Capacity Pooling in Health Care Systems – A Conceptual Analysis

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ABSTRACT

The Swedish healthcare system is being challenged by a continuously increasing demand for care, while there is a lack of capacity. The use of temporary agency staff has been increasing for the past years, even though that is a short-term solution that generates high costs and can lead to impaired patient safety and deteriorating work environment. A measure to reduce the cost of temporary agency staff is to replace agency staff with less costly internal staffing agency in order to maintain the flexibility that such capacity pools create in staff planning. A capacity pool is a general capacity that can be allocated to parts of the system where the existing workload and demand for capacity is unusually high. Therefore, the use of internal capacity pools is a method to improve capacity utilisation of current resources, which is particularly important for bottlenecks in the system (i.e. physicians and nurses). From a theoretical perspective, there are several types of advantages that can be achieved with capacity pooling. However, there is a lack of systematic research on the support of the implementation of internal capacity pools in healthcare systems. Little is known about what benefits and costs that can be expected, how they can be organised, their structure and size, and their impact on healthcare performance. This paper investigates the conceptual benefits with reducing dependence on temporary agency staff in healthcare systems and replacing them with internal staffing pools and presents a planned empirical research project in the field. For instance, the use of internal capacity pools is a mean towards a more effective matching of demand with current resources and can thereby be used as a tool to improve capacity utilisation. In addition, the use of capacity pools can contribute to an enhanced work environment due to the possibility to meet large variations in demand, and thereby reduce variations in workload and overtime work.

1. INTRODUCTION

The Swedish healthcare system is being challenged by a continuously increasing demand for care, while there is a lack of capacity. An international comparison shows that the quality of Swedish health care is sufficient, but that the waiting times to both primary and specialized care are adversely long, and the queues have continued to increase the past years (SKL 2015; Väntetider.se 2018-08-30). Reports issued by governmental authorities and the media frequently show that the capacity to meet the demand is insufficient and that the challenges are growing each year (see for example Väntetider.se 2018-08-30; DN.se 2018-03-05; Sveriges radio 2014-08-21; Sveriges radio 2017-07-03).

The insufficient capacity is an issue in both acute and non-acute care and in both smaller rural hospitals and larger university hospitals. For example, the average waiting time in the emergency department at one of the largest hospital in the country – Sahlgrenska University Hospital – was recently reported to have risen to four hours and 30 minutes, followed by an average one hour and 43 minutes wait until physician assessment (Socialstyrelsen.se, 2018-02-16). In a recent debate article, the Swedish Medical Association claimed that the lack of capacity in Swedish hospitals is threatening patient safety and increasing the risk of patient harm (GP.se, 2018-02-20b). Already, several cases of deceased patients while waiting for care have occurred and the responsible hospitals are currently under investigation (DN.se, 2018-01-30). The proportion of patients that had their surgery or treatment within the health care guarantee (that is 90 days from the decision that surgery or treatment is needed) was 72 % in January 2018 compared to 87 % in January 2013 (Väntetider.se, 2018-08-30). Hence, the problem is continuously increasing in the entire country. The short-term solution in many cases is to purchase more capacity at a high cost. Innovative solutions to increase system capacity, such as piece working doctors (SvT.se, 2018-02-13), have been tested in some cases, but many hospitals merely rely on the easy, but costly solution temporary agency staff.

The cost incurred by the Swedish regions for temporary agency staff have increased from SEK 1.9 billion in 2010 to SEK 4.6 billion in 2016, and in the first quarter 2018 the cost had increased with 6 % compared to the first quarter 2017 (SKL.se, 2018-05-09). This development has caused a lively discussion in the media and profession about the effects of agency staff on patient safety, work environment, and finances (SvT.se, 2016-12-27; SKL.se, 2017-12-08). Due to this development, all 20 regions in Sweden operate in accordance with an agreement within the Sveriges Kommuner och Landsting (SKL) since the beginning of 2017, with the goal to become independent of agency staff in the healthcare sector by 1 January 2019. SKL is an association for municipalities, county councils, and regions in Sweden. Each region decides based on their prerequisites of what actions are to be taken to succeed and develop their own action plan to achieve the goal. However, a common measure for all regions is to increase permanent staff by creating more attractive workplaces (SKL.se, 2017-12-08).

