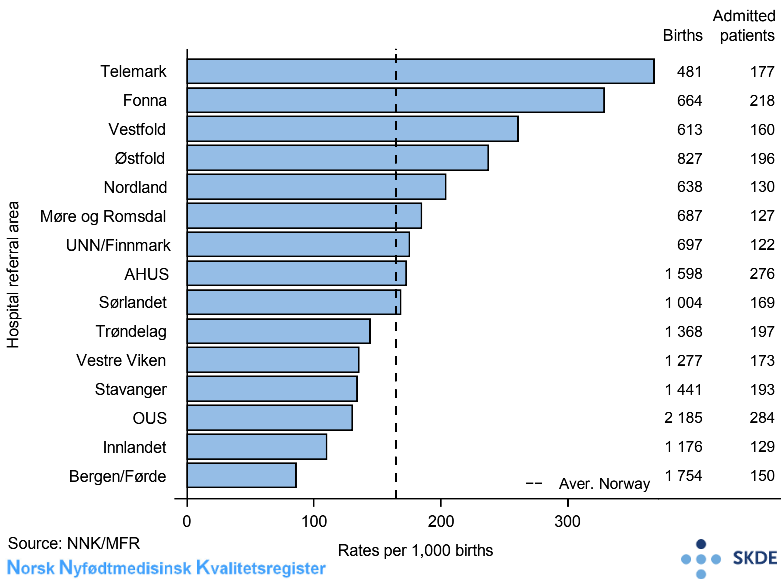

Figure 6.30: Phototherapy, admissions, gestational age 34 weeks to 36 weeks and 6 days (GA 34.0–36.6), rates per 1,000 births per hospital referral area, in total for the period 2009–2014.

For term infants, the patient rate for phototherapy varies from 2.5 patients per 1,000 births in Bergen/Førde hospital referral area to 29.1 patients per 1,000 births in the Telemark area. This means that more than eleven times as many term infants are transferred from a maternity unit to a neonatal unit for phototherapy in Telemark hospital referral area as in Bergen/Førde.

The patient rates for phototherapy also vary for late preterm babies (gestational age 34 weeks to

36 weeks and 6 days). The rate is 86 patients per 1,000 births in Bergen/Førde and 368 patients per 1,000 births in Telemark. This means that more than four times as many babies are transferred from a maternity unit to a neonatal unit for phototherapy in Telemark hospital referral area as in the Bergen/Førde area.

6.4.3 Summary

There is reason to ask whether there is unwarranted variation in the neonatal unit admission rates for infants with low blood sugar and infants who need phototherapy. Such transfers result in children being separated from their mother, and there is no medical basis for assuming that the variation in admission practices has any bearing on the quality of treatment, particularly not for phototherapy. There could be reason to ask whether this shows an overuse of admissions at the neonatal units that have the highest admission rates. For a more in-depth discussion of the results, see Chapter 7.

6.5 Use of intensive care

Every day, boxes are ticked for procedures and treatment measures carried out in relation to infants admitted to neonatal units in Norway. These procedures and treatments are divided into five categories from level 1, which requires relatively little resources, to level 5, which is very resource-intensive. Resource level 5 denotes intensive care provided to seriously ill infants. Each treatment day is assigned to a resource category in accordance with the procedure or treatment that triggers the highest resource classification.

Treatment at levels 4 of 5 can usually be classified as intensive care and will require one, or sometimes two, nurses per patient. Level 4 treatment often relates to ventilator treatment, but patients with withdrawal symptoms, patients in the early postoperative phase or patients admitted to regional units with complex abnormalities before surgery are also classified as level 4 patients.

Level 5 patients are patients with very severe pulmonary failure who need treatment with specialised techniques, for example nitrous oxide treatment. Patients undergoing therapeutic hypothermia following oxygen deprivation at birth or the day of death of an admitted patient are also classified as level 5 treatment. Most such treatment is provided at units responsible for national or regional functions, and most treatment days will therefore concern treatment that takes place at regional and national function level. However, some level 4 and level 5 treatment will take place at local hospital level.

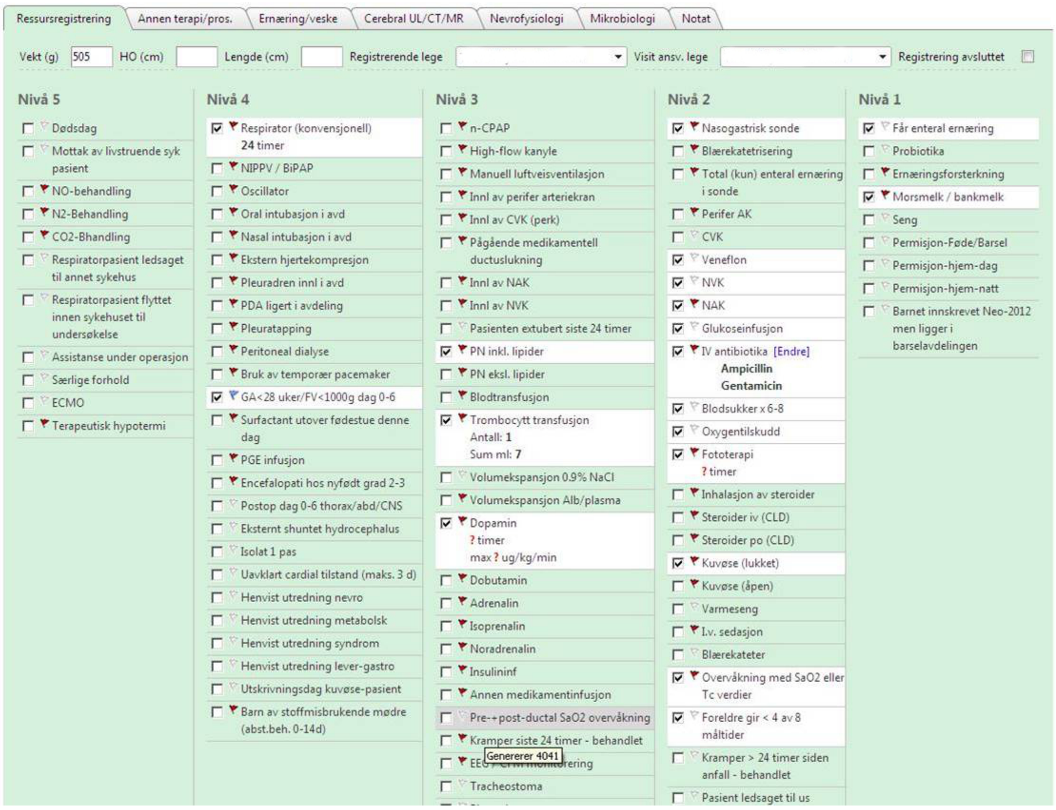

Figure 6.31: Registration form, the Norwegian Neonatal Network

The sample of intensive care patients consists of patients registered in the Norwegian Neonatal Network by daily ticking of the relevant boxes as having received at least one day of treatment at level 4 or level 5.

6.5.1 Infants with a gestational age of 37 weeks or more (GA > 36.6)

The number of term infants who receive intensive care (level 4 or 5) varies from 10.8 per 1,000 births in Telemark to 5.5 per 1,000 births in Vestre Viken. The intensive care rate for Telemark is thus twice as high as that of Vestre Viken. The national average is 7.5 patients per 1,000 births.

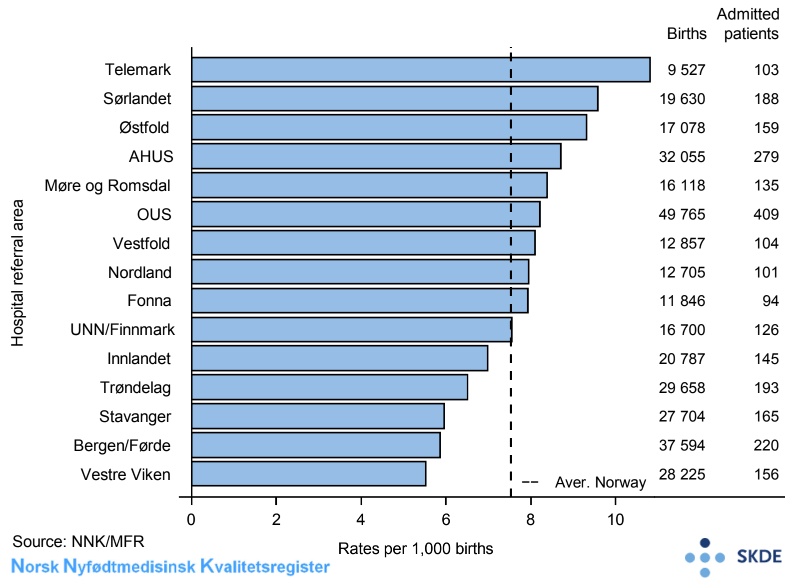

Figure 6.32: Resource use, patients, admissions, gestational age 37 weeks or more (GA > 36.6), rates per 1,000 births per hospital referral area, in total for the period 2009–2014.

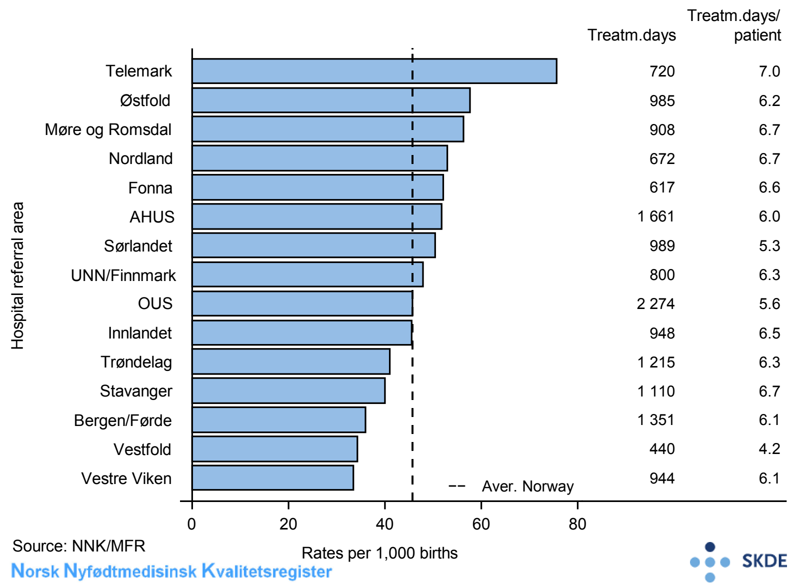

Figure 6.33: Resource use, length of stay, admissions, gestational age 37 weeks or more (GA > 36.6), rates per 1,000 births per hospital referral area, in total for the period 2009–2014.

The number of intensive care treatment days varies from 33.5 per 1,000 births in Vestre Viken to 76 patients per 1,000 births in Telemark. This means that Telemark hospital referral area has more than twice as many intensive care treatment days per 1,000 births as Vestre Viken. The national average is 45.7 intensive care treatment days per 1,000 births. The average number of intensive care treatment days per patient varies from 4.2 in Vestfold hospital referral area to 7.0 in Telemark.

6.5.2 Infants born at a gestational age of less than 37 weeks (GA < 37.0)

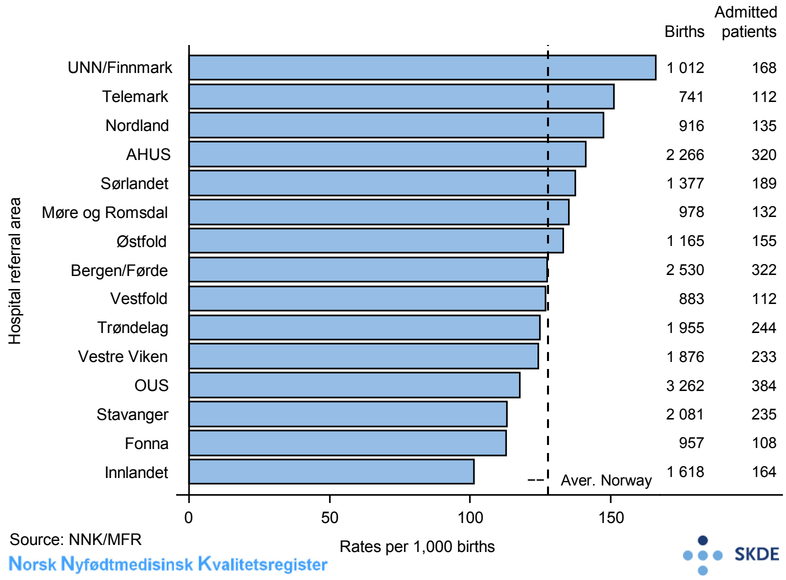

Figure 6.34: Resource use, patients, admissions, gestational age less than 37 weeks (GA < 37.0), rates per 1,000 births per hospital referral area, in total for the period 2009–2014.

