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Eiropas Savienības fondu darbības programmas "Izaugsme un nodarbinātība" 9.2.3.specifiskā atbalsta mērķa "Atbalstīt prioritāro (sirds un asinsvadu, onkoloģijas, perinatālā un neonatālā perioda un garīgās veselības) veselības jomu veselības tīklu attīstības vadlīniju un kvalitātes nodrošināšanas sistēmas izstrādi un ieviešanu, jo īpaši sociālās atstumtības un nabadzības riskam pakļauto iedzīvotāju veselības uzlabošanai" ietvaros īstenotā projekta Nr.9.2.3.0/15/I/001 "Veselības tīklu attīstības vadlīniju un kvalitātes nodrošināšanas sistēmas izstrāde un ieviešana prioritāro jomu ietvaros" nodevums Nr.6 - **Summary report of the Hospital volume-quality study**

World Bank Reimbursable Advisory Services:

Support to Develop a Health System Strategy for Priority Disease Areas in Latvia

Hospital Volume and Quality of Care in Latvia[1]

[1] This report was prepared by Ana Milena Aguilar Rivera (PhD) with contributions of Alaka Holla (PhD). Jeremy Veillard provide useful suggestions for policy recommendations, and Pauls Giovagnoli carried out the initial data cleaning and the merger of the NHS inpatient datasets.

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1 Introduction

1. Enhancing hospital performance and refining processes of care are crucial to improving health outcomes and increasing efficiency in Latvia. As in other European countries, Latvia's health care system faces rising costs and budgetary constraints in delivering effective, high quality, and timely health services, and making more effective use of limited available resources will be key to reducing costs and ensuring equity of access to quality healthcare. This report empirically examines whether greater attention to case volumes for both hospitals and physicians working in inpatient care can improve both the efficiency and quality of care in Latvia.

2. Case volumes (for both hospitals and physicians) have been used as a proxy for health care quality in the medical literature and in a number of countries' or health payers' referral policies. // An empirical relationship between case volumes and health outcomes has been documented extensively (Luft, Bunker et al. 1979, Begg, Cramer et al. 1998, Birkmeyer, Siewers et al. 2002), where high-volume hospitals and surgeons deliver better outcomes than institutions or physicians with lower volumes of activity across different medical conditions and procedures. This better performance among high-volume hospitals and physicians is believed result from more efficient decision-making, greater surgical expertise, and higher competency ("practice makes perfect' hypothesis), as well as with // multidisciplinary teamwork, local availability of other specialist services, ICU capabilities, and greater involvement with research (Ihse 2003), all factors that can foster better outcomes for patients.

3. Volume or caseload is also an easily standardized measure readily available in administrative data and can thus be routinely used by both hospital managers and policy-makers in decision-making. Volume-based indicators allow hospitals to monitor quality, evaluate their performance against explicit standards, and – through selective referral - redirect care to centers or physicians exceeding volume and quality standards (Luft, Hunt et al. 1987). To increase quality and reduce costs by concentrating cases in places where physical and human resources will be better used (and thus achieve economies of scale), healthcare payers also set minimal volume standards and incentivize selective referral to high-volume providers, a practice that is associated with improved training, quality of treatment, research, and economic efficiency (Archampong, Borowski et al. 2011). Procedural volumes have also been used to guide clinical guidelines and pathways, to certify physicians, and to accredit hospitals.

4. Using administrative data from the National Health Service and Center for Disease Prevention and Control, this study examines a set of publicly funded surgical procedures and high-risk conditions in Latvia from 2012 and 2014 across four clinical areas: cardiovascular, cancer, obstetrics and newborn care. The first objective of the analysis is to benchmark hospital and physician volumes observed in Latvia to standards from the clinical literature for clinical conditions or interventions for which an association between volume and outcome has been established in the medical literature. The study will also estimate the extent of any association between select procedural volumes and health outcomes financed by NHS, with a focus on quality of care and mortality.

5. The study's empirical findings and associated recommendations aim to motivate discussion between NHS, hospital managers, providers, and patients regarding the role of volume standards and selective referral in Latvia , and they should serve as complementary inputs into the infrastructure and human resource mapping exercise that the Ministry of Health and National Health Service are currently undertaking This current study is part of a World Bank Group reimbursable advisory services agreement

with the Latvian National Health Service, which aims to provide "Support to Develop a Health System Strategy for Priority Disease Areas in Latvia. "

6. The report is organized as follows. Section 2 provides describes the relationship between volume of care and health outcomes. Section 3 outlines the data sources and methods used in this report to benchmark hospitals in Latvia to internationally established volume thresholds and estimate similar volume-quality relationships. Sections 4 through 7 present the results for procedures and conditions related to cardiovascular, cancer, obstetric, and newborn care. Section 8 concludes with proposals for policy options that could enhance service quality and efficiency in hospitals while ensuring adequate geographic accessibility. The end of the report includes a technical annex and glossary.

2 The link between procedural volumes and health outcomes

7. A number of systematic reviews and meta-analysis have documented a strong link between volume and outcomes for a selective group of high-risk, typically low-volume complex procedures, such as cancer-related surgeries (for example, esophagectomy and pancreatectomy), transplantations, and cardiovascular surgery procedures, such as coronary artery bypass graft, abdominal aortic aneurysm repair, and valve replacement (Luft, Bunker et al. 1979, Begg, Cramer et al. 1998, Birkmeyer, Siewers et al. 2002, Birkmeyer, Stukel et al. 2003).[2] Other surgical procedures in this literature include more common cancer surgeries for breast, bladder, colorectal or breast cancer, as well as knee arthroplasty, hip replacement, laparoscopic hysterectomy, and bariatric surgery (Halm, Lee et al. 2002, Holt, Poloniecki et al. 2007, Gooiker, Van Gijn et al. 2010, Goossens-Laan, Gooiker et al. 2011, Tol, van Gulik et al. 2012, Pieper, Mathes et al. 2013, Murray, Healy et al. 2015, Nguyen, Wallace et al. 2015, Lin, Tao et al. 2016). In the United States, it is estimated that about 11,000 deaths nationally can be prevented over three years if patients who went to the lowest-volume hospitals received the same quality of care as those at the highest-volume hospitals (US News Report, 2015).

8. Based on this kind of evidence, policy makers have tried to use minimum hospital volumes for surgical procedures to improve patient outcomes. Some countries use volume thresholds as part of quality assurance programs. In the United States, for example, the Leapfrog group, a private entity formed by representatives from 155 major health insurance purchasers, has established recommendations for 5 selected complex surgical procedures - coronary artery bypass graft (CABG), percutaneous coronary interventions (PCI), pancreatectomy, elective abdominal aortic aneurysm repair (AAA), and esophagectomy (Leapfrog Group (2004)). This group recommends that only hospitals that meet annual minimum volume thresholds perform these procedures (Leapfrog Group 2004).