Increasing costs for temporary agency staff is not a unique Swedish phenomenon. For example, in the United States of America (the US), the cost of temporary agency staff has increased to such an extent that it created financial problems in the sector (see for example Dziuba-Ellis, 2006; Diaz et al., 2010; Roach et al., 2011). Approximately 75 % of US hospitals use staffing agencies as a short-term strategy to resolve staff shortages and to create flexibility in staff planning (Adams et al., 2015).

Several studies also indicate other problems, in addition to the financial issue when using temporary agency staff in healthcare facilities (Adams et al., 2015; Bates, 2013; Dziuba-Ellis,

2006; Mazurenko and Perma, 2015). Firstly, it can lead to impaired patient safety due to reasons such as lack of knowledge about hospital procedures and policies or mismatch in competence and skills. Secondly, agency staff may be less effective in comparison to permanent staff owing to reasons such as unfamiliarity with routines and systems used in the workplace. Third, it can lead to a deteriorating work environment due to reasons such as disturbance of normal working conditions and lack of organizational loyalty among temporary staff.

According to case studies that we found in our literature review, a measure to reduce the cost of temporary agency staff is to replace agency staff with less costly internal staffing agency in order to maintain the flexibility that such capacity pools create in staff planning (see for example Adams et al., 2015; Bates, 2013; Lebanik and Britt, 2015). The establishment of a region-wide internal staffing pool is also a measure that both Region Västra Götaland (VGR) and Region Värmland decided to investigate in their action plans to be independent of agency staff. Other Swedish regions are investigating similar arrangements linked to specific parts of their healthcare system, such as primary care and hospitals.

There are worthy arguments to reduce dependence on temporary agency staff in healthcare systems and replacing them with internal staffing pools. The question then arises, how do we effectively implement capacity pools in a healthcare system? The literature in this area is mainly directed towards the so-called float pools (pools of nurses) and is almost exclusively anecdotal (e.g. Bates, 2013; Lebanik and Britt, 2015; Linzer et al., 2011; Ruby and Sions, 2003). Little is known about how they are organized, their structure, and size, their impact on healthcare performance, and what benefits and costs can be expected. This is particularly true in relation to pooling in multi-hospital systems. Thus, there is a lack of systematic research on support of the implementation of capacity pools in healthcare systems (Cattani and Schmidt, 2005; Dziuba-Ellis, 2006; Mahar et al., 2011; Mazurenko and Perma, 2015; Smith-Daniels et al., 1988). Therefore, there is a significant need to create scientifically-based guidelines for how capacity pooling in healthcare should be designed and managed in order to take advantage of the current capacity in an optimal manner, and to analyze the prerequisites for pooling capacity in a healthcare system. Hence, the aim of the project described here is to develop a conceptual model with principles and guidelines for the implementation of capacity pools in healthcare systems. The important issues to be supported by the model are as follows: which specific categories of workforce resources (skills) or types of units should be pooled, at what level in the healthcare system the pools (safety capacity) should be located, how the optimal numbers of units should be determined, and how the safety capacity should be dimensioned (Mattsson and Wikner, 2017).

As mentioned above, the literature on capacity pooling in the healthcare setting is almost exclusively anecdotal. On the other hand, within the broader area of healthcare capacity management, there is significant previous research, even though most of them lack a clear relation to the issue of capacity pooling. One exception is a recent study (Alvekrans et al., 2016) on sales and operations planning (SoP) in healthcare, with Sahlgrenska University Hospital as the case organization. In that study, it is explored how basic capacity is and should be managed within different parts of the hospital, and the type of knowledge that managers use in different situations to make decisions regarding capacity. Considering this perspective, this pooling project study is closely related to the aforementioned SoP study as capacity pooling is about the efficient management of safety capacity, while the SoP study was about the management of basic capacity.