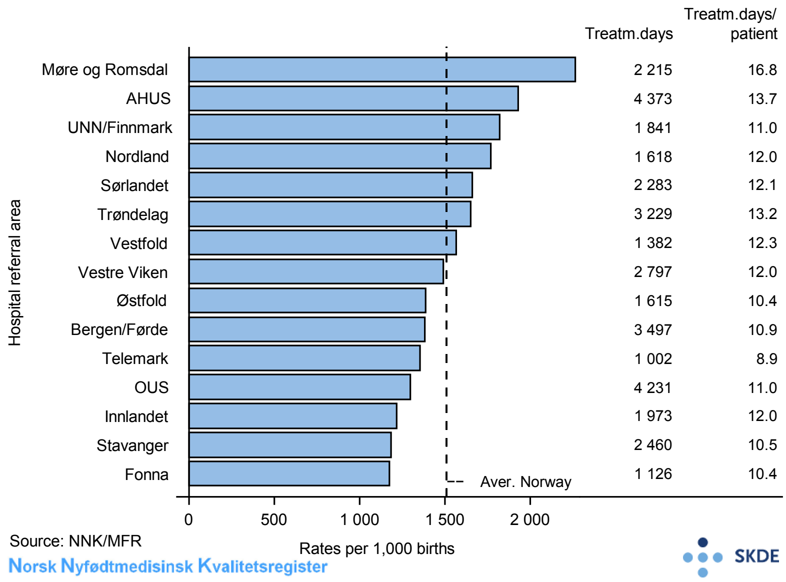

Figure 6.35: Resource use, length of stay, admissions, gestational age less than 37 weeks (GA < 37.0), rates per 1,000 births per hospital referral area, in total for the period 2009–2014.

The patient rate for intensive care treatment of preterm infants (gestational age less than 37 weeks) varies from 166 in UNN/Finnmark hospital referral area to 101 in the Innlandet area. This means that 60% more patients receive intensive care treatment in UNN/Finnmark hospital referral area than in Innlandet. The average rate for Norway is 128 intensive care patients per 1,000 births.

The number of days of intensive care treatment of preterm infants varies from 1,177 days per 1,000 births in Fonna hospital referral area to 2,265 days in the Møre og Romsdal area. This means that the number of intensive care treatment days in Møre og Romsdal hospital referral area is almost twice that of Fonna.

Residents of Telemark hospital referral area had the shortest average duration of intensive care treatment, at 8.9 days per patient. The longest average duration is found in Møre og Romsdal hospital referral area, at 16.8 intensive care treatment days per patient.

6.5.3 Summary

Twice as many term infants receive intensive care-level treatment in the hospital referral area with the highest rate compared with the area with the lowest rate. In addition to variation in the intensive care treatment rate, there are also differences in the average duration of such treatment. Combined, these factors result in more than twice as many intensive care treatment days per 1,000 births in Telemark as in Vestre Viken for term infants.

For preterm infants, there is a difference of 60% between the hospital referral areas with the highest and lowest admission rates. The duration of intensive care treatment varies between hospital referral areas also for this group. On average, residents of Møre og Romsdal receive such treatment for considerably longer periods than those living in other hospital referral areas, and, in combination with a relatively high patient rate, this gives a number of intensive care treatment days that is more than twice as high as for those resident in the Fonna area. For a more in-depth discussion of the results, see Chapter 7.

Chapter 7

Discussion

Many publications have described variation in the use of health services, treatment and results in neonatal medicine. Many of these works describe unwarranted or undesirable variation based on differences in professional preferences, for example K. A. Ziegler et al. (2016), Murthy et al. (2014), Numerato et al. (2015), Shah, Lui, et al. (2016), and Zeitlin et al. (2016).

There are geographical and social differences in morbidity in Norway for e.g. cardiovascular disease and lung diseases, but these differences are mostly lifestyle-related and develop over the course of a lifetime. There is no evidence that there are geographical differences in neonatal morbidity on such a scale that it could explain the variation in patient or bed day rates for infants admitted to neonatal units described in this healthcare atlas.

Norway has a public antenatal care system that most pregnant women make use of. Although no population-based studies have so far been conducted on the use of health services by pregnant women, there seems to be little reason to assume that there is a geographically based underuse that has a bearing on the length of pregnancy and health of the child.

However, we find differences in prematurity rates for infants born before the 37th week of pregnancy. Fonna hospital referral area (highest rate) has prematurity rates that are 30% higher than that of UNN/Finnmark hospital referral area (lowest rate). These rates are based on the distribution of 23,617 premature live births and stillbirths in the period 2009–2014 registered in the Medical Birth Registry of Norway. The differences between prematurity rates are moderate, but probably greater than should be expected to result from random variation in a data material of this size. This can thus be considered systematic variation. The Medical Birth Registry of Norway reports annual prematurity rates as a percentage of all births at county level, but it can be difficult to identify any significant variation from the absolute rates, where the percentage of premature births in the different counties varies between 5 and 7% of all births. It is somewhat surprising that the prematurity rates vary by as much as 30–40% between the hospital referral areas with the highest and lowest rate.

We cannot draw any conclusions regarding whether the variation we find in the incidence of premature births between Norwegian hospital referral areas is unwarranted or related to differences in maternal morbidity. However, this variation is significantly lower than the variation that Thompson et al. found in the USA (Thompson et al. 2005), where there were three times as many babies with low birthweight per 1,000 births in the area with the highest rate as in the area with the lowest rate. According to Thompson et al., the differences identified in the USA cannot be explained by underlying socio-economic or medical factors. On the other hand, Smith et al. found that the incidence of premature births in the UK varied considerably with socio-economic status (Smith et al. 2009), but that the mother's socio-economic status had no effect on child mortality or morbidity.

This healthcare atlas aims to assess the use of and variation in health services provided to neonates admitted to Norwegian neonatal units. By calculating rates as the number of incidents in relation to the number of births at the same gestational age as the infants for whom the incident is calculated, we ensure that any variation will be related to treatment provided at the neonatal units and that it is not influenced by differences between hospital referral areas in the risk of premature birth.

7.1 Variation in admissions and length of stays

Variation in admission rates for moderately premature and term infants has been documented e.g. by K. A. Ziegler et al. (2016). An increase in admission rates from 2007 to 2012 for infants with normal birth weight has been described for the USA (Harrison and D. Goodman 2015), again without corresponding medical changes in the birth population. In addition, significant differences between units have been documented in the timing of discharge home, differences that are not related to the infants' medical situation (Profit et al. 2006; Eichenwald, Blackwell, et al. 2001; Eichenwald, Zupancic, et al. 2011; Korvenranta et al. 2007).

Admissions to neonatal units probably demonstrate all three categories of care described by Wennberg (2010); effective or necessary care, preference-sensitive care and supply-sensitive care in the same group of patients and in the same type of unit.

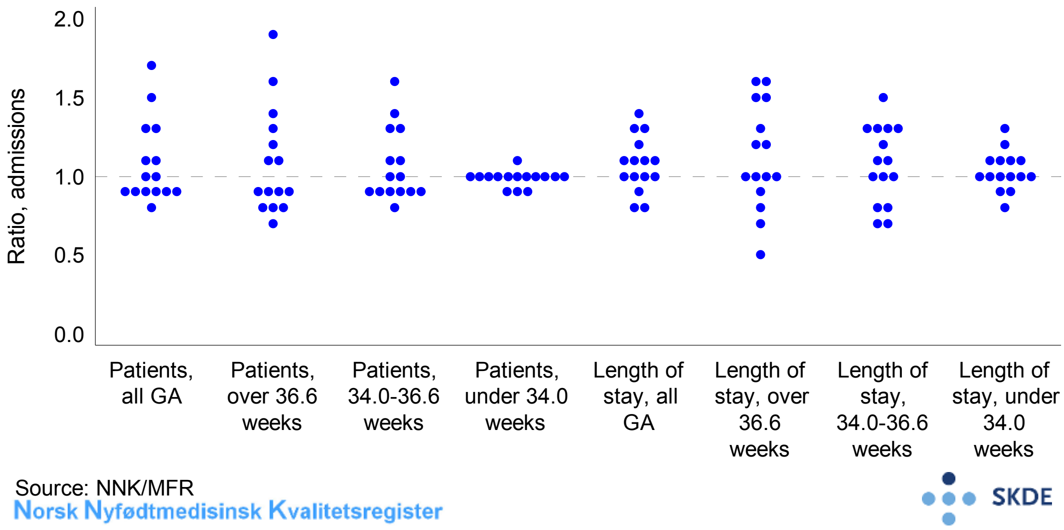

Figure 7.1: Variation profile, admissions, patients and length of stay.

At an overall level, for all admissions to neonatal units and for admissions of late preterm infants, the data material is quite big and the variation so high that it can be considered systematic. There are no known medical and demographical explanations why some hospital referral areas admit 16% of all neonates to neonatal units, while more than half of the areas admit fewer than 10%. Nor are there any indications that admitting 7–10% of all neonates lead to undesirable incidents in relation to increased morbidity or mortality.

In 2013 the Norwegian Society of Pediatricians, represented by all the chief senior consultants, carried out a benchmarking survey of all Norwegian paediatric departments where the departments themselves reported the number of staffed beds for neonates in their respective departments (not published). The benchmarking study showed considerable variation between health trusts in the number of beds per 1,000 births. The health trust with the highest bed rate (6.8 per 1,000 births) had twice as many beds per 1,000 births as the health trust with the lowest rate (3.4 per 1,000 births). We would expect health trusts with regional functions to have a higher bed rate than hospitals with local hospital functions, since these trusts treat more ill infants both from their own and from other hospitals' referral areas. Nevertheless, the lowest and highest bed rates in Norway are both found in hospitals with local hospital function. The possibility that there may be a certain link between capacity and variation cannot be ruled out, but a correlation analysis between the admission rate and bed rate shows that there is at best a moderate link with a non-significant correlation coefficient of 0.56.

The majority of infants admitted to a neonatal unit are admitted because it is necessary to treat them for conditions that either represent manifest disease or indicate a high risk of disease. However, there is reason to believe that admission criteria vary between units and that much of the variation between hospital referral areas is due to differences in preferences. The criteria and thresholds for admission seem to differ between departments. Much of the systematic variation in admissions is probably due to differences in practice for infants admitted at local hospital level within each hospital referral area, because admissions at regional level are more often due to conditions for which necessary care is required.

In many maternity wards, late preterm babies born after the 34th week of pregnancy will, with the appropriate adaptation and expertise, remain with their mother in the maternity unit without having to be moved to the neonatal unit. Local traditions and maternity unit capacity will both be relevant factors here. Keeping infants in the maternity unit, after a medical assessment of whether it is safe to do so, will reduce total resource use in the health service and avoid undesirable separation of mother and child in an important phase following childbirth.

Differing opinions among doctors regarding safety and risk probably also have a bearing on the decision about whether a child should be moved from the delivery and maternity unit to a neonatal unit. Limited maternity unit capacity can also contribute to a higher admission rate than is medically necessary, because infants with symptoms who could have remained under observation at the maternity unit require closer follow-up by the maternity unit staff. This need should be taken into account in maternity care capacity planning, because it is not in the children's or the parents' best interest to move a child to a neonatal unit unless it is necessary to do so for medical reasons. In addition, such transfers must be assumed to increase the overall use of resources in the health service.

For infants born more than six weeks prematurely, admission to a neonatal unit is deemed to constitute necessary treatment to ensure survival without injuries. These infants usually need monitoring for a short or longer period of time, and they often need breathing support or extra oxygen and nutritional support or antibiotic treatment.