[2] For instance, Birkmeyer, J. D., A. E. Siewers, E. V. Finlayson, T. A. Stukel, F. L. Lucas, I. Batista, H. G. Welch and D. E. Wennberg (2002). "Hospital volume and surgical mortality in the United States." New England Journal of Medicine **346**(15): 1128-1137. This study shows that mortality decreased as volume increased for 14 types of procedures (six different types of cardiovascular procedures and eight types of major cancer resections) in the United States between 1994 and 1999. Mortality rates differences (adjusted for differences such as case mix) between very-low-volume hospitals and very-high-volume hospitals were greater than 5 percent for esophagectomy and pneumonectomy; 2 to 5 percent for gastrectomy, cystectomy, repair of a non-ruptured abdominal aneurysm, and replacement of an aortic or mitral valve; and less than 2 percent for coronary-artery bypass grafting, lower-extremity bypass, colectomy, lobectomy, and nephrectomy.

9. Various countries in Europe have also used minimum volume standards to improve hospital quality of care either by including them in clinical guidelines or as indicators in quality hospital assurance programs. For example, since 2013, Italy's National Outcomes Program that assesses the National Health System has included a set of volume indicators for conditions with available evidence of an association between volume and outcome (Amato, Colais et al. 2012). The Netherlands and the United Kingdom have established minimum thresholds in national practice guidelines or/and surgeon accreditation standards. Other countries, such as France and Germany, concentrate select surgical services based on minimum standards.(de Cruppe, Ohmann et al. 2007). [3]

3 Methods

10. This section describes the methodological approach of the study. The technical annex contains a detailed description of the statistical analysis and definitions of variables.

11. First, procedures where a volume-outcome relationship had been demonstrated were identified, based on a review of the medical literature that focused on procedures associated with disease areas identified as high priorities in national and health strategy documents in Latvia - cardiovascular disease, cancer, and maternal, and perinatal health. [4] Five procedures were selected: two procedures that are critical for the treatment of circulatory and ischemic heart disease (the main causes of death in Latvia), percutaneous coronary intervention (PCI) and abdominal aortic aneurysm (AAA) repair; and resections for three type of cancer (breast, colorectal and ovarian). In addition to these complex procedures, the study analyzed high-risk pregnancies and high-risk newborns, as there is ample evidence that hospital volumes and the designated level of care (for example, access to a neonatal intensive care unit (NICU)) are associated with obstetric and perinatal outcomes.

Table 1: Procedures and conditions used in the analysis

Condition	**Procedure/cases**
Cardiovascular **disease**	(i) Percutaneous coronary intervention (PCI) (ii) Abdominal Aortic Aneurysm (AAA)

[3] Volume of patients or cases can also be used as a basis for the concentration or centralization of services. This can results in a local reconfiguration of health services or reorganization of hospital networks. Concentrating volume and expanding the variety of cases (by increasing catchment areas) is believed to reduce geographical inequalities in access to health care and allows technological advances to reach more patients in a cost-effective manner Meadows, C., W. Rattenberry and C. Waldmann (2011). "Centralisation of Specialist Critical Care Services." Journal of the Intensive Care Society 12(2): 87-89.. In these processes, however, concerns related to social costs represented in patient access to nearby care, disruptions of service menus, and disruptions of individual and institutional income need to be taken into consideration.

[4] The team looked for evidence on procedures related to mental health, but this literature concentrates primarily on surgical cases, and thus a volume-quality relationship could not be investigated for mental health.

Cancer	(iii)	Breast resections (mastectomies)
	(iv)	Colorectal resections
	(v)	Resections for ovarian cancer
Obstetrics	(vi)	High-risk deliveries
	(vii)	C-sections
	(viii)	Early elective deliveries
Newborn care	(ix)	High-risk cases (low-birth weight and premature births)

12. For these procedures, volume thresholds were identified from internationally accepted clinical guidelines and standards developed by national agencies, benchmarking programs and professional associations in the United States and Europe. [5]

13. The first step of the analysis consisted of a comparison of volumes observed in hospitals and among physicians in Latvia to these volume thresholds. Comparing high and low volume hospitals and physicians, the second step of the analysis estimated the extent of any association between volumes and health outcomes after adjusting for differences in case mix across hospitals, where health outcomes included quality of care indicators such as length of stay, readmission rates, and complications, in addition to various measures of mortality (in-hospital-mortality; 30-day, 60-day, 90-day mortality; and perinatal and neonatal mortality).

14. To complete these two steps of the analysis, the study relied on administrative data provided by the National Health Service and the Center for Disease Prevention and Control. Procedural volumes for each hospital and physician came from the inpatient and outpatient payment records of the National Health Service, as did the presence of complications and the overall case mix. These inpatient records, in addition to the death register of the Center for Disease Prevention and Control provided data on mortality, while the Medical Birth Register identified all pregnancies and births used in the analysis.

15. The results that come out of this analysis should be considered in the light of a number of caveats. First, the inpatient and outpatient payment records do not contain procedures that were privately financed (for example, if a patient wanted to bypass a waiting list). This restriction affects results only if there is reason to believe that a non-trivial number of patients are paying fully out-of-pocket for these services. Given that most of procedures included in the study are low-volume, expensive complex procedures, however, it is expected that NHS dataset include a majority of patients undergoing these operations.

16. Second, appropriate risk-adjustment remains a limitation in any study using administrative data. NHS payment data contain limited clinical information or processes of care that may confound a volume-quality relationship. In addition, in some conditions the number of observations was too small to perform risk-adjustment analysis, which limit its interpretation. Our grouping of hospitals aims to alleviate this limitation by studying hospitals and surgeons in aggregate.

[5] Among them are *European Society of Breast Cancer Specialists (EUSOMA)*; *European Society of Cardiology;* European Society for Vascular Surgery (ESVS); *National Comprehensive Cancer Network (NCCN);* EURO PERISTAT Action project; *European Board and College of Obstetrics and Gynaecology (EBCOG)*; *American College of Cardiology Foundation*; *Association of Upper Gastrointestinal Surgeons of Great Britain and Ireland*

17. Third, the results emerging from the hospital benchmarking analysis are only applicable to recommended volume thresholds in the literature. Although much of the empirical literature shows a significant association of procedural volumes and outcomes, few are able to determine a unique optimum volume standard for the studied procedures. This is because articles used different volume cut-offs to identify high and low volume hospitals and physicians. Meta-analysis and systematic reviews are useful resources to identify standards commonly evaluated and applied on clinical guidelines. However, without a tested threshold in a specific setting, it will be necessary to estimate empirically optimal cutoffs for each level of care and procedure group. To do this properly in Latvia, more in-depth clinical analyses would be needed, which is beyond the scope of this report.

4 Cardiovascular procedures

4.1 Abdominal aortic aneurysm repairs

19. The abdominal aorta is the main blood vessel that supplies blood to the abdomen, pelvis, and legs. When the abdominal aorta or a section of it widens, or dilates, a weak area can bulge outward, producing an aneurysm. An aneurysm that expands and remains untreated can break open, or rupture, which is a life-threating situation. Only 1 in 5 patients survives a ruptured abdominal aortic aneurysm (AAA).

20. Open repair surgery is the most frequent treatment option, and it can be done on a ruptured or unruptured AAA.[6] This operation involves exposing the aorta through a large incision in the abdomen, clamping it off, and inserting and sewing into place a plastic graft that provides a bridge for the blood flow. The procedure is extremely intricate, and it is associated with high postoperative morbidity and mortality. It requires proficiency with the use of complex equipment because technical errors may lead to clinically significant complications, such as arrhythmias, acute myocardial infarction (heart attacks), pulmonary embolism, postoperative hemorrhage, or graft infection (AHRQ, 2007). The fatality rate of the few patients who survive long enough to reach a hospital with a ruptured AAA is between 30 and 50 percent. Consequently, early identification of patients with an AAA and timely elective repair remain the most reliable strategy for preventing death from a ruptured AAA.