2. CAPACITY AND VARIATION

2.1. What is a capacity pool?

A capacity pool is a general capacity that can be allocated to parts of the system where the existing workload and demand for capacity is unusually high (Hopp and Lovejoy, 2013; Kuntz et al., 2015; Vanberkel et al., 2012). Therefore, capacity pools are a method to improve capacity utilization of current resources, which is particularly important for bottlenecks in the system (e.g. physicians and specialist nurses). The use of capacity pools is also a well-known and extensively used method to improve capacity utilization and the service level in retail and manufacturing industries. Thus, capacity pools are also a method to effectively achieve the goal of matching current resources and the healthcare demand, resulting in gains in terms of shorter waiting times for patients, increased service level, and patient safety (Alvekrans et al., 2016; Lupien et al., 2007; Mahar et al., 2011; Kc and Terwiesch, 2009; Kuntz, 2015; SOU 2016: 2 etc).

2.2. Variations in health care demand

The capacity planning of a system becomes more difficult with the degree of variations in a system (Slack & Lewis 2011). The total throughput time for a unit that passes through a system increases with an increasing variation (Anupindi et al. 2006). Therefore, in order to decrease the throughput time, one way is to decrease and manage the variations in a system. This is not always feasible with a reasonable amount of resources, since natural variations are difficult to control and will always be a part of a system. However, when several sources of variability are aggregated, the influence of the variability will decrease (see discussion in Terwiesch et al. 2011). Hence, if the capacity planning of several units of processes can be aggregated, the capacity needed to manage these units can decrease due to that the effect of the variability can be eliminated.

At hospitals wards, the variations in patient flow can be managed through several means. One short-term solution that is frequently applied is to relocate patients to other hospital wards with available capacity. These hospital wards are typically not treating the specific disease that the relocated patient has sought care for, and Socialstyrelsen (2011) argue that the patient mortality and risk for patient harm is directly increasing when patients are relocated. Moreover, relocating patients can often lead to increasing throughput times. Hence the solution is insufficient for both the individual patients but also the hospital as a system, since a larger capacity is needed to treat the same number of patients. The number of relocations of patients to other hospital wards are often higher during periods of high work load and less available personnel, which is an increasing risk for the patients. There are extreme cases when a lack of resources and a high inflow of patients have resulted in that patients have been moved to other hospitals both within and outside of the region, and sometimes even to hospitals in other countries due to lack of personnel and available beds (Sveriges radio, 2017-07-03; Sveriges radio, 2014-08-21). In these cases, the capacity of the healthcare system is used even less efficiently due to that extra resources are required, such as transportation teams, to transport the patient from one hospital to another.

Figure 1 below shows an example of the variability of occupied bed at two similar hospital wards at a hospital in Sweden during March 2018. The number of available personnel is

typically not adapted to the work load, but constant during the entire period. Hence, the variation of bed occupancy results in that in periods of high occupancy the work load is high, overtime work is frequently used, and the patient safety can be threatened (see discussion in Kuntz et al. 2015). On the other hand, during periods of low occupancy the work load is consecutively also low. The variation in bed occupancy can therefore lead to a less satisfactory work environment, since a work situation without large variations in workload is an important factor for a good psychosocial work environment (Hultberg 2007).