The bed day rates vary more than the admission rates, and are influenced both by admission practices and by when infants are considered ready to be discharged home. Variation in postmenstrual age (PMA) on discharge from hospital corresponding to that described in this atlas for moderately and early preterm infants have also been found to exist for moderately and extremely preterm infants (Profit et al. 2006; Eichenwald, Blackwell, et al. 2001; Eichenwald, Zupancic, et al. 2011; Korvenranta et al. 2007). This variation was linked to, among other things, differences in monitoring practices towards the end of the stay, and different criteria for how episodes of apnoea were interpreted and what consequences they had (Eichenwald, Zupancic, et al. 2011). The data also indicate that differences in approaches to feeding training contribute to differences in the length of hospital stays (Eichenwald, Blackwell, et al. 2001). Other factors that have been documented to have an effect on the length of stay are the use of systematic guidance programmes for parents in how to interact and communicate with the child (Melnyk et al. 2006; Gonya et al. 2014), the use of family-centred neonatal medicine with single rooms where parents can stay with their child (Ortenstrand et al. 2010), and adaptation of the physical environment so that the lighting changes between day and night (Vasquez-Ruiz et al. 2014).

Is it possible, then, to say anything about what is the correct level of admissions? Generally speaking, there is a low threshold for admitting a child with symptoms to a neonatal unit. The decision to admit an infant, particularly term infants and late preterm infants, is based on a risk assessment of whether they could be seriously ill. Seen in light of the clinical course of events that follow, it can be said that some infants are admitted without achieving any health gain from the stay as such, because the child's symptoms were not a sign of illness that required treatment. There is no reason to assume that any of the 18 neonatal units in the 15 hospital referral areas admit too few patients overall. However, it is difficult to use death or serious sequelae as an outcome parameter, since the overall mortality in this group of patients is very low.

There appears to be variation in admission rates for infants admitted to neonatal units that cannot be explained by random variation or medical or demographical factors, and that can thus be described as unwarranted. The variation, both in admission rates and bed day rates, seems to be caused by differences in practice for the group late preterm and term infants, while there is as expected little variation for infants with a gestational age of less than 34 weeks. There is relatively little variation between the hospital referral areas with admission rates below the national average, and there is no evidence of undesirable complications arising as a result of this practice. Grounds should be given for admission and bed day rates that are significantly higher than this, and, in the absence of such grounds, they can be considered to be undesirably high from a patient perspective, which means that they constitute undesirable variation.

Bed day rates and average length of stay for preterm infants also show a clinically relevant variation, and the bed day rates seem to vary more than the admission rates. Several measures and interventions have been documented to reduce the length of hospital stays, but short length of stay must be considered in relation to the breastfeeding rate on discharge. It is a goal for as many infants as possible to breastfeed or be fed breast milk when they go home, and a variety of circumstances relating to the mother and child can affect the sensitive process of establishing a good breastfeeding routine. These circumstances include the possibility to be together and expertise and guidance to the mother while the infant is hospitalised. The breastfeeding rate on discharge and, if relevant, after 3–4 weeks at home, can be a quality indicator with a bearing on the child's further growth and development, but it can also give an indication of whether the hospital has succeeded in creating good interaction between the mother and child. However, there is no evidence of any link between longer stays in neonatal units and increased breastfeeding rates in preterm infants. The opposite may just as well be the case, in that some units may succeed in establishing breastfeeding at an earlier stage, thereby making it possible to discharge children earlier. The Norwegian Neonatal Network's registration of breastfeeding is currently not sufficiently well quality-assured to allow these links to be investigated. Further work should be done to improve the register's data quality in this area.

7.2 Infections and sepsis

The analyses show variation both in the number of infants treated with antibiotics and in the total number of antibiotic treatment days. The treatment day rates vary more than the admission rates for infants started on antibiotic treatment.

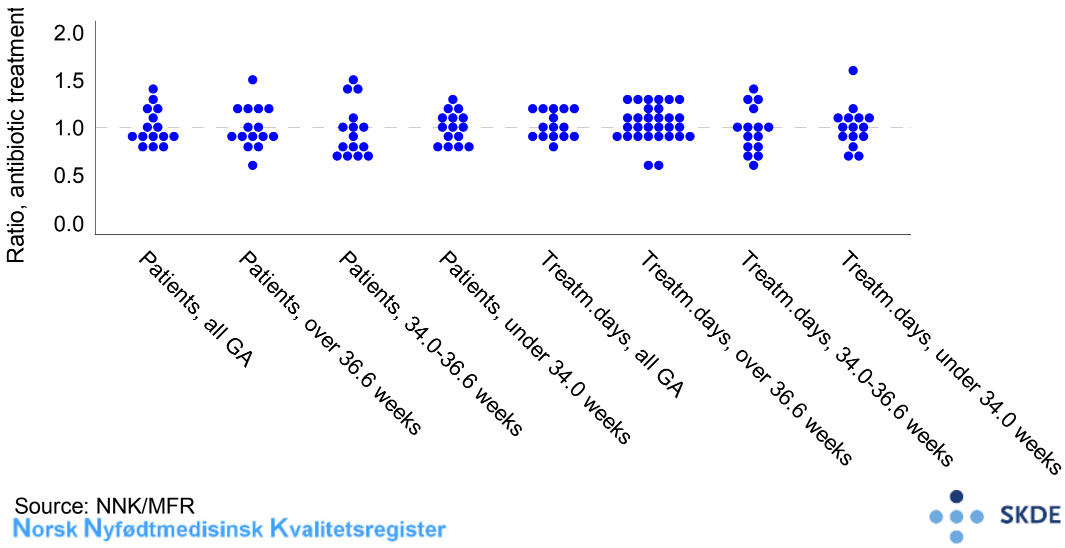

Figure 7.2: Variation profile, antibiotic treatment, patients and treatment days.

There is considerable variation in the use of sepsis as a diagnosis between hospital referral areas, and this variation has a bearing on the duration of treatment with antibiotics.

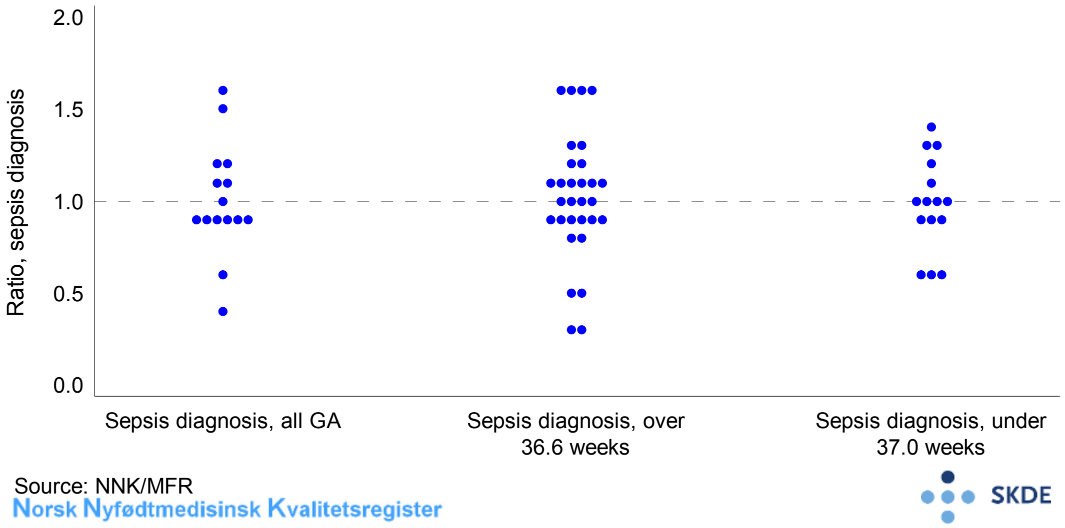

Figure 7.3: Variation profile, sepsis diagnosis, patients.

Others have also described considerable variation in the use of antibiotics. In California, the use of antibiotics was found to vary by a factor of 40 between 127 neonatal units (Schulman et al. 2015). There was also significant variation between units at the same level, and the variation was otherwise unrelated to morbidity. Units with high use of antibiotics had 35% more bed days than units that used little antibiotics.

This healthcare atlas describes variation between hospital referral areas in the use of antibiotics.

This variation cannot be explained by medical factors, different risk factors or random variation, neither for term infants nor for late preterm infants or infants born before the 34th week of pregnancy. This variation is therefore characterised as unwarranted variation.

We do not know whether the one death in the period 2009–2011 referred to by Fjalstad et al. (2016) was related to late start-up of antibiotic treatment, but group B streptococci, which caused this death, are feared because such infections sometimes result in death even when antibiotic treatment is started reasonably early.

One study, which also includes parts of the cohort covered by this healthcare atlas, discusses the use of the diagnosis early-onset sepsis. It argues that the actual rate of early-onset sepsis could probably be considerably lower than 9.1 per 1,000 births (Fjalstad et al. 2016). The number of diagnoses made on the basis of bacterial growth in blood cultures is significantly lower, at 0.5 per 1,000 births, but not all infections can be verified using this method. Many of the patients classified as having clinical sepsis were given this diagnosis because they had been treated for more than four days, but other clinical signs did not necessarily indicate infection. The findings described in this atlas support the assumption that the actual rate of sepsis in the population is considerably lower than 9.1 per 1,000 births. The use of the sepsis diagnosis varies by a factor of more than five between hospital referral areas, and even in the hospital referral area with the lowest rate, the sepsis diagnosis is used significantly more often than the actual number of cases would indicate. Hospital referral areas with a high rate of use of the sepsis diagnosis also have higher rates of antibiotic treatment days. This covariation could be an indication that overdiagnosis can result in overtreatment.

There is a set of common guidelines for the sepsis diagnosis in neonates in Norway, but the criteria are not all objective and involve a significant element of clinical judgement. It is possible to argue that more specific criteria for using the sepsis diagnosis could reduce the variation. The experience gained from the introduction of national guidelines for screening neonates for early-onset sepsis in the UK in 2012 shows that this will not necessarily be the result. These new guidelines resulted in an increase of 30% in the number of infants whose length of stay in neonatal units exceeded five days compared with the period before the guidelines were introduced. The number of infants who underwent a second blood test to measure CRP more than doubled, and the number of infants who underwent lumbar punctures increased by 65% (Mukherjee et al. 2015). Despite this considerable increase, the number of positive blood cultures or cerebrospinal fluid cultures with bacterial growth did not increase. The authors concluded that variation was reduced and the use of resources increased, without any detectable health gain for the patient group. Instead, the result was potential overtreatment.

The risk of serious infections is considerably higher for infants born at a low gestational age. In this group, infections often develop after days or weeks of treatment (late-onset sepsis), and the risk is primarily related to the treatment. In addition to the immediate complications, infections in preterm infants are often associated with an increased incidence of cerebral palsy and chronic lung disease (BPD) (Lapcharoensap et al. 2016; Mitha et al. 2013). A Norwegian study of infants with a birth weight of less than 1,000 grams found that 19.7% were diagnosed with late-onset sepsis (Rønnestad, Abrahamsen, et al. 2005). The incidence of late-onset infections in preterm infants can be reduced by means of documented infection prevention programmes (Payne et al. 2012; Polin et al. 2012), and differences in the incidence of such infections between units have been documented (Chien et al. 2002). About 60% of all infants with a gestational age of less than 34 weeks who are admitted are given antibiotics, and there is reason to believe that the majority of the most preterm infants are started on at least one course of antibiotics.

It has been the practice at some neonatal units to give prophylactic treatment with full doses of antibiotics to very preterm infants for as long as they have invasive central catheters in place. Prophylactic use of antibiotics does not reduce the incidence of infection, but is associated with more late-onset infections and increased mortality (Kuppala et al. 2011). In recent years, many units have changed their practice in accordance with new knowledge, and there is reason to believe that this will result in a reduction of the use of antibiotics in the group of infants with a gestational age of less than 28 weeks.

At worst, underuse of antibiotics in neonates could result in deaths. There is no evidence of such underuse in Norway, but guidelines and opinions about what is the correct or necessary level vary between units and doctors.

Overuse of antibiotics can also have undesirable consequences. Generally, overuse of antibiotics is a big and growing global problem that stimulates the development of resistant bacteria. It is therefore desirable to limit the number of patients treated and to use as narrow-spectrum antibiotics as possible. Use of antibiotics increases the admission rate as well as the length of stay (Schulman et al. 2015).

Concerns about the long-term consequences of early exposure to antibiotics are also growing. There are indications that even short-term exposure to antibiotics during the neonatal period could have long-term effects on the gut flora, and thus contribute to increasing the risk of illness in later life (Blaser 2014; Arboleya et al. 2015; DiGiulio 2015).

However, until new diagnostic technology is developed it is not possible to practise modern neonatal medicine safely without administering more antibiotics than what is necessary to treat patients who are proven to have infections.