21. For better outcomes and survival, an AAA repair requires a high-volume fully specialized vascular team. The surgeon provides expertise and technical skill, and specialized knowledge in vascular surgery is critical (Dimick and Upchurch 2008). How hospitals and surgeons manage complications during and after the procedure also determines patients' survival and later quality of life. Hospitals' capacity and processes affect how patients are treated after the operation (nurses, intensive care units, and diagnostic testing), and they prevent unnecessary deaths by protecting patients from postoperative complications.

[6] A second approach is performing an endovascular aneurysm repair (EVAR), which is a less invasive operation that repairs the AAA by placing a stent graft through a catheter inserted in the femoral artery. This approach, however, is relatively new.

22. Systematic reviews and meta-analysis have identified a strong relationship between AAA repair outcomes (mainly mortality) and both hospital and individual physician case volume and experience (Holt, Poloniecki et al. 2007, Killeen, Andrews et al. 2007, Young, Holt et al. 2007, Pieper, Mathes et al. 2013).[7] The most recent meta-analysis (Holt, Poloniecki et al. 2007) reported that the risk of dying after an elective AAA repair was 34 percent lower among patients treated in high-volume hospitals compared with those in low-volume hospitals, using a volume threshold of 43 AAAs per annum (Odds Ratios OR = 0.66; 95% Confidence Interval (CI) , 0.65–0.67). Similarly, patients undergoing ruptured aneurysm repair in high-volume hospitals exhibited 22 percent lower risk of dying than patients in low-volume hospitals (OR = 0.78; 95% CI, 0.73–0.82), with a threshold of 15 AAAs per annum. Meta-analysis results from Young, Holt et al. (2007) demonstrate that patients of high-volume physicians (<13 elective AAA cases per year) have a 44 percent lower risk of dying than patients of physicians with lower volumes (OR = 0.56; 95% CI, 0.54–0.57). Similarly, a study in the United States reported a 40 percent reduction in the relative risk of 30-day mortality in elective AAA repair conducted by a high-volume physician (95% CI, 0.12%-60%; *P* = .01). AAA repair by general surgeons compared with vascular surgeons was associated with 76 percent greater risk for death (95% CI, 10%-190%; *P* = .02) (Dimick, Cowan Jr et al. 2003).

23. Based on this evidence, national and international clinical practice guidelines usually recommend that AAAs be treated in high-volume units by specialized vascular surgeons or in units with documented lower in-hospital mortality for AAAs (Table 2). For example, the European Society for Vascular Surgery (ESVS) advises that AAA elective repairs be performed in hospitals with an annual AAA casework of 50 or more, by vascular specialists who have had a high caseload of AAA repairs (Moll, Powell et al. 2011). In the United States, the Leapfrog Group, which issues public reports on national standards of safety, quality, and efficiency in US hospitals, recommends a minimum volume of ≥50 per year and a surgeon volume of ≥8 for elective AAA repairs per year (Leapfrog Group 2004). In addition, the Agency for Healthcare Research and Quality (AHRQ) includes AAA volume as one of its inpatient quality indicators.

Table 2: Hospital and surgeon AAA volume standards

Source	Year	Volume standards recommendations
Meta-analysis	2007	Elective AAA hospital volume ≥ 43 AAAs per year and ruptured AAA threshold ≥ 15 AAAs per year.
	2007	Elective AAA minimum surgeon volume ≥ 13 AAAs per year.
European Society for Vascular Surgery (ESVS)	2011	"AAA repair should only be performed in hospitals performing at least 50 elective cases per annum, whether by open repair or EVAR".
	2011	"Elective AAA repair should only be performed by vascular specialists who undertake a high annual volume of AAA repairs"
European Society of Cardiology (ESC)	2014	Centers of excellence, so-called "aortic teams," established to treat AAAs.
Society for Vascular Surgery	2009	Elective open repair for AAAs should be performed at centers with a documented in-hospital mortality of <5% for open repair.

[7] Hospital and surgeon volume indicates how many AAA procedures a hospital or operator performs each year.

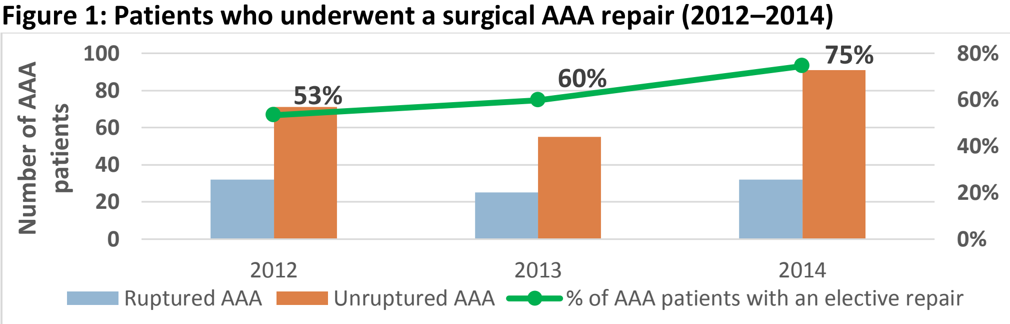
Leapfrog Group (USA)	2004/ 2007	Evidence-based hospital referral safety standards annual hospital volume threshold ≥50 and ≥8 elective AAA repair per surgeon per year
AHRQ	2007	AAA hospital volume is 10 or more procedures per year (Threshold 1) or 32 or more procedures per year (Threshold 2)

24. The analysis of payment data from Latvia uses the following thresholds when benchmarking hospitals and physicians and classifying them as high and low volume:

- Hospital volume ≥ 50 AAAs per year
- Hospital volume ≥ 15 AAAs per year (ruptured) and ≥ 43 AAAs per year (elective)
- Surgeon volume ≥ 10 AAAs per year

All patients in the payment records who underwent repair of an AAA, either ruptured or unruptured, were included in the analysis, but to capture differences in processes of care and volume thresholds between emergent and unruptured AAAs, a separate analysis was done for each type of surgery.[8] Between 2012 and 2014, 306 patients were admitted for an AAA, of which 89 (or 29 percent) were treated for a ruptured aneurysm, while 217 (71 percent) were treated for an unruptured aneurysm. Not all AAA patients required surgical repair. On average, nearly all patients with a ruptured aneurysm (88 patients) underwent emergency surgery, and 88 percent of patients (190 patients) with an unruptured aneurysm were admitted for emergency care**.** Error! Reference source not found.shows that between 2012 and 2014 the number of patients undergoing an operation for ruptured AAAs remained around 30 patients per year, while the average number of patients undergoing unruptured AAA repair increased from 70 in 2012 to 90 in 2014. Despite a significant decrease in patients being admitted for an unruptured AAA repair in 2013 the proportion of elective repairs among these patients increased over time from 53% in 2012 to 75% in 2014.[9]