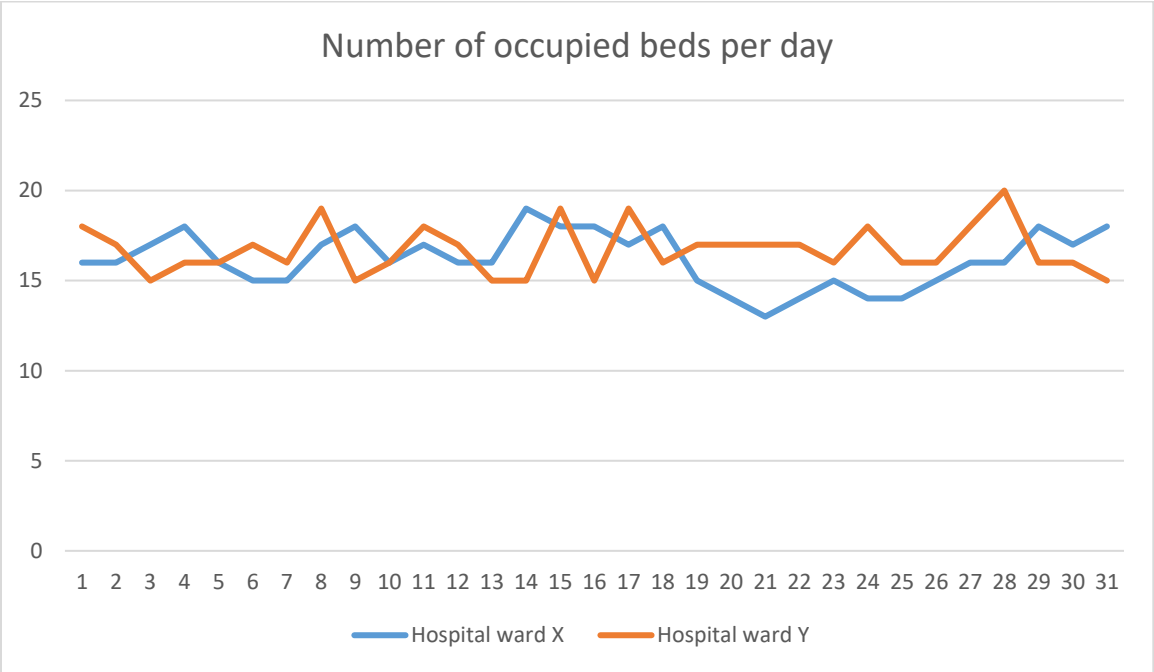

Figure 1. Occupied beds per day at hospital ward X and hospital ward Y respectively in March 2018.

Assume that 0.25 nurses and 0.5 assistant nurses are required to care for one occupied bed. In Figure 1 above, it can hence be concluded that in order to maintain a service level of 90 %, ward X will need 5 nurses and 9 assistant nurses during one shift (to cover for 18 beds) and ward Y will need 5 nurses and 10 assistant nurses during one shift (to cover for 19 beds). Hence, the total number of personnel required to staff the two wards during one shift is 10 nurses and 19 assistant nurses. During 10 % of the time the occupancy level will be over 100 % which directly can affect the patient mortality and risk of patient harm (see for example discussion in Kuntz et al. 2015). Furthermore, patients are risked being relocated to other units or hospitals due to the high occupancy, as mentioned in the discussion above.

Now assume that hospital ward X and hospital ward Y would have shared capacity for the hospital beds. Figure 2 below shows the number of occupied beds at both wards simultaneously the same month as in Figure 1. The capacity required to maintain a service level of 90 % will in this example be 9 nurses and 18 assistant nurses, hence a total reduction of one nurse and one assistant nurse compared to the example in Figure 1.