The use of antibiotics for neonates reflects a conflict between two precautionary principles that are both generally applicable in modern medicine. On the one hand, there is a need to ensure that infants who should be treated receive treatment, even though this will necessarily entail a certain level of overtreatment. On the other hand, one does not want to expose infants unnecessarily to medication that could have adverse effects such as development of antibiotic resistance or an increased risk of future illness relating to changes in the child's bacterial flora. It is not always easy to strike a balance between these two considerations.

Nevertheless, some hospital referral areas seem to have a high use of antibiotics, which means that unwarranted variation exists, both in terms of the number of infants treated with antibiotics and in the number of days of such treatment they undergo. Considering that the mortality for term infants from infection is very low, it may seem that hospital referral areas with low antibiotic usage rates are closer to the correct balance between short-term and long-term risk.

There is also great variation in the use of the sepsis diagnosis for neonates, and this variation must be categorised as unwarranted. Overdiagnosis of sepsis seems to be associated with high antibiotic usage rates, and the specialist community should therefore discuss measures to promote a more precise use of the diagnosis sepsis in neonates. One such measure has been implemented from and including 2015 through the national registration tool the Norwegian Neonatal Program. After four days of antibiotic treatment, the program now requires an active answer to the questions of whether you wish to continue the treatment and whether you wish to set a diagnosis of sepsis.

7.3 Ventilator treatment

Some infants need ventilator treatment to survive. However, the number of infants undergoing ventilator treatment has varied considerably between countries, and also between units. Even though new techniques for avoiding ventilator treatment have been developed, the extent to which these techniques have been introduced varies between different units (Berger et al. 2013; Sweet et al. 2016). The variation in the use of ventilators can be due to differences in patient group composition, but it has been documented that choosing treatment strategies that prevent pulmonary damage will significantly reduce the need for ventilator treatment (Levesque et al. 2011; Gopel, Kribs, A. Ziegler, et al. 2011; Verder et al. 2009).

The use of ventilator treatment can be influenced by different thresholds for initiating such treatment, how and when surfactant (a drug that makes the lungs less stiff) is administered, and different criteria for and opinions about when ventilator treatment should be replaced by less invasive methods such as CPAP (air blown into the infant's nose while it is breathing spontaneously) or no respiratory support (Gopel, Kribs, A. Ziegler, et al. 2011; Verder et al. 2009; Isayama et al. 2016).

The European Guidelines on the Management of Respiratory Distress Syndrome (RDS) recommends using strategies to reduce ventilator use in favour of non-invasive respiratory support (Sweet et al. 2016). Ventilator use is associated with complications such as chronic lung disease, cerebral palsy, cerebral haemorrhage, air leak syndrome, ventilator-induced pneumonia and infections (Gopel, Kribs, A. Ziegler, et al. 2011; Isayama et al. 2016; Sweet et al. 2016; Gopel, Kribs, Hartel, et al. 2015; Alexandrou et al. 2014). The risk of complications increases with increasing duration of treatment.

Variation in ventilator treatment is probably preference-sensitive, both as regards the number of patients treated and the duration of treatment, and the variation described in this atlas appears to increase with gestational age.

There is considerable variation in the number of patients who undergo ventilator treatment as well as in the number of treatment days for all infants who undergo ventilator treatment, regardless of the length of pregnancy. This variation cannot easily be explained by medical differences or case mix, and can therefore be characterised as unwarranted.

Variation is greatest for the group with a gestational age between 28 weeks and 36 weeks and 6 days, but the sample for this group is smaller than for the population as a whole, so there may be a bigger element of random variation. Nearly 2.5 times as many infants are admitted for ventilator treatment in the UNN/Finnmark area as in Vestre Viken hospital referral area. As expected, there is more variation in treatment days than in admissions figures. More than five times as many days of ventilator treatment is administered in Sørlandet hospital referral area as in Vestre Viken, and the average duration of ventilator treatment is more than three times as long for patients resident in the Sørlandet area as for patients resident in Vestre Viken hospital referral area.

The variation in the group of infants with a gestational age between 28 weeks and 36 weeks and 6 days should be investigated in greater detail. There is no reason to believe that the patient group composition differs between hospital referral areas. Infants in this group are often relatively mature and breathe spontaneously at birth with no need for intubation, but can gradually develop more serious lung conditions that require treatment over the course of their first hours or within a few days. There is evidence that early administration of surfactant to infants in this group treated with CPAP (increasing oxygen requirement > 30%) can prevent worsening of RDS and shorten the ventilator treatment period (Verder et al. 2009; Gopel, Kribs, A. Ziegler, et al. 2011). The drug is administered through a plastic tube or feeding tube inserted into the child's trachea. In many cases, the breathing tube can be removed immediately after the procedure, thus avoiding placing the infant on a ventilator, but there is reason to believe that the use of such techniques and the assessment of when ventilator treatment is required have varied between neonatal units and treatment providers. A systematic review of differences in practice between units can help to clarify how important the variation in the use of preventive treatment strategies is to the observed variation in ventilator use.

There is reason to conclude that there is unwarranted variation, both in the number of infants treated and in the number of ventilator treatment days for infants born after 28 weeks or more of pregnancy, both preterm and term infants. Therefore, there is reason to ask whether what we see in the hospital referral areas with the highest rates is overtreatment that could have been reduced had other treatment strategies been chosen.

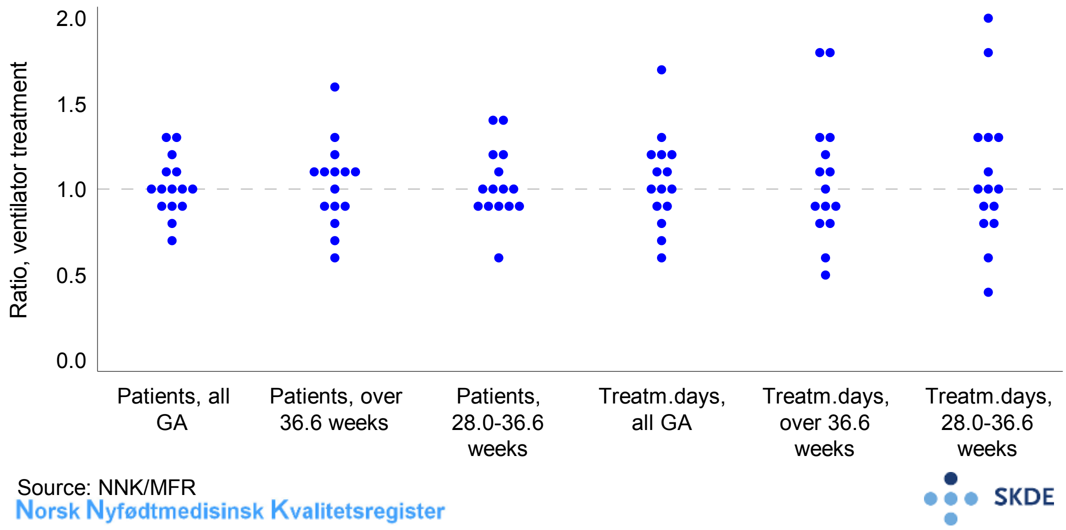

Figure 7.4: Variation profile, ventilator treatment, patients and treatment days.

Most infants born at a gestational age of less than 28 weeks are born at a regional hospital. In addition, a relatively small number of infants are born at this gestational age in each hospital referral area. We have therefore chosen to present ventilator use together for the hospital referral areas in each of Norway's four health regions. This will also provide an approximately correct picture of variation based on the location where most of this treatment is carried out.

It is worth noting that there is little variation in the treatment rates for ventilator treatment between the four health regions, but that Western Norway Regional Health Authority has significantly fewer treatment days. However, we cannot automatically conclude that this should be characterised as unwarranted variation.

Infants born before the 25th week of pregnancy are the group that significantly increases the number of treatment days. These infants undergo significantly longer periods of ventilator treatment than those with a gestational age of more than 25 weeks, and treatment periods of 20–50 days are not uncommon. Norwegian neonatologists have had somewhat differing opinions about the treatment of the most immature preterm infants. If such disagreements also manifest themselves in differences between hospital referral areas in terms of who are treated, this will be reflected in the ventilator treatment times for this group. A more detailed review of the treatment administered to the most preterm infants is therefore required before we can conclude as to whether the variation observed between Western Norway RHA and Central Norway RHA is warranted or unwarranted. Such an extensive and detailed review falls outside the scope of this healthcare atlas. If the variation was found to be related to different preferences concerning the treatment of the most preterm infants, this would give grounds to discuss this further in light of the objective that the Norwegian health service is to provide equitable services regardless of where people live with real participation in treatment choices by next of kin.

7.4 Hypoglycaemia and phototherapy

We have included low blood sugar and phototherapy for jaundice in late preterm and term infants in this atlas because we have reason to believe that they both show variation related to local preferences and differences in treatment culture between hospitals. These differences could be based on differences in medical assessments, but could also be related to differences in local bed capacity (supply-sensitive variation), either in the form of insufficient maternity unit capacity or because the local neonatal unit has sufficient capacity to allow infants to be transferred without this putting the capacity under pressure.

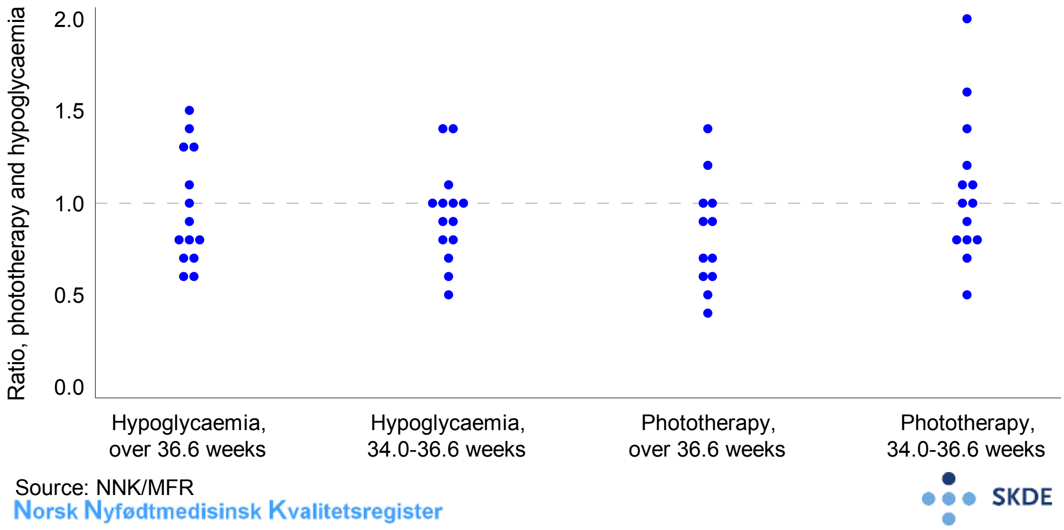

Figure 7.5: Variation, hypoglycaemia and phototherapy, patients.

If an infant develops moderately low blood sugar at a maternity unit, transfer to the neonatal unit can be avoided by initiating feeding measures and monitoring body temperature to ensure that the infant does not become cold. Unnecessary separation of mother and child can thus be avoided. There is no reason to believe that a fundamental geographical difference exists in the risk of term infants or late preterm infants developing hypoglycaemia. This gives reason to assume that most of the variation relates to differences in preference, but we cannot rule out the possibility that there could be an element of actual differences in the incidence of the condition caused by local procedures for follow-up of infants at risk.

There is no reason to believe that the number of infants who need phototherapy for jaundice varies between hospital referral areas. No other treatment procedure in Norwegian paediatric medicine enjoys the same level of consensus and support, and there is reason to believe that the criteria for initiating phototherapy are reasonably uniformly practiced, both by paediatric departments and by maternity units. The guidelines for when infants should be started on phototherapy are set out in nomograms that cover the child's first ten days and are available at all Norwegian maternity and neonatal units.

The variation observed in the number of infants transferred from maternity to neonatal units for phototherapy, by a factor of more than eleven for term infants and more than four for late preterm infants, is therefore completely unrelated to the incidence of jaundice that requires treatment in the birth population. The variation should thus be interpreted as unwarranted.

The expected need for phototherapy is about 4.5% of all infants with a gestational age of 34 weeks or more (Tønne et al. 2010). Telemark hospital referral area's rates for the relevant gestational age groups indicate that all who need phototherapy in this hospital referral area are treated at neonatal units. The rates for Bergen/Førde hospital referral area indicate that approximately 14% of infants in need of this type of treatment receive it at a neonatal unit. The other infants with jaundice must be assumed to receive the treatment they need in the maternity units, in accordance with the guidelines.