Figure 1: Patients who underwent a surgical AAA repair (2012–2014)



25. Between 2012 and 2014, only one hospital in Latvia – Pauls Stradins University Hospital - met the minimum volume standard of 50 cases per year for AAA repair (Figure 2). During this period, 306 AAA[10] repairs were performed at 11 hospitals by 26 surgeons. Among these hospitals, Pauls Stradins treated 198 AAA, 65 percent of all AAAs during these 3 years or an average of 70 AAA per year. This

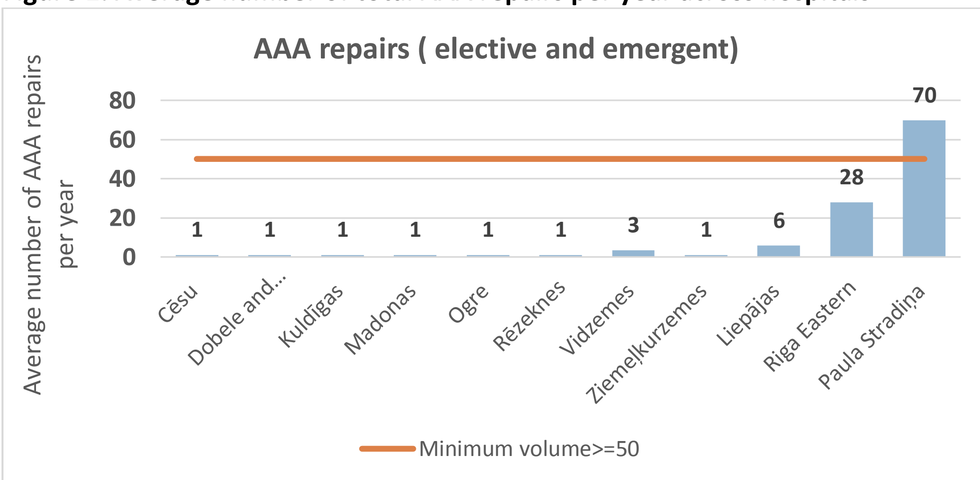
[8] Manipulation codes 22007, 22008, and 22011.

[9] The number of patients with an unruptured AAA (55), and consequently those with an elective repair (25), was significantly lower in 2013 than in 2012 and 2014.

[10] Out of the 306 AAA, 12 AAA had hospital information missing. We use information on hospital branch (filial) and hospital where the patient died to match all these cases to their respective hospitals.

hospital also houses the Latvia Centre of Cardiology and the largest training center in cardiovascular procedures. The second tertiary care hospital, Riga Eastern University Hospital, treated 81 AAA during the same period, an average of 28 AAA per year, (27 percent), and two regional and seven district hospitals altogether treated a small share of AAAs (8 percent).

Figure 2: Average number of total AAA repairs per year across hospitals



Note: Average annual volume per hospital between 2012 and 2014

26. The annual physician volume ranges between 1 and 20 AAAs per year. Surgeons were classified as low-volume (≤5), medium volume (5–10), and high-volume (≥10). Only 4 of the 26 physicians met the volume threshold of 10 or more repairs per year. These few doctors, who were concentrated in the high-volume hospital Pauls Stradins, treated 30 percent of all AAA repairs and 45 percent of that hospital's repairs. Another third of all AAA repairs (93 AAA) were performed by 22 low-volume surgeons.[11] The remaining 40 percent were performed by 12 medium –volume physicians.[12] The hospital with the second highest volume (Eastern Riga) does not have a high-volume AAA specialist among the surgeons that performed an AAA during these three years, despite having treated 27 percent of all AAAs.

27. The analysis also examines the link between AAA volumes and quality of care and mortality, although, the small number of deaths that occurred within volume categories warrants caution in interpreting the results. The findings may indicate trends, but they are not sufficient to provide a robust estimate of a relationship. Nevertheless, studies on AAA volume–quality have found that a larger number of cases usually strengthens the volume–outcome relationship rather than weakens it.[13]

[11] Among the 22 physicians, there were 9 physicians with only one AAA performed per year; 7 of them were either general surgeons or vascular surgeons.

[12] Because surgeon volume is estimated yearly, physicians can fall into different volume categories depending on their yearly performance.

[13] When AAA volume indicators are not affected by disease severity and comorbidities, risk adjustment was not performed, based on AHRQ guidelines (AHRQ, 2007).

28. In Latvia, low-volumes are associated with higher mortality for AAA repair for both hospitals and physicians. The overall in-hospital mortality for AAA repair for 2012–2014 was 12 percent. Thirty-eight of the 306 AAA patients died in the hospital; 24 of these deaths (or 63 percent) occurred in low-volume hospitals (<50 AAA repairs per year), and 33 of the 38 patients (or 87 percent) were treated by low-volume surgeons (<10 AAA repairs). Mortality ranged between 22 percent for low-volume hospitals and 7 percent for the high-volume hospital (Table 3). Almost all deaths were associated with low-volume surgeons, and most of these deaths followed a ruptured AAA. The following sections analyze elective and ruptured AAA repairs separately.

Table 3: Volumes and mortality for AAA repair.

		In-hospital mortality*		
	Patients	**Low-volume surgeons**	**High-volume surgeons**	**%**
Low-volume hospitals	108	23	1	22%
High-volume Hospitals >50 AAA per year	198	10	4	7%

**Proportion with fewer than 20 observations.*

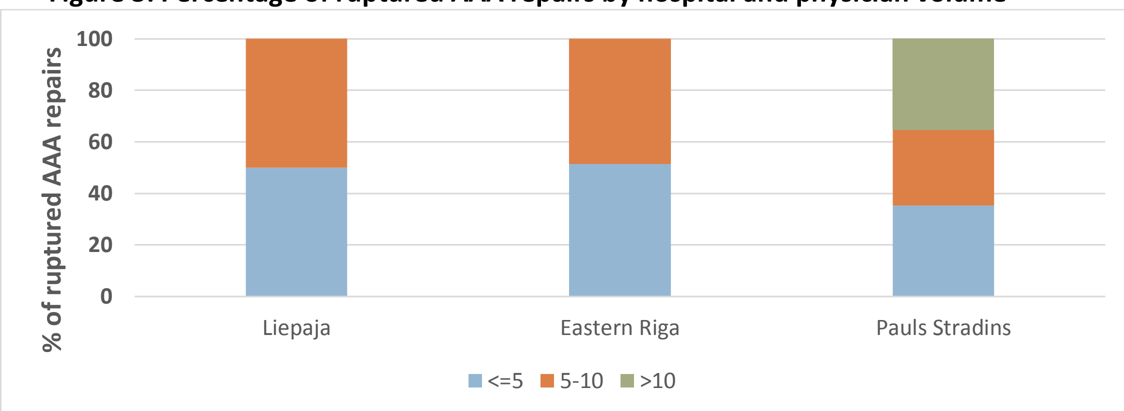
4.1.1 Ruptured AAA repairs

29. Minimum hospital volume thresholds cannot usually be enforced for ruptured AAAs, particularly at small rural or isolated hospitals. Because ruptured AAA repairs often require diagnosis in a hospital setting, these patients tend to reach the nearest hospital rather than a high-volume center. Consequently, these AAA patients are more likely to be treated at low-volume hospitals and by nonvascular surgeons. According to international clinical guidelines, however, patients with ruptured AAA should be immediately transported to a vascular surgeon, if possible. If this is not possible, the operation should be performed by a high-volume surgeon.