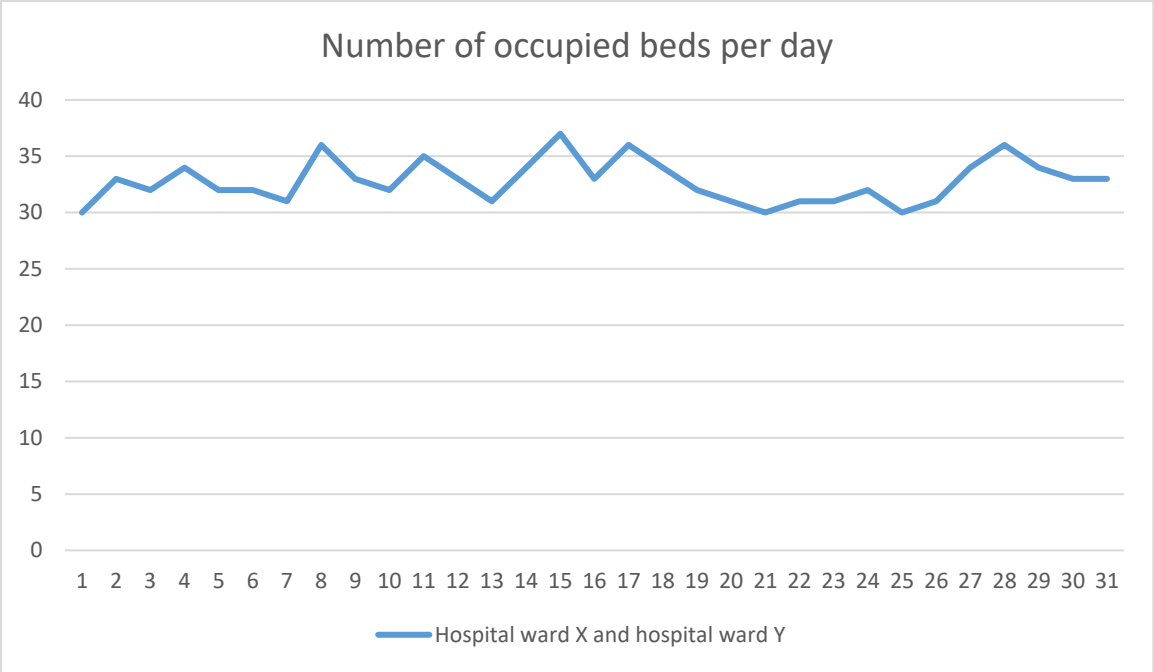

Figure 2. The number of occupied beds at hospital ward X and hospital ward Y summarized in March 2018.

2.3. Variations in health care capacity

In the Swedish healthcare system, both basic capacity (capacity used to handle expected demand) and safety capacity (capacity used to handle the variations in actual demand) is, to a large extent, planned at the actual unit or clinic where the short-term need for capacity actually arises. The advantage of this approach is that the control of capacity is directly linked to the current situation on a unit or clinic. The significant disadvantage with such an approach is that capacity in different parts of the system is managed independently.

Short term leave is one of several factors that affects the variation in health care capacity at the hospital wards. Figure 3 below shows the short term leave for hospital ward X and hospital ward Y on a monthly basis in year 2017 (data on a daily basis is currently unavailable). The trend for short term leave shows the same seasonal trend for both wards, but there are some exceptions. If the capacity would be planned on an aggregated level for both units, the effect of the variation in short-term leave would be reduced in some of the months during the year, and hence less capacity would be required to cover for the short-term leave.