This forms the basis for concluding that there is unwarranted variation in the neonatal unit admission rates for infants with low blood sugar and infants who need phototherapy. Such transfers result in infants being separated from their mother, and there is no medical basis for assuming that the variation in admission practices has any bearing on the quality of treatment. There could be reason to ask whether this shows an overuse of admissions at the neonatal units that have the highest admission rates.

7.5 Use of intensive care

There are 60% more infants receiving intensive care-level treatment in Telemark hospital referral area than in Vestre Viken. Twice as many term infants (gestational age 37 weeks or more) receive intensive care-level treatment in the hospital referral area with the highest rate compared with the area with the lowest rate (the hospital referral areas of Telemark and Vestre Viken, respectively).

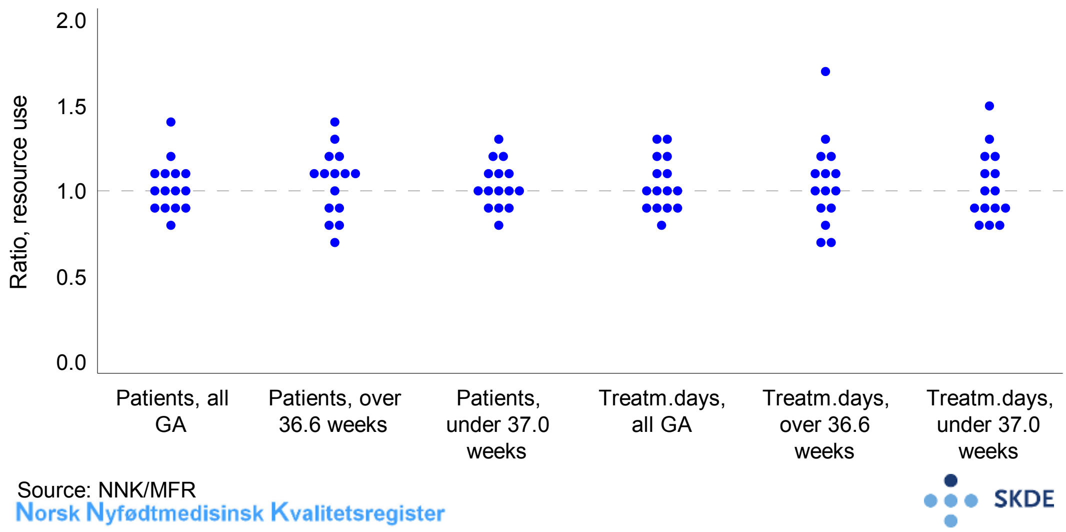

Figure 7.6: Variation profile, resource use, patients and treatment days.

There is also a 60% difference between the hospital referral areas with the highest and lowest admission rates (the hospital referral areas of UNN/Finnmark and Innlandet, respectively) for preterm infants (gestational age less than 37 weeks).

If you have a high number of infants with short average period of intensive care-level treatment, that could indicate that healthier infants are treated at the highest resource level than if you have a low patient rate in combination with a high treatment day rate and long average treatment period per patient - as observed when comparing Telemark and Møre og Romsdal for term infants.

It is not a given that there is a linear relationship between the use of more intensive care treatment procedures and better treatment outcomes (Shah, Mirea, et al. 2015; Vinall et al. 2014). There is no obvious medical explanation for the observed variation in rates for the use of intensive care resources, particularly for term infants, and there is reason to ask whether this variation is unwarranted. There is also nothing in the Norwegian Neonatal Network's reports to indicate that the results of medical treatment in terms of survival or treatment outcomes differ between hospital referral areas, and this gives reason to ask whether this variation also indicates that infants in the hospital referral areas that have the highest rates are overtreated.

7.6 Does more treatment result in better health?

Studies conducted on adult patients have shown that more treatment will not necessarily result in better outcomes than less treatment (Fisher et al. 2003a; Yasaitis et al. 2009), and in some cases more treatment seems to be associated with poorer treatment outcomes and reduced patient satisfaction (Fisher et al. 2003b).

The Norwegian health economist Jan Abel Olsen has described how the health gain from an increased use of health services depends on the level of use before the increase (Olsen 1993). If the level was high before the increase, an increase brings less health gain than if it was low. Such an effect has also indirectly been demonstrated in neonatal medicine (D. C. Goodman, Fisher, Little, Stukel, and C.-H. Chang 2001; D. C. Goodman, Fisher, Little, Stukel, and C.-h. Chang 2001; D. C. Goodman, Fisher, Little, Stukel, C.-h. Chang, and Schoendorf 2002). Neonatal mortality, adjusted for morbidity and socioeconomic factors between 246 defined hospital referral areas with pertaining neonatal units in the USA, dropped as the number of neonatologists increased until a rate of 2.7 neonatologists per 10,000 births had been reached. Increasing coverage further was not found to have any effect on neonatal mortality.

One important reason why more treatment does not necessarily improve survival rates or health is that treatment is also associated with risk. Intensive care treatment always entails a potential for serious, sometimes even life-threatening, complications. Using MR and cognitive examinations, Vinall et al. (2014) found that children who had undergone many invasive procedures, such as having catheters inserted into their veins, intubation and urinary catheterisation, showed poorer neurological and cognitive development at the age of five than children who had undergone fewer such procedures. These results were also valid after adjusting for differences in child morbidity during treatment.

The Canadian Neonatal Network found poorer medical outcomes in units with the highest treatment intensity compared with units with lower treatment intensity for comparable groups of patients (Shah, Mirea, et al. 2015). They discuss whether this could be an indication of an overuse of resources that mostly results in complications and side effects. In a prospective study from Marseille, Ligi et al. found that the incidence of undesirable or harmful incidents in an neonatal intensive care unit was 25.6 incidents per 1,000 bed days (Ligi et al. 2008). What is defined as treatment complications and undesirable incidents is subject to discussion, but this study seems to use a relatively conservative estimate defining them as incidents involving direct harm or a concrete potential of harm to the patient. The most common incident was medication errors.

On the other hand, underuse of well-documented treatments with a bearing on survival and treatment outcomes has also been identified. A recently published study (Zeitlin et al. 2016) documents that compliance with four well-documented best practices for the treatment of preterm infants born between the 24th and 33rd weeks of pregnancy in different regions of Europe varies from 32% in Portugal to 75% in Estonia. The measures are documented to reduce morbidity and mortality in this treatment group.

Material differences in survival for extremely preterm infants related to differences in treatment intensity have also been identified. The Swedish EXPRESS study investigated survival rates in preterm infants born before the 27th week for pregnancy and found that perinatal mortality varied from 22% in the Uppsala region to 46% in the Ørebro region (Serenius, Sjörs, et al. 2014). The two regions of Umeå and Uppsala had significantly better survival rates than the other five regions, and it was found that the two regions with the highest survival rates took a more proactive approach to the treatment of the mother before birth and of the immediate treatment of the child in connection with birth. The EXPRESS study (Serenius, Sjörs, et al. 2014; Serenius, Blennow, et al. 2015) has also shown that despite a higher survival rate for extremely preterm infants in the regions of Uppsala and Umeå, there is not a higher percentage of children with serious late complications than in the regions with lower survival rates.

There are thus indications in the literature that it is both possible and probable that both over- and undertreatment occur of patients admitted to neonatal units, and that this has an effect on the incidence of serious complications and survival. There are also indications of such differences existing between regions in Norway. There have been different views on, and probably variation in, practices and treatment intensity between regional units that may have had an effect on survival, particularly for the most preterm infants (Frafjord and Ellingsen 2013). The specialist community has discussed treatment intensity for more than 30 years, and even though all agree that the parents should be involved in decision-making, it seems that the prevailing medical opinion at the individual unit is the factor with the strongest bearing on treatment choices.

7.7 Conclusion and summary

This healthcare atlas identifies unwarranted variation in admission rates, length of stay rates and treatment rates for infants treated at neonatal units in Norway.

For most samples, we have sufficient data to assume that random variation is only a minor element of the total variation observed. The variation of 20% in admission rates for infants with a gestational age of less than 34 weeks (necessary care) probably reflects the scale of random variation in a medium-sized sample in this healthcare atlas. The element of random variation can be somewhat bigger for small samples and somewhat smaller for big samples (se also Chapter 5 Method).

There are indications in the literature that any socio-economic differences between hospital referral areas do not influence morbidity as long as adjustments are made for differences in the incidence of premature births, as we have done here. Since as good as all infants are admitted to neonatal units from a delivery or maternity unit, there is no reason to believe that differences in geography influence admission and treatment rates, although we cannot rule out the possibility that they may have a certain effect on the length of stay rates.

On the basis of the above, there is reason to assume that most of the variation described in this atlas primarily relates to differences in treatment preferences between neonatal units in the different hospital referral areas and healthcare regions. We cannot rule out the possibility that some differences may be related to capacity (supply-sensitivity), but there is no clear correlation between bed capacity in neonatal units and variation in admission rates.

There is little medical basis for assuming that health gains for neonates increase with increasing admission or treatment rates.

This atlas' quality and completeness of data are also unique in an international context. The creation of this healthcare atlas has been made possible by our access to a well-established national quality register with full participation from all the country's neonatal units. The work of obtaining the basis for calculating these rates is carried out every day in all neonatal units in Norway, as well as in the Norwegian Neonatal Network. The main findings of this atlas were presented to representatives of the neonatal units at the annual conference in October 2016.

The medical directors of all Norway's paediatric departments have been involved in the process of preparing and subsequently discussing the Child Healthcare Atlas for Norway. The experience of this process so far is very promising, and shows that there are good reasons to enlist the support of the specialist communities in such processes and to give them a sense of ownership of the data presented. This is not least true when the results can be perceived as challenging. A healthcare atlas shall not and cannot be used to name the unit with the best treatment and quality.

The Norwegian Neonatal Healthcare Atlas shows sometimes considerable variation in admission and treatment practices. The further work to reduce variation and ensure equitable treatment of Norwegian neonates should first and foremost be carried out by the specialist community itself through open discussion and by the initiation of register-based research if it is difficult to arrive at an answer to what is the correct level of treatment. We hope that the process that started in the specialist community after the Child Healthcare Atlas was published will continue after the Norwegian Neonatal Healthcare Atlas has been launched and benefit all infants admitted to Norwegian neonatal units every year, as well as their parents.

References

Alexandrou, G., G. Martensson, B. Skiold, M. Blennow, U. Aden, and B. Vollmer (2014). "White matter microstructure is influenced by extremely preterm birth and neonatal respiratory factors". *Acta Paediatr.* 103.1, pp. 48–56.

Arboleya, S., B. Sanchez, C. Milani, S. Duranti, G. Solis, N. Fernandez, C. G. de los Reyes-Gavilan, M. Ventura, A. Margolles, and M. Gueimonde (2015). "Intestinal microbiota development in preterm neonates and effect of perinatal antibiotics". *J. Paediatr.* 166.3, pp. 538–544.

Balteskard, L., T. Deraas, O. H. Førde, T. Magnus, F. Olsen, and B. Uleberg (2015). *Day surgery in Norway 2011–2013, a selection of procedures*. English version June 2017, ISBN: 978-82-93141-26-6.

Berger, T. M., M. Fontana, and M. Stocker (2013). "The journey towards lung protective respiratory support in preterm neonates". *Neonatology* 104.4, pp. 265–274.

Blaser, M. J. (2014). "Mikrobemangel". *Oslo: Mime forlag*.

Bratlid, D., B. Nakstad, and T. W. Hansen (2011). "National guidelines for treatment of jaundice in the newborn". *Acta Paediatr.* 100.4, pp. 499–505.

Bratlid, D. and A. Nordermoen (2010). "Behandling av svært for tidlig fødte barn de siste 40 år." *Tidsskrift for den Norske Legeforening* 130.11, pp. 1127–1129.

Burns, M. L., H. J. Stensvold, K. Risnes, H. J. Guthe, H. Astrup, S. M. Nordhov, T. R. Selberg, A. Rønnestad, A. M. Lang, M. Grønn, G. Helsvik, L. K. Lund, D. H. Frøisland, E. A. Nygaard, R. Støen, T. E. Calisch, A. Vatne, C. Klingenberg, R. Solberg, K. Hochnowski, A. Andreassen, R. Stornes, F. Bergqvist, B. Myklebust, A. Tiarks, P. Ivan, O. G. Nemeth, and F. R. Gulpen (2016). "Inotropic Therapy in Newborns, A Population-Based National Registry Study". *Pediatr Crit Care Med* 17.10, pp. 948–956.