30. In Latvia, 1 out of 3 AAA repairs was for a ruptured AAA, and most of these repairs (82 percent) were treated at the two university hospitals, either at Eastern Riga (44 percent) or Pauls Stradins (38 percent). Both of these hospitals were close to meeting the minimum volume of 15 ruptured AAA per year (with 14 AAA, and 12 AAA per year on average, respectively). However, 8 low-volume hospitals (≤ 15 AAAs/year) treated 16 percent of all ruptured AAAs.

31. Despite the fact that most ruptured AAA repairs are treated at a university hospital (Eastern Riga or Pauls Stradins), 48 percent of ruptured AAA repairs were still performed by low-volume physicians (≤5), and only 15 percent were performed by high-volume physicians (≥10). Figure 3 shows that patients with a ruptured AAA treated at either at Liepaja or Eastern Riga were more likely to be treated by a low-volume physician (50–54 percent) than if they would have been admitted at Pauls Stradins. Even in this high volume hospital, 18 percent of patients with a ruptured AAA repair were treated by physicians who had performed fewer than 5 AAA repairs per year. Moreover, few of these physicians conduct such operations every year. It is unclear why physicians with such low volumes are performing a complex and relatively rare procedure in the two university hospitals, but the most likely explanation is that many of these procedures are emergency admissions, and hospitals, even those in Riga, are not fully prepared to treat these patients, suggesting that clinical guidelines for AAA patients are missing or need to be strengthened.

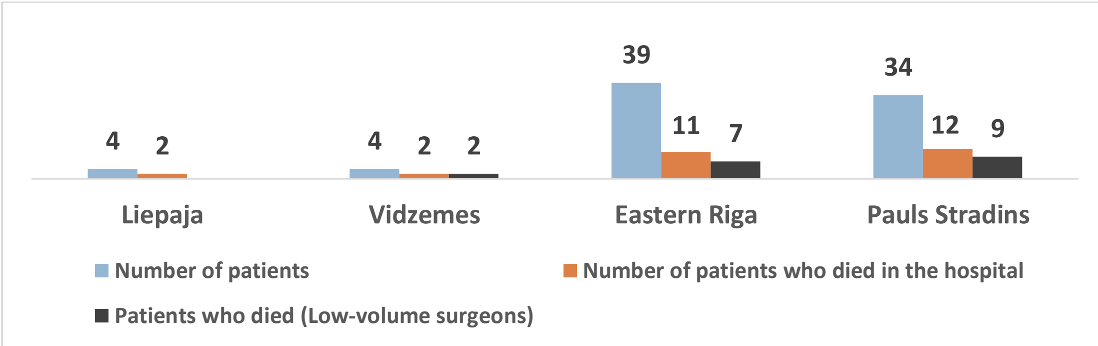
Figure 3: Percentage of ruptured AAA repairs by hospital and physician volume



32. The unadjusted mortality rate after a ruptured AAA repair in Latvia is around 40%, which is below the estimated mortality rates in the United Kingdom (UK) and United States of America (USA) (53% and 66% respectively).[14] The patients of low-volume physicians, however, exhibit higher mortality rates regardless of which hospital provided treatment. Between 2012 and 2014, 32 out of 89 patients with a ruptured AAA died in the hospital. Of these 32 deaths, 53 percent were associated with low-volume surgeons, 35 percent with medium-volume surgeons, and 12 percent with high-volume surgeons. Figure 4 shows that in each of the 4 hospitals with more than 1 AAA repair per year, low-volume surgeons' patients' experienced higher in-hospital mortality than patients treated by higher-volume physicians. For instance, 7 out of 11 patients who died in Eastern Riga hospital were treated by low-volume surgeons, whereas 9 out of 12 patients who died in Pauls Stradins were treated by either low or medium volume surgeons. The results suggest that these two hospitals might be able to improve patients' survival by limiting the number of AAA repairs treated by low-volume physicians.

[14] See Karthikesalingam, Alan, et al. "Mortality from ruptured abdominal aortic aneurysms: clinical lessons from a comparison of outcomes in England and the USA." *The Lancet* 383.9921 (2014): 963-969.

Figure 4: In-hospital mortality among patients with ruptured AAA by surgeon volume



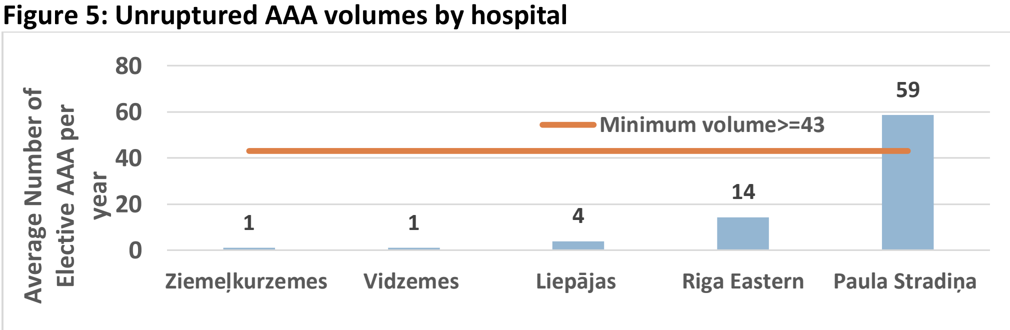
Note: 6 hospitals with <1 AAA per year not shown.

4.1.2 Unruptured AAA repairs

33. When an aneurysm is detected before it ruptures, elective surgical repair may be indicated. In most cases, a patient can chose the hospital and be transferred to another hospital without risk to his or her life. Clinical AAA guidelines for unruptured AAA repair indicate that patients should be transferred to a high-volume specialized center for repair, and the procedure should be performed by high-volume vascular surgeons.

34. In Latvia, only one hospital – Pauls Stradins - met the volume standard of 43 elective AAA repairs per year (Figure 5). Approximately 70 percent of AAA repairs were elective and were performed at 5 hospitals. Pauls Stradins performed an average of 59 AAA elective repairs per year, whereas Eastern Riga performed 14 on average. The other 3 hospitals performed 1 or 4 AAA repairs per year.

Figure 5: Unruptured AAA volumes by hospital



Note: Average annual volume per hospital between 2012 and 2014

35. Most of the elective AAA repairs during 2012 and 2014 were performed in the high-volume hospital (76 percent), but more than 50 percent of these procedures were performed by low or medium volume physicians (≤10 AAA per year). Eastern Riga treated 18.5 percent of all elective AAA repairs, about 14 per year, but 20 percent of these were performed by four low-volume physicians and none by a high-volume physician. Moreover, two regional hospitals and one district hospital carried out 11 unruptured AAA repairs during the 2012-2014 period. Liepaja, the only regional hospital performing

elective AAA repairs each year, had 9 elective surgical repairs in three years, but they were carried out by one doctor.