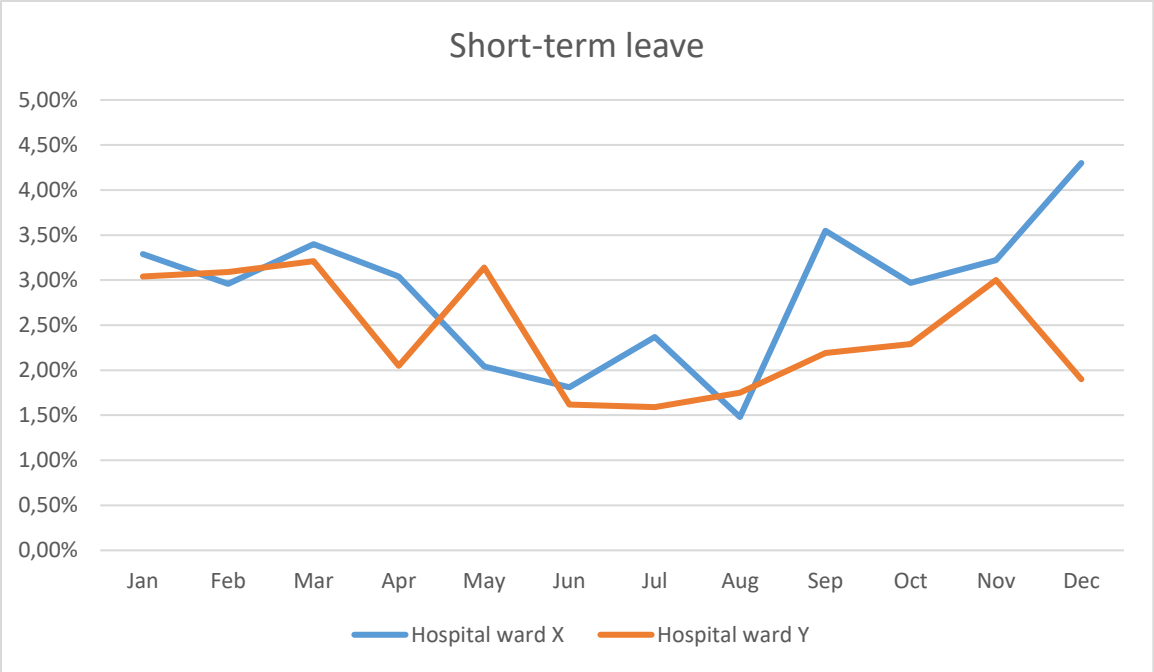

Figure 3. Variations in short term leave at hospital ward X and hospital ward Y during year 2017.

2.4. Advantages and disadvantages with capacity pools

External temporary agency staff is today frequently used at Swedish hospitals to cover for lack of capacity. There are studies that shows that the use of external agency staff is a threat to patient safety due to that the temporary staff are unfamiliar with the particular hospital ward and its routines (Adams et al., 2015; Bates, 2013; Dziuba-Ellis, 2006; Mazurenko and Perma, 2015). Moreover, the use of external temporary agency staff is an expensive solution which results in high costs for the hospitals and the society each year. The use of internal temporary agency staff, hence capacity pools, can on the other hand be beneficial. This could result in a positive effect on patient safety, since the variation in bed occupancy can be managed with internal personnel that have a knowledge about the organization and its routines. Moreover, the use of internal capacity pools will likely be a cheaper solution compared to the use of external agency staff.

There are reports that claim that the work environment in capacity pools are unsatisfactory, and for example experienced nurses have reported an anxious and lonely work (Bates 2013). Hence, it is important to assure the right prerequisites for both the employees and the hospital wards in a capacity pool. Bates (2013) suggests for example communication, feedback and staff support from the charge nurse at the hospital ward. Moreover, the unit that receives the service from the capacity pool must be well prepared. For instance, clear routines, predefined work tasks and informative documents about the unit could be provided to the capacity pool staff.

On the other hand, internal capacity pools can also be a tool for creating a better working environment and a more attractive workplace. According to Hultberg (2007), a reasonable workload without large variations and overtime work with the possibility of recovery is one of the most important factors for a good psychosocial work environment. Improved production and capacity planning leads to reduced variations in workload and less overtime work (Brandt and Palmgren, 2015). However, it requires that plans can be realized smoothly, even if

deviations occur, such as short-term leave and occasions with unexpected high demand. Internal capacity pools are tools that create volume flexibility to manage such deviations, and thus also tools for creating a better working environment (Hultberg, 2007; Kuntz et al., 2015; Mahar et al., 2015; Noon et al., 2003).

2.5. The organization of the capacity pool

The units in the capacity pool should have similar competence requirements for their nurses. Theoretically, the pooling effect becomes stronger when the pool consists of more units, everything else being equal. On the other hand, the marginal effect of another unit in the pool diminishes, and it is in general more challenging to build pools with more units from a practical perspective as, for example, the required competence similarity, organizational issues, geographical issues, and other factors. Therefore, determining the optimal number of units in the pool is a question of optimization in the specific case. Hence, one of the aims of this project is to study how many and which types of units in different contexts should be included in the same pool. We plan to do this through a factor or cluster analysis based on data from a survey study among managers.

The demand for nurses across units in the pool should be more or less uncorrelated, or even better, negatively correlated. Based on actual data, the degree of demand correlation between the units can be measured, and the results can be used to analyze the theoretical potential of different pooling configurations. This is also one of the aims of this project—to evaluate the statistical suitability among units to be included in the same capacity pool.

