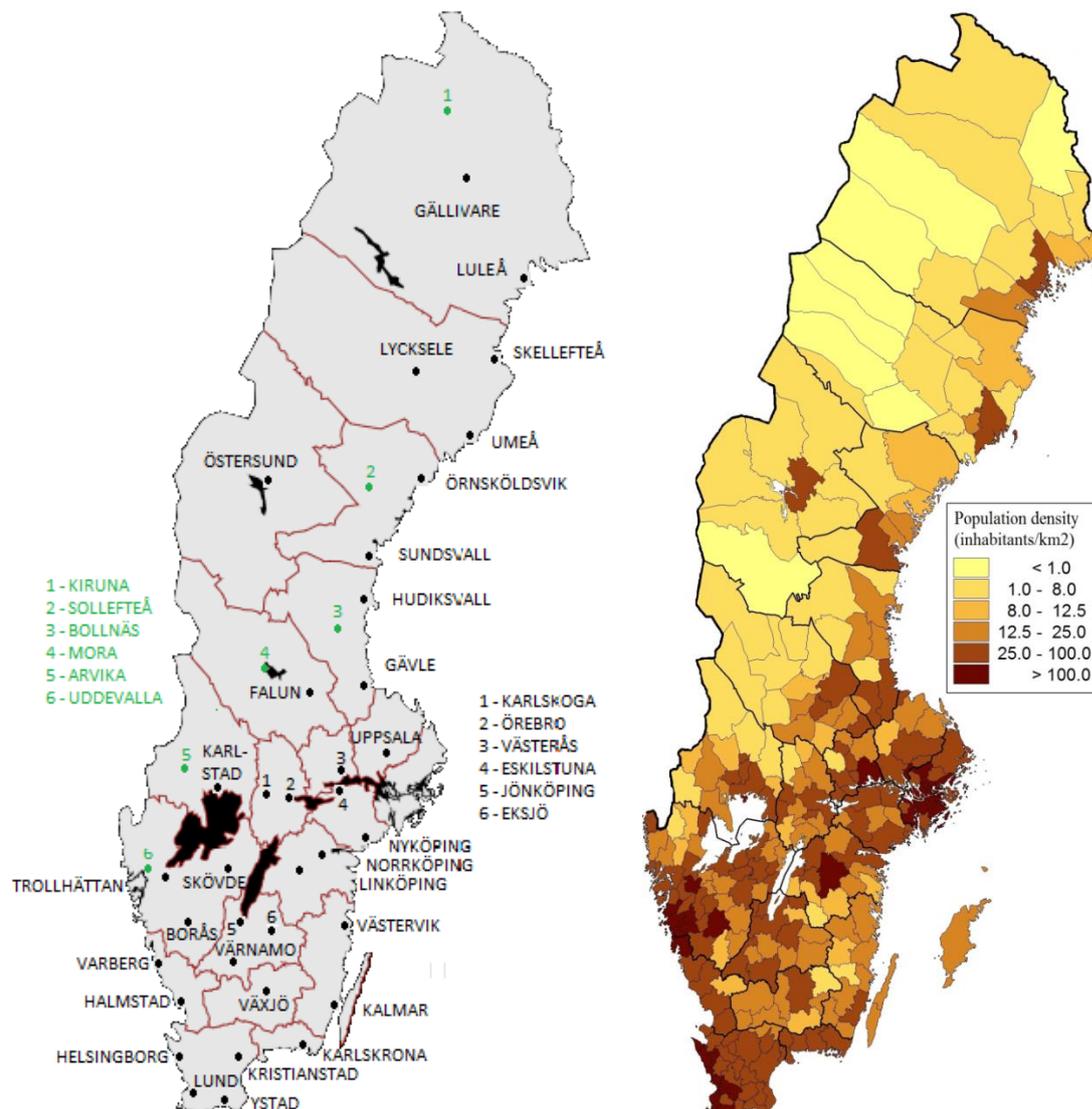


Which Swedish municipalities should have maternity wards?