36. Overall, unadjusted in-hospital mortality after an elective AAA was estimated to be 2.8 percent (6 cases), whereas 30-day mortality was 3.2 percent. This makes Latvia's performance similar to other European countries. For instance, overall mortality in the UK is 2.4 percent for elective AAA repair. The analysis also indicates that Pauls Stradins had an in-hospital mortality of 1.2%, a figure three times lower than the one exhibited by Eastern Riga (4.8 percent).[15] One of the main differences among these two hospitals is the proportion of patients treated by high-volume surgeons.

37. Similar to the case of ruptured AAA repairs, lower quality of care and higher mortality were associated with low-volume physicians for unruptured AAA repairs. For instance, as Table 4 shows, patients treated by less active physicians had a longer length of stay on average than patients treated by high-volume physicians (13 vs 10 days); they also had higher 30-day readmission rates (7.9% vs 2.6%). Moreover, although only 6 out of 217 patients died in the hospital (2.8%), most of the deaths were associated with low-volume surgeons (5 of 6).

Table 4: Low-volume and lower quality indicators among elective AAA repairs

	ALOS	30-day readmission	in-hospital mortality	30-day mortality
Low-volume surgeon (<10)	12.7	7.9%	3.6%	4.3%
High-volume surgeon (>=10)	9.5	2.6%	1.3%	1.3%

**Proportion with less than 20 observations.*

4.1.3 Recommendations for AAA repairs

38. In Latvia, AAA repairs are mostly performed in the two university hospitals in Riga. Only one hospital, Pauls Stradins, met the overall minimum volume threshold established in the literature during the 2012-2014 period. This hospital houses the National Cardiology Center and also has the four physicians who met the minimum volume standard for physicians. Few surgical repairs were performed in small hospitals. Most of these were done for unplanned ruptured AAAs, but some elective AAA repairs were carried out at very low volume hospitals, and it is unclear why they were not transferred to a higher volume hospital. Although surgical repairs were primarily performed in medium- and high-volume hospitals, one third were carried out by low-volume physicians. AAA mortality rates in Latvia are similar to other countries. However, both lower-volume hospitals and physicians were associated with lower quality of care and higher mortality for both unruptured and ruptured AAAs.

39. These findings suggest that Latvia might be able to improve patients' survival by limiting the number of AAA repairs treated by low-volume physicians. Given the small number of AAA repairs per

[15] This is only suggestive, as there were only 4 deaths among these two hospitals.

year (approximately 100), treatment of AAA repairs at high-volume centers by high-volume physicians should not be too difficult to achieve with an appropriate health policy framework that takes procedural volumes into account. All appropriate patients with a ruptured AAA would ideally be transported or transferred to specialist vascular care within 30 minutes of diagnosis. When distance is not an issue (for example, within Riga), all ruptured cases should be treated at the high-volume hospital and by high-volume surgeons. Transferring patients who live more than 30 minutes from Riga may not be possible, so emergency services could instead provide a high-volume vascular surgeon to these hospitals and assess whether the patient may be transferred after the operation.

40. For unruptured AAAs there is no reason why treatment cannot be restricted to high-volume centers rather than very low volume hospitals treating fewer than 10 AAAs per year. In addition, it is essential that high- and medium-volume hospitals ensure that AAA repairs are performed by specialized surgeons. In particular, high-volume vascular surgeons should be on call for emergency cases.

41. Implementing these kinds of recommendations, however, will likely require the development of clinical pathways with selective referral to (and transfers) to high-volume hospitals and high-volume physicians. It is equally important to have clinical guidelines for AAAs to establish when surgical repairs should not be done because the risks of operating may be higher than the risk of rupture. This point is critical because low-volume providers may attempt to increase their volume but may realize no improvements in quality of care if they perform the procedure on patients who may not qualify or benefit.

42. These selective referral and transfer guidelines would ideally be incorporated into the contracts that the National Health Service writes with hospitals. Given the severity of an AAA, it is essential that shifting procedures to high-volume providers does not reduce access to care for patients living outside of Riga and that the high-volume hospital is able to absorb additional patients.

43. Volume standards could also be incorporated into the training and certification process for vascular surgery. For instance, in the United States AAA repairs are mostly performed by vascular surgeons who have had at least 2 years of training in this specialty and have done at least 20 endovascular aneurysm repairs and 30 open abdominal surgeries. Thus, the number of certified vascular surgeons is small, but they are highly experienced.

44. These volumes could also be published as quality indicators. In the United States, the volume for AAA repairs is used to benchmark hospitals to help patients choose a hospital and to alert providers and state health agencies to potential problem areas that might need further investigation. As such, AAA repair volumes are publicly reported so consumers can have access this information.[16]

[16] Adding additional elements to the benefits package may also bring down mortality. Early identification of patients with AAA, for example, and timely elective repair represent the most reliable strategy for prevention of death from a ruptured AAA. Screening programs for men over 65 can reduce the incidence of ruptured AAAs and the associated mortality. For instance, a screening program in United Kingdom, which was initiated in 2009 and slowly rolled out across the country, has proven to be a cost-effective intervention (Glover, M J et al 2014). It is estimated that offering men ultrasound screening when they turn 65 has reduced the rate of premature death from a ruptured AAA by as much as 50 percent (Thompson SG, Ashton HA, Gao L et al.2009).

4.2 Percutaneous Coronary Interventions

45. Coronary heart disease is the leading cause of death in Latvia. Primary percutaneous coronary intervention (PCI)[17] is one of two coronary revascularization techniques currently used in the treatment of ischemic heart disease, with the other being coronary artery bypass grafting. A PCI, also known as coronary angioplasty or percutaneous transluminal coronary angioplasty, is a nonsurgical technique for treating obstructive coronary artery disease (CAD), including unstable angina, acute myocardial infarction, and multi-vessel CAD. The objective of the procedure is to open a blocked coronary artery and restore blood flow to heart tissue by using a balloon and metal stents. When available, angioplasty with stenting is considered the optimal method for patients experiencing STEMI (ST-segment elevated myocardial infarction)[18]. Angioplasty with stenting is also a rescue treatment for patients treated by thrombolysis for whom blood flow restoration has failed.

46. Numerous studies have investigated the relationship between volume of procedures and outcomes for PCIs, and the evidence suggests a volume–outcome relationship at the institutional level, as well as the physician level (Kontos, Wang et al. 2013, Badheka, Patel et al. 2014, Lin, Tao et al. 2016). The most recent meta-analysis (Post, Kuijpers et al. 2010), which included 10 studies comprising 1,322,342 patients in 1,746 hospitals, indicated that patients treated in a high-volume hospital exhibit lower in-hospital mortality compared with those treated in a low-volume hospital—a relative risk reduction of 13 percent (OR = 0.87; confidence interval [CI] 0.83–0.91). These articles used different volume cutoffs, but when the analysis focused on studies with a cutoff point of 400, a similar estimate was found.