Which professions that should be included in the capacity pools depends on the demand of the different units. There is generally a national lack of nurses, especially specialized nurses, but also assistant nurses, while in some parts of the hospital system the lack of physicians within different fields is a greater issue. In some departments and fields there is an extensive introduction program of newly employed nurses and assistant nurses, and it can take up to several years to become entirely independent in the work place. Hence, specialized units included in the capacity pool issues a demand on both the competence of the employees in the capacity pool, but also on the hospital ward to identify work tasks that can be conducted by less experienced employees.

Different hospital wards need different service levels in order to secure a high patient safety care, depending on for example the mixture of acute and non-acute care. There are studies that show that an occupancy of more than 90 % is increasing the risk of mortality substantially (Kuntz et al. 2015). Moreover, the specialization of different wards differs, and the most specialized wards can sometimes be the last instance a patient can receive care, for example intensive care units. These hospital wards require a higher service level in order to secure that the patient demand always can be met. Hence, wards with a high amount of acute care, a large variation of bed occupancy, and the requirement of a high service level due to its nature of care, will have a lower total capacity utilization. These wards will likely benefit to be included in a capacity pooling system.

3. RESEARCH MODEL AND PROJECT DESCRIPTION

The project is planned to be carried out in three steps. The first step is referred to as a pre-study, with the aim to explore the perceived potential of capacity pooling among middle- and top-level managers in the healthcare system. Thus, in this step, empirical knowledge is developed about perceived opportunities and obstacles for capacity pooling in different types of specialties and at different levels of the healthcare system. Methodologically, the pre-study will primarily rely on in-depth interviews with managers, but a broader questionnaire study is also planned in order to verify the generalizability of the results from the interviews.

The sample frame of the interview study is specialty department managers at Sahlgrenska University Hospital (SU), which includes four hospitals; Sahlgrenska sjukhuset, Östra sjukhuset, Mölndals sjukhus, and Högsbo sjukhus. This hospital group covers all the specialties in the region and account for approximately 50 % of total healthcare costs in the region. The specialties were divided into eight clusters based on the following criteria; medical or surgical specialties, mainly outpatient or inpatient care, and mainly planned or emergency care. For example, cluster one includes medical specialties with mainly inpatient and emergency care. In addition to these eight clusters, another cluster of primary care is added.

We plan to interview one manager in each cluster and through a broader survey, we expect to verify the results from the interviews with all deputy hospital managers and a selection of specialty department managers at the other seven hospital administrations within VGR. The first step is currently in progress and will be finished at the end of 2018. Currently, some interviews have already been conducted and others have been scheduled.

The second step is referred to as the case study, which aims to analyze the actual secondary data to measure where and how pooling can be used more specifically to improve capacity planning in the healthcare system. The three main issues this step will deal with are what types of and how many units should be included in the same pool, and what size of different pools should we have. An overly simple example may be used to elaborate these issues. Assume that a healthcare division consists of four units that are similar in terms of competence requirements for nurses. Further, assume that the expected daily demand for nurses and its variation has been estimated for each unit as shown in the table below, and that demand is shown to be approximately normally distributed and independent across units. In order for each unit to reach a 90% service level without a pooling approach, a safety capacity of 1.28 standard deviations is required at each unit. Thus, the total safety capacity required at the division is 19 nurses.

	Unit			
	1	2	3	4
Mean	10	15	20	5
Standard deviation	3.1	3.9	5.5	2.4
Safety capacity required for a 90 % service level	4	5	7	3

Now, suppose that capacity planning with a pooling approach is used instead. The expected daily demand for nurses for the division as a whole is simply the sum of the expected demand for the units, that is, 50 nurses. However, the standard deviation for the division as a whole is the square root of the sum of the squared standard deviations for the units. This can be calculated to be 7.8 nurses. Hence, to reach a 90% service level for the division as a whole, using capacity

pooling, a total safety capacity of 10 nurses is required. In other words, a pooling approach can reduce the required safety capacity by almost 50% without lowering the service level.

The case study will primarily be based on statistical analyses of data regarding actual levels of supply of and demand for capacity in different parts of the healthcare system over time and the possible interaction between them. We also plan to conduct interviews with managers in order to put into context the results from the statistical analyses. This second step will partly rely on insights from the pre-study, thus it is planned for the period 2019–2020.