As in previous closures of public services, the shutdown of the maternity ward in Sollefteå has led to a debate about the availability of services in different parts of Sweden. In this text I analyze where maternity wards ("clinics") should be located if citizens' travel distance determines placement. I use a distance database from the Swedish Agency for Growth Policy Analysis, and data from the National Board of Health and Welfare and Statistics Sweden. The three metropolitan areas (Stockholm County, Gothenburg and Malmö) and the island of Gotland are excluded from the analysis.

There are currently maternity wards in 36 places, shown as black dots in the left figure and named in black text. The places in green are discussed later in the text. A population density map (from Nordregio) is also included.



Solving the problem of placing 36 clinics to minimize citizens' average travel distance, where all municipalities' main town are candidates for getting a clinic, results in an average distance of 22 km, compared to 22.6 km in the actual allocation. Five of today's 36 clinics would be "reallocated". Two changes are small: Trollhättan and Falun would not get clinics, but clinics would be allocated in nearby Uddevalla and Borlänge. The biggest change would instead be that an additional town in

central Sweden, Mora, marked in green, would get a clinic, "at the expense of" Ystad, in the extreme south. Intuitively, two clinics in Dalarna County make sense: Falun/Borlänge is located in the southeastern part of the county, and the inhabitants of the county's northwestern parts are more than 200 km away. One might be led to believe that the same reasoning would apply to Jämtland County, but since its population is half of that of Dalarna, and only one city has a large population concentration (Östersund), the county does not gain an extra clinic in the optimal allocation. Instead, the remaining two changes are that Bollnäs and Arvika, also marked in green, get clinics, whereas Hudiksvall and Karlskoga do not.

If we imagine that the national government wants to improve accessibility and increase the number of clinics by one sixth (a number I chose arbitrarily), to 42 optimally placed clinics, the first 36 optimal placements remain the same. Ystad, Trollhättan, Karlskoga and Hudiksvall would also "regain" their clinics, indicating that these locations are geographically central. In addition, Sollefteå and Kiruna would get clinics.

Instead of studying a theoretically optimal allocation, perhaps it is of more interest to use today's allocation as the point of departure, and study which locations would get clinics if the number is expanded with (up to) six new, optimally placed, clinics. The location that most reduces the average distance in the country, if it gets a clinic, is Mora, discussed above, followed by Uddevalla, Arvika, Bollnäs, Norberg and Sollefteå.

From these two related analyses (and some robustness tests), the conclusion up to this point is that clinics in the four towns of Arvika, Bollnäs, Mora and Uddevalla would be prioritized to reduce the average distance in the country. Then follow Sollefteå and Kiruna. All six locations are marked in green in the above map. If further clinics would be added, the two prioritized locations should potentially be the Fagersta-Norberg-Avesta area, and Kalix (not shown on the map). Except for Uddevalla, these locations are in the country's sparsely populated areas, and northward. Notably, they previously had clinics. The latest closures are Kiruna (2002), Mora (2009), Kalix (2011) and Sollefteå (2017).

Against the backdrop of the discussion regarding the closure of the Sollefteå clinic, I also study Västernorrland County separately. If the county should have two clinics, Sundsvall and Örnsköldsvik are the optimal locations, in accordance with today's actual placement. If three units are to be placed, a unit would be allocated to Kramfors, which is southeast of Sollefteå, halfway down towards the coast. Obtaining this location as part of the optimum demonstrates the problem of analyzing each county individually: Västernorrland has an "inward bend" from the west, and Sollefteå is relatively close to the county border. The population in the Jämtland areas that would have Sollefteå as their nearest clinic (such as Bispgården, Hammarstrand, Hoting and Rossön) is now excluded from the analysis. The optimal location therefore ends up closer to the coast. From a geographical-mathematical (and economic?) viewpoint, doing the analysis county by county is questionable.

Healthcare in Sweden is organized at the county level, not nationally. A first discussion point therefore concerns how such decentralization affects the location-allocation analysis. If each county individually decides the number and placement of clinics, there is a risk that the nationwide resources will not be utilized optimally. In our context, this means that the same average distance to healthcare could be provided with fewer clinics, if decisions were taken centrally. Given this fact, and considering today's county level organization, it follows that the county councils should cooperate

(and there is indeed certain such cooperation in place). Counties in which many inhabitants have their closest clinic in a neighboring county, could contribute to the funding of the neighboring county clinic, as it would benefit its citizens, who get shorter distances.