47. While acute PCI complications are uncommon, physicians need practice and experience to avoid negative outcomes. Thus, maintaining the practical skills necessary for interventional cardiology requires a minimum number of procedures per annum (Dawkins, K. D et. Al 2005), and surgeon volume was found to be associated with lower mortality in recent studies (Minges, Wang et al. 2011, Badheka, Patel et al. 2014). A large 5-year study in the United States found that the adjusted risk of mortality among patients treated by a physician performing less than 50 procedures per year, 50–75 procedures per year, or more than 75 procedures per year was 1.31%, 0.78%, and 0.54%, respectively. According to a meta-analysis by Strom, Wimmer et al. (2014), mortality and major adverse cardiac events increase as physician volumes decrease for PCIs. Among the studies rated as having high or very high quality in this review, 67 percent showed a significant trend between increasing volume and reduced mortality. However, a weighted estimate was not significant, and studies differed in defining high volume, with the number of PCIs in this category ranging from 11 to 150 PCIs per year.

Table 5: Hospital and physician PCI volume standards

Organization	Year	Volume standards
Leapfrog Group (USA)	2004/ 2007	Facility minimum volume: 400 Physician minimum volume: 75
American College of Cardiology	2011/	Facility minimum volume: 200 (2013) updated from 400

[17] Primary PCI refers to PCIs that are (i) performed in the hospital where a patient was first admitted and (ii) take place before any thrombolytic (fibrinolysis) has been administered during inpatient care. In some cases EMS may have provided it, but it was not identifiable in the discharge data set.
[18] STEMI occurs when a complete (as opposed to partial) occlusion occurs in a major coronary artery previously affected by atherosclerosis. This causes a full (as opposed to partial) thickness damage of heart muscle.

Foundation *American Heart Association* *American College of Physicians Task Force on Clinical Competence and Training* *Society for Cardiovascular Angiography and Interventions*	2013	(2011). Interventional cardiologists minimum volume: 50 coronary interventional procedures per year averaged over a 2-year period (2013), updated from a minimum of 75 PCIs (2011). Facilities should develop internal review processes to assess performance of physicians with less than 50 PCIs per year. Physicians should have board certification in interventional cardiology and maintain certification.
European Society of Cardiology *European Association for Cardio-Thoracic Surgery*	2014	Physician minimum volume for PCI for acute coronary syndrome: 75 Physicians should have appropriate training. Facility minimum volume for PCI for acute coronary syndrome: 400 Facility should have an established 24-hour/7-day service for the treatment of patients with acute coronary syndrome. Physician minimum volume for PCI for spontaneous coronary artery dissection: 75 Physicians should have appropriate training. Facility minimum volume for PCI for spontaneous coronary artery dissection: 200
Joint Working Group on PCI of British Cardiovascular Intervention Society (BCIS) and the British Cardiovascular Society.	2005	Facility minimum volume: 200 but 400 is recommended. Physician minimum volume: 75. Physicians working at minimum level are encouraged to develop a strategy for increasing their own activity to 150 procedures a year or more. For a physician in training fewer than 75 per year is possible for the training period only if a mentor oversees the procedure in the laboratory.

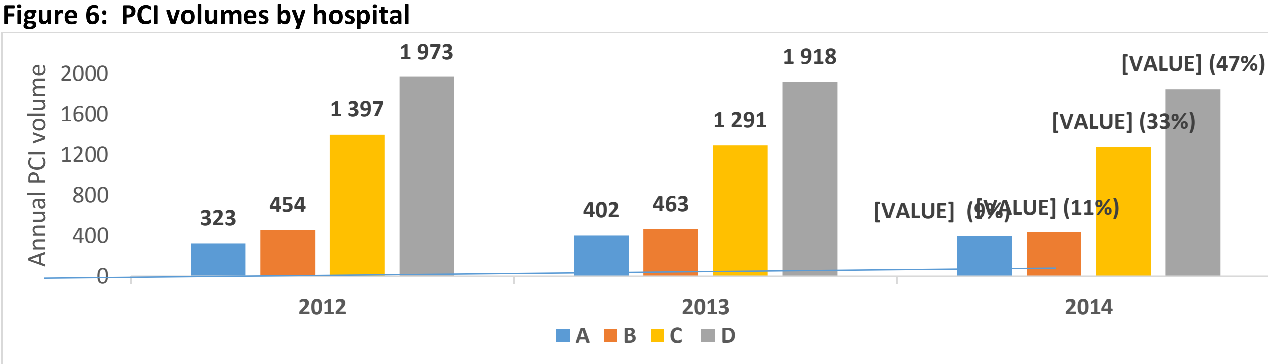
48. This study uses the most common cutoffs found in clinical guidelines – a threshold of 400 PCIs per year for hospitals and a threshold of 75 PCIs per year for physicians. Physicians were grouped in 3 volume categories: those performing less than 25 PCI per year, those performing 25–74, and those performing more than 75 per year. The analysis includes all publicly funded PCIs performed in inpatient settings, including emergency and elective procedures and angioplasties with and without stents performed in people over 18 years old.[19] Given the importance of PCI for the survival of patients with acute myocardial infarction, the analysis also studies the volume of PCIs performed in STEMI patients.

[19] Manipulation codes 60072, 60073, and 60074. The analysis was done exclusively on PCIs reported in the inpatient database. The definition of PCI in this study does not include diagnostic angiographies. Unfortunately, the current coding does not permit identifying whether a procedure was elective or planned.

49. In Latvia, PCI procedures are concentrated in 4 cardiac catheterization laboratories. Two of these centers are in Riga and form part of the tertiary hospital network, whereas the other two centers are located in the regions (Latgale and Kurzemes). All of these hospitals also perform elective outpatient PCIs, which accounted for 40 percent of all state-financed PCIs. Outpatient and inpatient PCIs together accounted for 6,200 PCIs per year on average, about 3,123 PCIs per million habitants. Each country has different health care needs and cardiovascular profiles, but Latvia 's PCI rate appears to be relatively high compared with the United Kingdom's rate of 1,500 PCIs per 1 million habitants.

50. All hospitals exceeded the recommended volume threshold of 400 PCIs per year, with the exception of one regional center that fell short of the benchmark in 2012 (Figure 6). On average, 4,000 publicly funded inpatient PCIs were performed in these hospitals annually from 2012 to 2014. Pauls Stradins Clinical University Hospital, which houses the Latvia Cardiology center, provided nearly half of these PCIs during this period. Riga Eastern Clinical University Hospital (East Riga) provided a third of these PCIs, primarily at its "Gaiļezers" clinical center where emergency and day-surgery patients are admitted.[20] Both Daugavpils and Liepaja regional hospitals had about 400 inpatient PCIs per year – together 20 percent of the total.

Figure 6: PCI volumes by hospital



51. Initially, based on the data, there were 85 doctors who had performed 12,164 PCIs.[21] Among them, 47 physicians had performed only one PCI per year. Because these cases may be the result of miscoding, we restricted the surgeon volume analysis to annual volumes greater than or equal to 2 PCIs per year.[22] After further quality adjustments, 38 physicians remained in the analysis .[23] From 2012-2014, physician volume ranged between 2 and 1530 PCIs per year, including both outpatient and inpatient procedures across hospitals. Figure 7 shows that 19 doctors (50 percent) met the minimum volume

[20] Please note that about 2,000 outpatient PCIs per year were also performed at Pauls Stradins Hospital (not included), while the number of PCIs at Eastern Riga includes both day surgery and inpatient care.