The third step of this project is an experimental implementation of capacity pooling in a real hospital setting, with the purpose to test the principal conclusions from the second step. This step has not yet been elaborately planned as it relies, to a large extent, on results from the first two steps, particularly the second step. A possible approach is to divide the third step into two sub-stages. In the first sub-stage, we plan to determine a staffing pool configuration on an appropriate system level within the healthcare system in VGR based on the results from the two first steps. This means determining what units and categories of healthcare professionals are to be included in the staffing pool and the safety capacity per professional category required for a certain service level (i.e. the fraction of orders that the pool can deliver). Next, we analyse the theoretical pooling effects in quantitative terms, such as service level, safety capacity, and cost savings.

In the second sub-stage, we plan to implement a "test bed" within the healthcare system in VGR based on the results and learning from sub-stage one in order to evaluate how appropriately the proposed conceptual model for implementation of internal staffing pools in healthcare systems is in a real-world situation where the practical pooling effects can be affected by several conditions that are not easy to anticipate. In this stage, we can also analyze the practical pooling effects in qualitative terms, such as working environment and patient safety.

The third step is tentatively planned to be carried out from 2021–2022 in cooperation with the project team assigned to investigate the prerequisites for a region-wide internal staffing agency in VGR.

4. POSSIBLE RESULTS OF THE PROJECT

The project is expected to result in an understanding of how capacity pools can be implemented and used in healthcare systems. We aim to develop a conceptual model with principles and guidelines that supports for instance which specific categories of workforce resources or types of units should be pooled, at what level in the healthcare system the capacity pools should be located, how the optimal numbers of units should be determined, and how the safety capacity should be dimensioned.

Depending on the characteristics of the hospital wards, the use of capacity pools is likely to result in different effects. Hospital units that have a high amount of acute inflow of patients, a large variation of bed occupancy, and the requirement of a high service level due to its nature of care will likely benefit with the capacity pooling systems. When the capacity is planned isolated on one unit the capacity utilization will consecutively be lower with the above-mentioned characteristics, since there will be periods where the inflow of patients and bed occupancy is low due to the large variations. If these types of wards are included in a capacity pooling system the effect of variations will be reduced on an aggregated level, and the same

amount of resources can be used to produce a larger amount of care. Hence, the capacity pool will most likely be a solution to meet the variability in health care demand.

Hospital wards that are characterized with a higher amount of non-acute care and lower variations in bed occupancy will experience another effect of being included in a capacity pooling system than the units with large variations in health care demands. In the wards with a larger amount of non-acute care there is a greater possibility to control the inflow of patients and thereby the variations of bed occupancy. The capacity utilization is higher, and the use of capacity pools will instead have a greater effect on the variation of health care capacity, such as short-term leave.

In some departments there is a lack of specialized nurses, but other departments within the same specialty experience a lack of physicians. For example, there might be a lack of anesthesiology nurses in one unit, but the number of anesthesiologists is balanced, while there is a lack of anesthesiologists in another unit, but the number of anesthesiology nurses is sufficient. Hence, on an aggregated level the amount of resources might be enough, but on a unit level insufficient. A possible effect of the use of capacity pools is that the lack of capacity within the same specialty between departments can be reduced, especially if the capacity pools are organized on a multi-hospital system.

A possible hinder for the use of capacity pools on a multi-hospital system is the geographical distance between hospitals. For example, in Västra Götalandsregionen, the distance between the hospitals vary between ten kilometers and 155 kilometers. Hence, the possible benefits and cost reduction from the capacity pooling system might be contradicted by the fact that health care personnel are spending valuable time to travel between hospitals.

To summarize, the project is expected to result in knowledge on how to organize healthcare systems more efficiently than today and how to use the same amount of resources to produce a larger amount of care. We will have a greater understanding on how to effectively achieve the goal of matching current resources with the healthcare demand, resulting in gains in terms of shorter waiting times for patients, increased service level and capacity utilization, and enhanced patient safety.

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