Chien, L. Y., Y. Macnab, K. Aziz, W. Andrews, D. D. McMillan, and S. K. Lee (2002). "Variations in central venous catheter-related infection risks among Canadian neonatal intensive care units". *Pediatr. Infect. Dis. J.* 21.6, pp. 505–511.

DiGiulio, D. B. (2015). "Prematurity and perinatal antibiotics: a tale of two factors influencing development of the neonatal gut microbiota". *J. Paediatr.* 166.3, pp. 515–517.

Dishoeck, A.-M. van, H. F. Lingsma, J. P. Mackenbach, and E. W. Steyerberg (2011). "Random variation and rankability of hospitals using outcome indicators". *BMJ Quality & Safety* 20.10, pp. 869–874.

Eichenwald, E. C., M. Blackwell, J. S. Lloyd, T. Tran, R. E. Wilker, and D. K. Richardson (2001). "Inter-neonatal intensive care unit variation in discharge timing: influence of apnea and feeding management". *Pediatrics* 108.4, pp. 928–933.

Eichenwald, E. C., J. A. Zupancic, W. Y. Mao, D. K. Richardson, M. C. McCormick, and G. J. Escobar (2011). "Variation in diagnosis of apnea in moderately preterm infants predicts length of stay". *Pediatrics* 127.1, e53–58.

Fisher, E. S., D. E. Wennberg, T. A. Stukel, D. J. Gottlieb, F. Lucas, and É. L. Pinder (2003a). "The Implications of Regional Variations in Medicare Spending. Part 1: The Content, Quality, and Accessibility of Care". *Ann. Intern. Med.* 138.4, pp. 273–287.

Fisher, E. S., D. E. Wennberg, T. A. Stukel, D. J. Gottlieb, F. Lucas, and É. L. Pinder (2003b). "The Implications of Regional Variations in Medicare Spending. Part 2: Health Outcomes and Satisfaction with Care". *Ann. Intern. Med.* 138.4, pp. 288–298.

Fjalstad, J. W., H. J. Stensvold, H. Bergseng, G. S. Simonsen, B. Salvesen, A. E. Rønnestad, and C. Klingenberg (2016). "Early-onset Sepsis and Antibiotic Exposure in Term Infants: A Nationwide Population-based Study in Norway". *Pediatr. Infect. Dis. J.* 35.1, pp. 1–6.

Frafjord, E. and T. Ellingsen (2013). *En bitteliten kjempeutfordring*. Magasinet Plot, nr.14, 51–66.

Glover, J. A. (1938). "The Incidence of Tonsillectomy in School children". *Proc. R. Soc. Med.* 31.10, pp. 1219–1236.

Gonya, J., E. Martin, R. McClead, L. Nelin, and E. Shepherd (2014). "Empowerment programme for parents of extremely premature infants significantly reduced length of stay and readmission rates". *Acta Paediatr.* 103.7, pp. 727–731.

Goodman, D. C., E. S. Fisher, G. A. Little, T. A. Stukel, and C.-H. Chang (2001). "The Uneven Landscape of Newborn Intensive Care Services: Variation in the Neonatology Workforce". *Eff. Clin. Pract.* 4.4, pp. 143–149.

Goodman, D. C., E. S. Fisher, G. A. Little, T. A. Stukel, and C.-h. Chang (2001). "Are Neonatal Intensive Care Resources Located According to Need? Regional Variation in Neonatologists, Beds, and Low Birth Weight Newborns". *Pediatrics* 108.2, pp. 426–431.

Goodman, D. C., E. S. Fisher, G. A. Little, T. A. Stukel, C.-h. Chang, and K. S. Schoendorf (2002). "The Relation between the Availability of Neonatal Intensive Care and Neonatal Mortality". *N. Eng. J. Med.* 346.20, pp. 1538–1544.

Gopel, W., A. Kribs, C. Hartel, S. Avenarius, N. Teig, P. Groneck, D. Olbertz, C. Roll, M. Vochem, U. Weller, A. von der Wense, C. Wieg, J. Wintgens, M. Preuss, A. Ziegler, B. Roth, and E. Herting (2015). "Less invasive surfactant administration is associated with improved pulmonary outcomes in spontaneously breathing preterm infants". *Acta Paediatr.* 104.3, pp. 241–246.

Gopel, W., A. Kribs, A. Ziegler, R. Laux, T. Hoehn, C. Wieg, J. Siegel, S. Avenarius, A. von der Wense, M. Vochem, P. Groneck, U. Weller, J. Moller, C. Hartel, S. Haller, B. Roth, E. Herting, I. R. Konig, G. Stichtenoth, M. Bendiks, E. Kattner, T. Strahleck, K. Mehler, C. Hunseler, B. Hadzik, K. Moser, K. Buder, S. Lenze, E. Raedler, P. Gudowius, D. Anhalt, N. Teig, W. Nikischin, M. Rudiger, and A. Katalinic (2011). "Avoidance of mechanical ventilation by surfactant treatment of spontaneously breathing preterm infants (AMV): an open-label, randomised, controlled trial". *Lancet* 378.9803, pp. 1627–1634.

Harrison, W. and D. Goodman (2015). "Epidemiologic Trends in Neonatal Intensive Care, 2007-2012". *JAMA Pediatr* 169.9, pp. 855–862.

Ibáñez, B., J. Librero, E. Bernal-Delgado, S. Peiró, B. López-Valcarcel, N. Martínez, and F. Aizpuru (2009). "Is there much variation in variation? Revisiting statistics of small area variation in health services research". *BMC Health Serv. Res.* 9.1.

IOM (Institute of Medicine) (2013). *Variation in health care spending: Target decision making, not geography*. Ed. by J. P. Newhouse, A. M. Garber, R. P. Graham, M. A. McCoy, M. Mancher, and A. Kibria. Washington, DC: The National Academies Press.

Isayama, T., H. Iwami, S. McDonald, and J. Beyene (2016). "Association of Noninvasive Ventilation Strategies With Mortality and Bronchopulmonary Dysplasia Among Preterm Infants: A Systematic Review and Meta-analysis". *JAMA* 316.6, pp. 611–624.

Klingenberg, C. and B. Nakstad (2015). *Neonatale diagnosekoder i ICD-10. forslag til enhetlige nasjonale kriterier for diagnosekoder i nyødtmedisin*. Skriftserie for leger, Den norske Legeforening.

Korvenranta, E., M. Linna, U. Häkkinen, M. Peltola, S. Andersson, M. Gissler, M. Hallman, H. Korvenranta, J. Leipälä, L. Rautava, O. Tammela, and L. Lehtonen (2007). "Differences in the length of initial hospital stay in very preterm infants". *Acta Paediatr.* 96.10, pp. 1416–1420.

Kuppala, V. S., J. Meinzen-Derr, A. L. Morrow, and K. R. Schibler (2011). "Prolonged initial empirical antibiotic treatment is associated with adverse outcomes in premature infants". *J. Paediatr.* 159.5, pp. 720–725.

Lapcharoensap, W., P. Kan, R. J. Powers, G. M. Shaw, D. K. Stevenson, J. B. Gould, D. D. Wirtschafter, and H. C. Lee (2016). "The Relationship of Nosocomial Infection Reduction to Changes in Neonatal Intensive Care Unit Rates of Bronchopulmonary Dysplasia". *J. Paediatr.*

Levesque, B. M., L. A. Kalish, J. LaPierre, M. Welch, and V. Porter (2011). "Impact of implementing 5 potentially better respiratory practices on neonatal outcomes and costs". *Pediatrics* 128.1, e218–226.

Ligi, I., F. Arnaud, E. Jouve, S. Tardieu, R. Sambuc, and U. Simeoni (2008). "Iatrogenic events in admitted neonates: a prospective cohort study". *Lancet* 371.9610, pp. 404–410.

Melnyk, B. M., N. F. Feinstein, L. Alpert-Gillis, E. Fairbanks, H. F. Crean, R. A. Sinkin, P. W. Stone, L. Small, X. Tu, and S. J. Gross (2006). "Reducing premature infants' length of stay and improving parents' mental health outcomes with the Creating Opportunities for Parent Empowerment (COPE) neonatal intensive care unit program: a randomized, controlled trial". *Pediatrics* 118.5, e1414–1427.

Mitha, A., L. Foix-L'Hélias, C. Arnaud, S. Marret, R. Vieux, Y. Aujard, G. Thiriez, B. Larroque, G. Cambonie, A. Burguet, P. Boileau, J. C. Rozé, M. Kaminski, P. Truffert, and P.-Y. Ancel (2013). "Neonatal infection and 5-year neurodevelopmental outcome of very preterm infants". *Pediatrics* 132.2, e372–380.

Moen, A., F. Olsen, B. Uleberg, A. H. Steindal, P. Otterdal, T. Deraas, T. Magnus, and L. Balteskard (2015). *Child Healthcare Atlas for Norway*. English version June 2017, ISBN: 978-82-93141-27-3.

Mukherjee, A., L. Davidson, L. Anguvaa, D. A. Duffy, and N. Kennea (2015). "NICE neonatal early onset sepsis guidance: greater consistency, but more investigations, and greater length of stay". *Arch. Dis. Child. Fetal Neonatal Ed.* 100.3, F248–249.

Murthy, K., F. D. Dykes, M. A. Padula, E. K. Pallotto, K. M. Reber, D. J. Durand, B. L. Short, J. M. Asselin, I. Zaniletti, and J. R. Evans (2014). "The Children's Hospitals Neonatal Database: an overview of patient complexity, outcomes and variation in care". *J. Paediatr.* 34.8, pp. 582–586.

Numerato, D., G. Fattore, F. Tediosi, R. Zanini, M. Peltola, H. Banks, P. Mihalicza, L. Lehtonen, S. Svereus, R. Heijink, S. T. Klitkou, E. Fletcher, A. v. Heijden, F. Lundberg, E. Over, U. Hakkinen, and T. T. Seppala (2015). "Mortality and Length of Stay of Very Low Birth Weight and Very Preterm Infants: A EuroHOPE Study". *PLoS ONE* 10.6, e0131685.

Olsen, J. A. (1993). "But health can still be a necessity…". *J. Health Econ.* 12.2, pp. 187–191.

Ortenstrand, A., B. Westrup, E. B. Broström, I. Sarman, S. Akerström, T. Brune, L. Lindberg, and U. Waldenström (2010). "The Stockholm Neonatal Family Centered Care Study: effects on length of stay and infant morbidity". *Pediatrics* 125.2, e278–285.

Payne, N. R., J. Barry, W. Berg, D. E. Brasel, E. A. Hagen, D. Matthews, K. McCullough, K. Sanger, and M. D. Steger (2012). "Sustained reduction in neonatal nosocomial infections through quality improvement efforts". *Pediatrics* 129.1, e165–173.

Perrin, J. M., C. J. Homer, D. M. Berwick, A. D. Woolf, J. L. Freeman, and J. E. Wennberg (1989). "Variations in Rates of Hospitalization of Children in Three Urban Communities". *N. Eng. J. Med.* 320.18, pp. 1183–1187.

Polin, R. A., S. Denson, M. T. Brady, L. A. Papile, J. E. Baley, W. A. Carlo, J. J. Cummings, P. Kumar, R. A. Polin, R. C. Tan, K. L. Watterberg, M. T. Brady, C. L. Byington, H. Davies, K. M. Edwards, M. P. Glode, M. A. Jackson, H. L. Keyserling, Y. A. Maldonado, D. L. Murray, W. A. Orenstein, G. E. Schutze, R. E. Willoughby, and T. E. Zaoutis (2012). "Strategies for prevention of health care-associated infections in the NICU". *Pediatrics* 129.4, e1085–1093.

Profit, J., J. A. Zupancic, M. C. McCormick, D. K. Richardson, G. J. Escobar, J. Tucker, W. Tarnow-Mordi, and G. Parry (2006). "Moderately premature infants at Kaiser Permanente Medical Care Program in California are discharged home earlier than their peers in Massachusetts and the United Kingdom". *Arch. Dis. Child. Fetal Neonatal Ed.* 91.4, F245–250.

Rønnestad, A., T. G. Abrahamsen, S. Medbø, H. Reigstad, K. Lossius, P. I. Kaaresen, T. Egeland, I. E. Engelund, L. M. Irgens, and T. Markestad (2005). "Late-onset septicemia in a Norwegian national cohort of extremely premature infants receiving very early full human milk feeding". *Pediatrics* 115.3, e269–276.