Perhaps opposing the above arguments, there are other aspects, such as that each county may best know the healthcare needs of its citizens (an argument for decentralization). In addition, maternity wards may need to be combined with additional healthcare, such as neonatal clinics and other specialist care. High fixed costs would be an additional argument for having clinics in fewer locations. Some of these aspects can be integrated into a modified analysis. As an example, in the optimization problem, one may limit the list of candidate locations to those places that already have a hospital, or require a certain minimum (forecast) number of deliveries. Other important aspects are availability of doctors, midwives and nurses, the fact that different types of pregnancy and birth (such as early/late) may require different types of health care specialties/hospitals, and potential quality differences between large and small hospitals.

The number and location of clinics is a political decision. I have used the current number of clinics as the starting point, but one could use another number, such as 26 or 46. A similar reasoning holds for the type of analysis conducted. I have minimized the average distance, which does not rule out that some municipalities/counties get very long distances. Behind the current average distance of 22.6 km, major regional differences are hidden: the counties with the longest average distances are Norrbotten - 54 km, Dalarna - 49 km, Jämtland - 45 km, while it is 13 km in Skåne. As an alternative, it is possible to justify a (Rawlsian) analysis such as "no individual should have more than 150 km to a clinic" (which would lead to many more units in the north and probably much higher costs). In order to study the distribution of clinics between north and south, I instead experimented, for the case of 36 optimally placed clinics, with a "cost function" that increases more than linearly in distance. When using the distance raised to the power of 1.5, northern Sweden gets one additional clinic, if the distance is squared there are four additional units (in both cases at the expense of a corresponding reduction in the south). These alternative specifications will reduce the variance in the distance to the closest clinic. If data on the probability of childbirth complication as a function of distance, or some other welfare measure, were available, such data could be used as a basis for the analysis.

Another important question is which population data is used. I have used the entire population. For a given number of clinics to be placed, the relevant issue then is the overall spatial population distribution. The proportion of women of childbearing age varies, however. The group between 15 and 44 years varies from 12% in some northern municipalities to 22-23% in the metropolitan regions. If this data is instead used, which would lead to fewer clinics in the north and more in the south, one implicitly factors in and accepts the depopulation process, ongoing in many northern areas. If, in addition, the projected population in ten years' time is used, the north would probably be further underweighted. One aspect that would instead result in more clinics in the north is if the analysis takes into account that winter weather conditions are more common.

Summing up, in this short text I have used a well-established method in Mathematical Programming to study how the allocation of a vital public service – maternity wards - can be analyzed, based on a distance measure. I also discussed a few specific locations that currently have no clinic. As the national government has the spatial allocation of public services on its agenda, the text can hopefully contribute to the discussion.

Details about the optimization problem:

I use the same method as in my [2016 article in the Journal of the Swedish Economic Association](#) (and as in a [related paper, published in Socio-Economic Planning Sciences](#)) in which I analyzed the spatial allocation of Citizen Service Centers. The problem solved is a p-median problem: The combination of 36 locations that minimizes the population-weighted distance in the country to a maternity ward is selected, from a candidate list of 257 towns ("municipality seats", typically constituting a municipality's main population center). The optimization problem has 10 to the power of 44 different possible solutions and is solved by an algorithm, implemented in software, using "Branch and Bound", and other methods. The distance matrix (based on the National road data base) has data on all actual road distances between each of Sweden's approximately 1950 built-up areas ("tätorter"). The problem specification and data used imply that certain simplifications are made and potentially relevant aspects omitted, such as that we do not study the costs or the number of births at different clinics, nor potential congestion. The rural population has been aggregated to nearby built-up areas, and all distances are between the built-up areas' centroid points, which are also the points where potential clinics are located. I do not analyze travel time, seasonal variation, access to public transport, quality differences between roads, or the effect of using higher resolution spatial data. Researchers at Dalarna University have analyzed similar problems with high resolution population and road data, the importance of which would increase if there were a substantially higher number of clinics to be allocated, and if candidate locations were not limited to municipality seats only.