Rønnestad, A., H. J. Stensvold, and L. M. Mæland Knudsen (2016). *Norsk Nyfødtmedisinsk Kvalitetsregister – Årsrapport for 2015 med plan for forbedringstiltak*. NNK (Norsk Nyfødtmedisinsk Kvalitetsregister), Oslo universitetssykehus HF Rikshospitalet.

Rosenthal, T. (2012). "Geographic variation in health care". *Ann. Rev. Med.* 63, pp. 493–509.

Schulman, J., R. J. Dimand, H. C. Lee, G. V. Duenas, M. V. Bennett, and J. B. Gould (2015). "Neonatal intensive care unit antibiotic use". *Pediatrics* 135.5, pp. 826–833.

Serenius, F., G. Sjörs, M. Blennow, V. Fellman, G. Holmsträm, K. Maršál, E. Lindberg, E. Olhager, L. Stigson, M. Westgren, and K. Källen (2014). "EXPRESS study shows significant regional differences in 1-year outcome of extremely preterm infants in Sweden". *Acta Paediatr.* 103.1, pp. 27–37.

Serenius, F., M. Blennow, K. Maršál, G. Sjörs, and K. Källen (2015). "Intensity of perinatal care for extremely preterm infants: outcomes at 2.5 years". *Pediatrics* 135.5, e1163–1172.

Shah, P. S., K. Lui, G. Sjörs, L. Mirea, B. Reichman, M. Adams, N. Modi, B. A. Darlow, S. Kusuda, L. San Feliciano, J. Yang, S. Håkansson, R. Mori, D. Bassler, J. Figueras-Aloy, S. K. Lee, N. Badawi, P. Marshall, and others. (2016). "Neonatal Outcomes of Very Low Birth Weight and Very Preterm Neonates: An International Comparison. " *J. Paediatr.* 177, pp. 144–152.

Shah, P. S., L. Mirea, E. Ng, A. Solimano, S. K. Lee, P. S. Shah, A. Harrison, A. Synnes, T. Sokoran, W. Yee, K. Aziz, Z. Kalapesi, K. Sankaran, M. Seshia, R. Alvaro, S. Shivananda, O. Da Silva, C. Nwaesei, K. S. Lee, M. Dunn, N. Rouvinez- Bouali, K. Dow, E. Pelausa, K. Barrington, C. Drolet, P. Riley, V. Bertelle, R. Canning, B. Bulleid, E. Chalmers, C. Ojah, L. Monterrosa, A. Deshpandey, J. Afifi, A. Kajetanowicz, and S. K. Lee (2015). "Association of unit size, resource utilization and occupancy with outcomes of preterm infants". *J Perinatol* 35.7, pp. 522–529.

Silverman, W. A. (1992). "Overtreatment of neonates? A personal retrospective". *Pediatrics* 90.6, pp. 971–976.

SKDE (2016). *Indikatorer for måling av uberettiget variasjon. Utredning fra SKDE for de regionale helseforetakene*. SKDE rapport, 4/16. ISBN: 978-82-93141-16-7.

Smith, L. K., E. S. Draper, B. N. Manktelow, and D. J. Field (2009). "Socioeconomic inequalities in survival and provision of neonatal care: population based study of very preterm infants". *BMJ* 339, b4702.

Stensvold, H. J., C. Klingenberg, R. Stoen, D. Moster, K. Braekke, H. J. Guthe, H. Astrup, S. Rettedal, M. Grønn, and A. E. Ronnestad (2017). *Neonatal Morbidity and One-Year Survival of Extremely Preterm Infants*. In press.

Stensvold, H. J., K. Strømmen, A. M. Lang, T. G. Abrahamsen, E. K. Steen, A. H. Pripp, and A. E. Rønnestad (2015). "Early Enhanced Parenteral Nutrition, Hyperglycemia, and Death Among Extremely Low-Birth-Weight Infants". *JAMA Pediatr* 169.11, pp. 1003–1010.

Sweet, D. G., V. Carnielli, G. Greisen, M. Hallman, E. Ozek, R. Plavka, O. D. Saugstad, U. Simeoni, C. P. Speer, M. Vento, G. H. Visser, and H. L. Halliday (2016). "European Consensus Guidelines on the Management of Respiratory Distress Syndrome - 2016 Update". *Neonatology* 111.2, pp. 107–125.

Thompson, L. A., D. C. Goodman, C. H. Chang, and T. A. Stukel (2005). "Regional variation in rates of low birth weight". *Pediatrics* 116.5, pp. 1114–1121.

Tønne, A., A. Meberg, and H. B. Hager (2010). "Endring i diagnostikk og behandling av hyperbilirubinemi hos nyfødte". *Tidsskrift for den Norske Legeforening* 130.1, pp. 18–20.

Vasquez-Ruiz, S., J. A. Maya-Barrios, P. Torres-Narvaez, B. R. Vega-Martinez, A. Rojas-Granados, C. Escobar, and M. Angeles-Castellanos (2014). "A light/dark cycle in the NICU accelerates body weight gain and shortens time to discharge in preterm infants". *Early Hum. Dev.* 90.9, pp. 535–540.

Verder, H., K. Bohlin, J. Kamper, R. Lindwall, and B. Jonsson (2009). "Nasal CPAP and surfactant for treatment of respiratory distress syndrome and prevention of bronchopulmonary dysplasia". *Acta Paediatr.* 98.9, pp. 1400–1408.

Vinall, J., S. P. Miller, B. H. Bjornson, K. P. Fitzpatrick, K. J. Poskitt, R. Brant, A. R. Synnes, I. L. Cepeda, and R. E. Grunau (2014). "Invasive procedures in preterm children: brain and cognitive development at school age". *Pediatrics* 133.3, pp. 412–421.

Wennberg, J. E. (2010). *Tracking Medicine: A Researcher's Quest to Understand Health Care*. Oxford University Press.

Wennberg, J. E. and A. Gittelsohn (1973). "Small Area Variations in Health Care Delivery: A population-based health information system can guide planning and regulatory decision-making". *Science* 182.4117, pp. 1102–1108.

Yasaitis, L., E. Fisher, T. A. Mackenzie, and J. Wasson (2009). "Healthcare intensity is associated with lower ratings of healthcare quality by younger adults". *J. Ambul. Care Manage.* 32.3, pp. 226–231.

Zeitlin, J., B. N. Manktelow, A. Piedvache, M. Cuttini, E. Boyle, A. van Heijst, J. Gadzinowski, P. Van Reempts, L. Huusom, T. Weber, S. Schmidt, H. Barros, D. Dillalo, L. Toome, M. Norman, B. Blondel, M. Bonet, E. S. Draper, and R. F. Maier (2016). "Use of evidence based practices to improve survival without severe morbidity for very preterm infants: results from the EPICE population based cohort". *BMJ* 354, p. i2976.

Ziegler, K. A., D. A. Paul, M. Hoffman, and R. Locke (2016). "Variation in NICU Admission Rates Without Identifiable Cause". *Hosp Pediatr* 6.5, pp. 255–260.

Appendix A

Some things you should know about communicating statistics using maps

A map is a powerful communication tool that provides an intuitive and simplified picture of a set of figures. However, maps can also be seductive and highly misleading, and it is important for readers to be aware of some fundamental aspects. When choosing a cartographic form of expression, there are several choices to make that entail advantages as well as disadvantages. The most commonly used cartographic presentation is known as the choropleth map. In such maps, each area (the interactive atlas uses health trust areas) are assigned a shade of colour depending on which class the data value falls within. The advantage of this is that it is easy to identify the areas described, while the disadvantage is that large health trust areas will be visually dominant, while smaller areas get far less attention.

Classification is another factor that one should be aware of when interpreting maps. All the variables presented are in principle continuous variables (rates are at interval/ratio level). In order to present this in a meaningful form on a map, this information must be simplified - we need to classify (group) the information. It is an unfortunate effect of such generalisation that it may hide big differences between data values in the data set and/or emphasise minor differences between variable values on the map. In order to counteract this, the method known as Jenks natural breaks has been chosen for the interactive atlas, and four classes are used. This classification method uses an algorithm to maximise homogeneity within each class as well as heterogeneity between classes. It is recommended that maps produced using this method be supplemented by a frequency histogram where users can find the 'thresholds' in the distribution of data observations. The interactive atlas includes such a frequency histogram (bar chart) that is intended to be used alongside the map to interpret the variations observed.

Maps are intended to provide a simplified picture of reality, but maps are also produced on the basis of a number of subjective choices. These choices have a bearing on other people's perception of reality. Just as with figures and statistics, one should take a critical approach when interpreting maps. Therefore, be aware of the rhetorical possibilities of the map.

Appendix B

Definition of hospital referral areas / catchment areas

The hospital referral areas are defined on the basis of the health trusts' catchment areas, i.e. the geographical areas that the different health trusts cover. We use short versions of the names of hospital referral areas in the report and in the table below. The short names of the hospital referral areas are defined in Table 5.1 on page 29.

Three of Oslo's city districts (Grorud, Stovner and Alna) belong to the catchment area of Akershus University Hospital (Ahus). Since the Norwegian Neonatal Network has no information about city districts, the three districts in question are coded on the basis of the mother's postal code. The postal codes that correspond to these city districts were identified using data provided by Statistics Norway. Several postal codes cover addresses from more than one city district. In such cases, the postal code is assigned to the district where the majority of people in the postal code area in question live. This is a somewhat crude and imprecise categorisation, but it is deemed to be sufficiently accurate to link most neonatal unit treatment of patients from the three districts to the correct hospital referral area.

Hospital referral areas	Municipalities
UNN/Finnmark	2002 Vardø, 2003 Vadsø, 2004 Hammerfest, 2011 Kautokeino, 2012 Alta, 2014 Loppa, 2015 Hasvik, 2017 Kvalsund, 2018 Måsøy, 2019 Nordkapp, 2020 Porsanger, 2021 Karasjok, 2022 Lebesby, 2023 Gamvik, 2024 Berlevåg, 2025 Tana, 2027 Nesseby, 2028 Båtsfjord, 2030 Sør-Varanger, 1805 Narvik, 1851 Lødingen, 1852 Tjeldsund, 1853 Evenes, 1854 Ballangen, 1902 Tromsø, 1903 Harstad, 1911 Kvæfjord, 1913 Skånland, 1917 Ibestad, 1919 Gratangen, 1920 Lavangen, 1922 Bardu, 1923 Salangen, 1924 Målselv, 1925 Sørreisa, 1926 Dyrøy, 1927 Tranøy, 1928 Torsken, 1929 Berg, 1931 Lenvik, 1933 Balsfjord 1936 Karlsøy, 1938 Lyngen, 1939 Storfjord, 1940 Kåfjord, 1941 Skjervøy, 1942 Nordreisa, 1943 Kvænangen
Nordland	1804 Bodø, 1837 Meløy, 1838 Gildeskål, 1839 Beiarn, 1840 Saltdal, 1841 Fauske, 1845 Sørfold, 1848 Steigen, 1849 Hamarøy, 1850 Tysfjord, 1856 Røst, 1857 Værøy, 1859 Flakstad, 1860 Vestvågøy, 1865 Vågan, 1866 Hadsel,

	1867 Bø, 1868 Øksnes, 1870 Sortland, 1871 Andøy, 1874 Moskenes, 1811 Bindal, 1812 Sømna, 1813 Brønnøy, 1815 Vega, 1816 Vevelstad, 1818 Herøy, 1820 Alstahaug, 1824 Vefsn, 1825 Grane, 1826 Hattfjelldal, 1827 Dønna, 1828 Nesna, 1822 Leirfjord, 1832 Hemnes, 1833 Rana, 1834 Lurøy, 1835 Træna, 1836 Rødøy
Trøndelag	1632 Roan, 1633 Osen, 1702 Steinkjer, 1703 Namsos, 1711 Meråker, 1714 Stjørdal, 1717 Frosta, 1718 Leksvik, 1719 Levanger, 1721 Verdal, 1724 Verran, 1725 Namdalseid, 1736 Snåsa, 1738 Lierne, 1739 Røyrvik, 1740 Namsskogan, 1742 Grong, 1743 Høylandet, 1744 Overhalla, 1748 Fosnes, 1749 Flatanger, 1750 Vikna, 1751 Nærøy, 1755 Leka, 1756 Inderøy, 1567 Rindal, 1601 Trondheim, 1612 Hemne, 1613 Snillfjord, 1617 Hitra, 1620 Frøya, 1621 Ørland, 1622 Agdenes, 1624 Rissa, 1627 Bjugn, 1630 Åfjord, 1634 Oppdal, 1635 Rennebu, 1636 Meldal, 1638 Orkdal, 1640 Røros, 1644 Holtålen, 1648 Midtre Gauldal, 1653 Melhus, 1657 Skaun, 1662 Klæbu, 1663 Malvik, 1664 Selbu, 1665 Tydal
Møre og Romsdal	1502 Molde, 1504 Ålesund, 1505 Kristiansund, 1511 Vanylven 1514 Sande, 1515 Herøy, 1516 Ulstein, 1517 Hareid, 1519 Volda 1520 Ørsta, 1523 Ørskog, 1524 Norddal, 1525 Stranda, 1532 Giske, 1526 Stordal 1528, Sykkylven, 1529 Skodje, 1531 Sula, 1534 Haram, 1535 Vestnes, 1539 Rauma, 1543 Nesset, 1545 Midsund, 1546 Sandøy, 1547 Aukra, 1548 Fræna, 1551 Eide, 1554 Averøy, 1557 Gjemnes, 1560 Tingvoll, 1563 Sunndal, 1566 Surnadal, 1571 Halsa, 1573 Smøla, 1576 Aure
Bergen/Førde	1401 Flora, 1411 Gulen, 1412 Solund, 1413 Hyllestad, 1416 Høyanger, 1417 Vik, 1418 Balestrand, 1419 Leikanger, 1420 Sogndal, 1421 Aurland, 1422 Lærdal, 1424 Årdal, 1426 Luster, 1428 Askvoll, 1429 Fjaler, 1430 Gaular, 1431 Jølster, 1432 Førde, 1433 Naustdal, 1438 Bremanger, 1439 Vågsøy, 1441 Selje, 1443 Eid, 1444 Hornindal, 1445 Gloppen, 1449 Stryn, 1201 Bergen, 1233 Ulvik, 1234 Granvin, 1235 Voss, 1238 Kvam, 1241 Fusa, 1242 Samnanger, 1243 Os, 1244 Austevoll, 1245 Sund, 1246 Fjell, 1247 Askøy, 1251 Vaksdal, 1252 Modalen, 1253 Osterøy, 1256 Meland, 1259 Øygarden, 1260 Radøy, 1263 Lindås, 1264 Austrheim, 1265 Fedje, 1266 Masfjorden,
Fonna	1106 Haugesund, 1134 Suldal, 1135 Sauda, 1145 Bokn, 1146 Tysvær, 1149 Karmøy, 1151 Utsira, 1160 Vindafjord, 1211 Etne, 1216 Sveio, 1219 Bømlo, 1221 Stord, 1222 Fitjar, 1223 Tysnes, 1224 Kvinnherad, 1227 Jondal, 1228 Odda, 1231 Ullensvang, 1232 Eidfjord,
Stavanger	1101 Eigersund, 1102 Sandnes, 1103 Stavanger, 1111 Sokndal, 1112 Lund, 1114 Bjerkreim, 1119 Hå, 1120 Klepp, 1121 Time, 1122 Gjesdal, 1124 Sola, 1127 Randaberg, 1129 Forsand,

	1130 Strand, 1133 Hjelmeland, 1141 Finnøy, 1142 Rennesøy, 1144 Kvitsøy
Østfold	0101 Halden, 0104 Moss, 0105 Sarpsborg, 0106 Fredrikstad, 0111 Hvaler, 0118 Aremark, 0119 Marker, 0122 Trøgstad, 0123 Spydeberg, 0124 Askim, 0125 Eidsberg, 0127 Skiptvet, 0128 Rakkestad, 0135 Råde, 0136 Rygge, 0137 Våler, 0138 Hobøl
AHUS	0121 Rømskog, 0221 Aurskog-Høland, 0226 Sørum, 0227 Fet, 0228 Rælingen, 0229 Enebakk, 0230 Lørenskog, 0231 Skedsmo, 0233 Nittedal, 0234 Gjerdrum, 0235 Ullensaker, 0237 Eidsvoll, 0238 Nannestad, 0239 Hurdal, 0211 Vestby, 0213 Ski, 0214 Ås 0215 Frogn, 0216 Nesodden, 0217 Oppegård, Including Oslo's city districts Grorud, Alna, Stovner
OUS	0301 Oslo Excluding city districts Grorud, Alna, Stovner
Innlandet	0236 Nes, 0402 Kongsvinger, 0403 Hamar, 0412 Ringsaker, 0415 Løten, 0417 Stange, 0418 Nord-Odal, 0419 Sør-Odal, 0420 Eidskog, 0423 Grue, 0425 Åsnes, 0426 Våler, 0427 Elverum, 0428 Trysil, 0429 Åmot, 0430 Stor-Elvdal, 0432 Rendalen, 0434 Engerdal, 0436 Tolga, 0437 Tynset, 0438 Alvdal, 0439 Folldal, 0441 Os, 0501 Lillehammer, 0502 Gjøvik, 0511 Dovre, 0512 Lesja, 0513 Skjåk, 0514 Lom, 0515 Vågå, 0516 Nord-Fron, 0517 Sel, 0519 Sør-Fron, 0520 Ringebu, 0521 Øyer, 0522 Gausdal, 0528 Østre Toten, 0529 Vestre Toten, 0533 Lunner, 0534 Gran, 0536 Søndre Land, 0538 Nordre Land, 0540 Sør-Aurdal, 0541 Etnedal, 0542 Nord-Aurdal, 0543 Vestre Slidre, 0544 Øystre Slidre, 0545 Vang
Vestre Viken	0219 Bærum, 0220 Asker, 0532 Jevnaker, 0602 Drammen, 0604 Kongsberg, 0605 Ringerike, 0612 Hole, 0615 Flå, 0616 Nes, 0617 Gol, 0618 Hemsedal, 0619 Ål, 0620 Hol, 0621 Sigdal, 0622 Krødsherad, 0623 Modum, 0624 Øvre Eiker, 0625 Nedre Eiker, 0626 Lier, 0627 Røyken, 0628 Hurum, 0631 Flesberg, 0632 Rollag, 0633 Nore og Uvdal, 0711 Svelvik, 0713 Sande
Vestfold	0701 Horten, 0702 Holmestrand, 0704 Tønsberg, 0706 Sandefjord, 0709 Larvik, 0714 Hof, 0716 Re, 0719 Andebu, 0720 Stokke, 0722 Nøtterøy, 0723 Tjøme, 0728 Lardal
Telemark	0805 Porsgrunn, 0806 Skien, 0807 Notodden, 0811 Siljan, 0814 Bamble, 0815 Kragerø, 0817 Drangedal ,0819 Nome, 0821 Bø, 0822 Sauherad, 0826 Tinn, 0827 Hjartdal, 0828 Seljord, 0829 Kviteseid, 0830 Nissedal, 0831 Fyresdal, 0833 Tokke, 0834 Vinje
Sørlandet	0901 Risør, 0904 Grimstad, 0906 Arendal, 0911 Gjerstad,

	0912 Vegårshei, 0914 Tvedestrand, 0919 Froland, 0926 Lillesand, 0928 Birkenes, 0929 Åmli, 0935 Iveland, 0937 Evje og Hornnes, 0938 Bygland, 0940 Valle, 0941 Bykle, 1001 Kristiansand, 1002 Mandal, 1003 Farsund, 1004 Flekkefjord, 1014 Vennesla, 1017 Songdalen, 1018 Søgne, 1021 Marnardal, 1026 Åseral, 1027 Audnedal, 1029 Lindesnes, 1032 Lyngdal, 1034 Hægebostad, 1037 Kvinesdal, 1046 Sirdal

Appendix C

Summary of ratios, minimum and maximum rates

Table C.1: Summary of ratios, minimum and maximum rates

		GA	FT	FT_2	FT_3	N	Highest rate – Lowest rate		Rate Norway
Admissions	Patients	All	2.16	1.71	1.51	34,738	156 – 72	(Vestfold – Bergen/Førde)	94
		>36.6	2.62	1.96	1.74	21,080	116 – 44.1	(Vestfold – Bergen/Førde)	62
		34.0–36.6	2.05	1.64	1.45	7,434	711 – 348	(Vestfold – Bergen/Førde)	453
		<34.0	1.19	1.12	1.09	6,224	962 – 807	(Vestre Viken – Vestfold)	864
	Length of stay	All	1.78	1.58	1.42	444,865	1,656 – 933	(Telemark – Bergen/Førde)	1,209
		>36.6	2.99	2.16	1.97	111,523	518 – 173	(Vestfold – Bergen/Førde)	326
		34.0–36.6	2.3	1.8	1.68	84,142	7,901 – 3,440	(UNN/Finnmark – Bergen/Førde)	5,127
		<34.0	1.51	1.23	1.19	249,200	43,790 – 29,025	(UNN/Finnmark – OUS)	34,577
Antibiotic treatments	Patients	All	1.76	1.58	1.47	14,007	53 – 30.3	(Stavanger – Bergen/Førde)	38.1
		>36.6	2.31	1.51	1.43	8,632	36.7 – 15.9	(Stavanger – Bergen/Førde)	25.2
		34.0–36.6	2.22	2.03	1.96	1,659	154 – 69	(Vestre Viken – AHUS)	101
		<34.0	1.65	1.45	1.37	3,716	673 – 407	(Vestre Viken – Innlandet)	516
	Treatment days	All	1.48	1.36	1.3	94,565	316 – 214	(Nordland – Bergen/Førde)	257
		>36.6	2.34	1.43	1.41	49,123	190 – 81	(Østfold – Bergen/Førde)	144
		34.0–36.6	2.36	1.9	1.74	9,097	784 – 333	(Sørlandet – Vestfold)	554
		<34.0	2.24	1.6	1.38	3,6345	8,052 – 3,593	(Møre og Romsdal – Vestfold)	5,043
	Patients with sepsis diagnosis	All	4.54	2.3	1.46	5254	23 – 5.1	(Nordland – Bergen/Førde)	14.3
		>36.6	5.55	3.1	1.6	4132	19.9 – 3.6	(Nordland – Bergen/Førde)	12.1
		<37.0	2.41	2.12	2.05	1122	67 – 27.7	(Nordland – Bergen/Førde)	47.5
Ventilator treatment	Patients	All	1.75	1.59	1.27	3,108	11.1 – 6.3	(Møre og Romsdal – Vestre Viken)	8.4
		>36.6	2.73	1.69	1.48	1,074	5 – 1.8	(Møre og Romsdal – Vestre Viken)	3.1
		28.0–36.6	2.45	1.61	1.35	1,177	77 – 31.5	(UNN/Finnmark – Vestre Viken)	53
	Treatment days	All	2.84	1.91	1.55	24,926	117 – 41.1	(Møre og Romsdal – Bergen/Førde)	68
		>36.6	3.42	3.21	1.56	4,786	25.5 – 7.5	(Telemark – Vestfold)	14
		28.0–36.6	5.21	2.86	1.65	5,545	498 – 96	(Sørlandet – Vestre Viken)	251
Hypoglycaemia	Patients	>36.6	3.58	2.47	2.08	2,090	13.3 – 3.7	(Telemark – Møre og Romsdal)	6.1
		34.0–36.6	5.26	2.59	1.9	1,160	168 – 32	(Telemark – Møre og Romsdal)	71
Phototherapy	Patients	>36.6	11.63	6.25	3.29	2,351	29.1 – 2.5	(Telemark – Bergen/Førde)	6.9
		34.0–36.6	4.3	2.99	2.01	2,701	368 – 86	(Telemark – Bergen/Førde)	165
Intensive care	Patients	All	1.62	1.35	1.3	5,590	20.8 – 12.9	(Telemark – Vestre Viken)	15.2
		>36.6	1.96	1.64	1.56	2,577	10.8 – 5.5	(Telemark – Vestre Viken)	7.5
		<37.0	1.64	1.34	1.31	3,013	166 – 101	(UNN/Finnmark – Innlandet)	128
	Treatment days	All	1.54	1.46	1.37	51,276	182 – 118	(Møre og Romsdal – Stavanger)	139
		>36.6	2.26	1.69	1.57	15,634	76 – 33.5	(Telemark – Vestre Viken)	45.7
		<37.0	1.92	1.63	1.49	35,642	2,265 – 1,177	(Møre og Romsdal – Fonna)	1,509

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