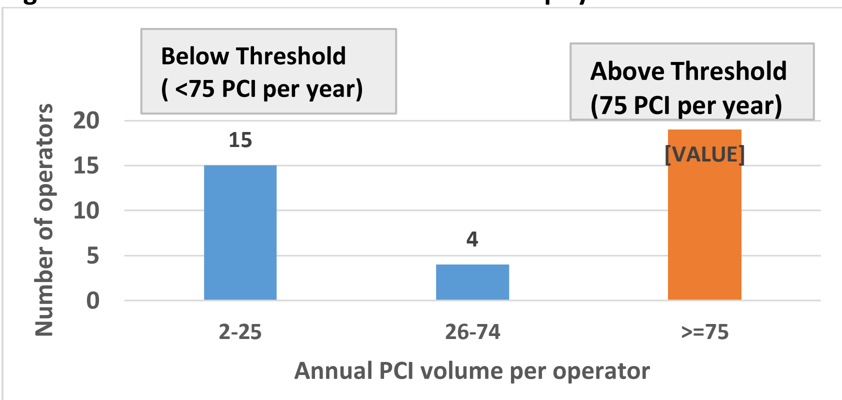
[21] Initially, there were 12,176 cases, but 158 cases were dropped either because the corresponding hospital ID was missing (156), or they were carried out in hospitals with only one case (for example, Children's Hospital and Kuldigas Hospital).

[22] Please note, however, that 24 of these 47 physicians were either cardiologists, heart surgeons or had angiography /angioplasty credentials.

[23] First, we exclude cases in which the performing doctors were not cardiologists, heart surgeons or had angiography /angioplasty credentials (3 doctors-35 cases). Second, when the ID of the doctor performing the procedure was (202 cases), we substitute it with information on the attending doctor provided that they were either cardiologists, heart surgeons or had angiography /angioplasty credentials themselves.

standard of 75 PCIs per year during the 2012-2014 period. Overall, 15 of these 38 physicians (40 percent) performed between 2 and 25 procedures per year on average, and 4 surgeons (10 percent) performed between 26 and 74 procedures per year.[24] With a lower cutoff of 50 PCIs per year, 21 physicians (55 percent) met the standard.

Figure 7: The distribution of PCI volumes for physicians



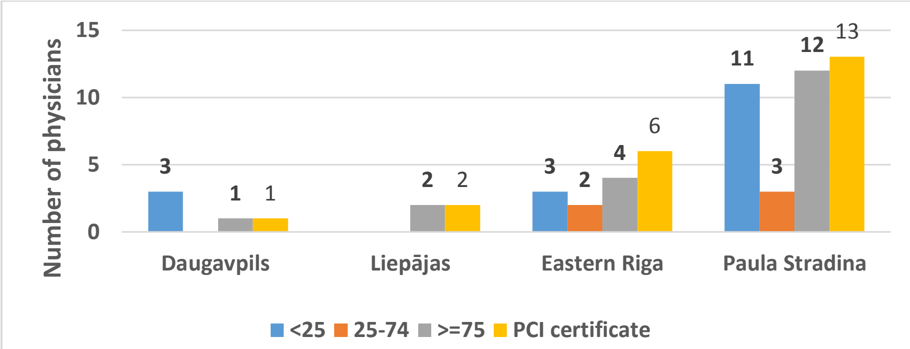
Note: figure based on median PCI surgeon volume across the three years (2012-2014)

52. Coronary interventions in Latvia were concentrated among high-volume physicians**.** While 94 percent of PCIs in these centers were performed by high-volume physicians (≥75 PCIs per year), about 6 percent (773 PCIs) were performed by low-volume physicians with less than 75 PCIs per year. Because emergency and STEMI patients may be admitted during the night when specialists are not present, PCIs may occasionally be carried out by attending emergency doctors. For example, 56 percent of PCIs performed by low-volume physicians (<=25 PCIs per year) in Pauls Stradins Hospital were associated with emergency admissions, which indicates a need to strengthen the emergency department. However, the remaining 44 percent of PCIs performed among low-volume physicians in the same hospital were not emergency admissions and could have been carried out by more experienced physicians.

53. Both procedural volume and certification in interventional cardiology influence surgeon expertise in performing PCIs. In the case of Latvia, 22 of the 38 physicians performing PCIs were certified to carry out PCIs including stents, and these qualified physicians performed nearly all of PCIs . As expected, both high-volume operators and those with PCI credentials are concentrated in the two tertiary care hospitals, but as Figure 8 shows, these hospitals also have equal number of low-volume physicians. In addition, while all surgeons in Liepaja hospital were both high-volume and PCI specialist, Daugavpils hospital had only one out of 4 surgeons being high-volume or PCI specialist.

[24] It is possible that these cases also suffer from some form of miscoding, but it is not possible to ascertain it given that all of them are cardiologists or heart surgeons or had an angioplasty or angiography certification. A number of them have observations over two or three years.

Figure 8: Number of physicians, by PCI volume and hospital



Note: figure based on median PCI surgeon volume across the three years (2012-2014)

54. The patients of these low-volume physicians experience lower quality of care and exhibit higher mortality, as suggested by an analysis that also adjusted estimates by age, sex, emergency admission, STEMI, and a comorbidity index. For instance, patients treated by low-volume physicians remained in the hospital for 6.1 days on average, in comparison with 4.6 days for patients treated by high-volume operators (a difference of 1.5 days *P*<.0001).

55. Since major adverse cardiac events frequently occur within one month of a PCI, in-hospital mortality and the 30 day readmission rate are considered proxies of the quality of care experienced by patients. About 342 of 12, 164 PCI patients died in the hospital during 2012–2014. Overall, PCI in-hospital mortality was 2.81 percent, ranging from 0.70 percent in elective (non-STEMI) PCI to 5.9 percent in ST-segment elevation myocardial infarction patients. The overall 30-day readmission rate was 7.1 percent.

56. Table 6 shows that high-volume physicians were associated with a lower risk of patients dying in the hospital (adjusted and unadjusted). Crude in-hospital mortality ranged from 5.6% percent among patients of low-volume physicians (<75) and 2.6 percent among the patients of high-volume physicians. When a cut-off of 50 PCIs per year is considered instead, mortality ranges between 5.2 percent among low-volume physicians and 2.7 percent among physicians performing at least 50 PCIs per year. Multivariable logistic regressions indicated that patients treated by high-volume physicians (>75 per year) had a 44 percent reduction in the risk of in-hospital mortality (adjusted relative risk 0.56; 95% CI 0.39–0.77). However, patients treated by low-volume physicians (<75 PCIs per year) had a 103 percent increase in the risk of dying in the hospital (adjusted relative risk 2.03; 95% CI 1.47–2.89). When a cutoff of 50 PCIs instead of 75 PCIs was used in the model, patients treated by high-volume physicians had a 46 percent reduction in the risk of in-hospital mortality (adjusted relative risk 0.54; 95% CI 0.33–0.88).

Table 6: Quality of care and mortality by PCI physician volume

Surgeon volume	ALOS	30-day readmission	In-hospital mortality (unadjusted)	In-hospital mortality (adjusted)	Deaths
2-74	6.1	8.7%	5.6%	3.5%	43
>=75	4.6	7.0%	2.6%	2.7%	293

** Adjusted by age, sex, emergency admission, STEMI, stents, year of treatment, and a comorbidity index. All PCIs performed between 2012 and 2014.*

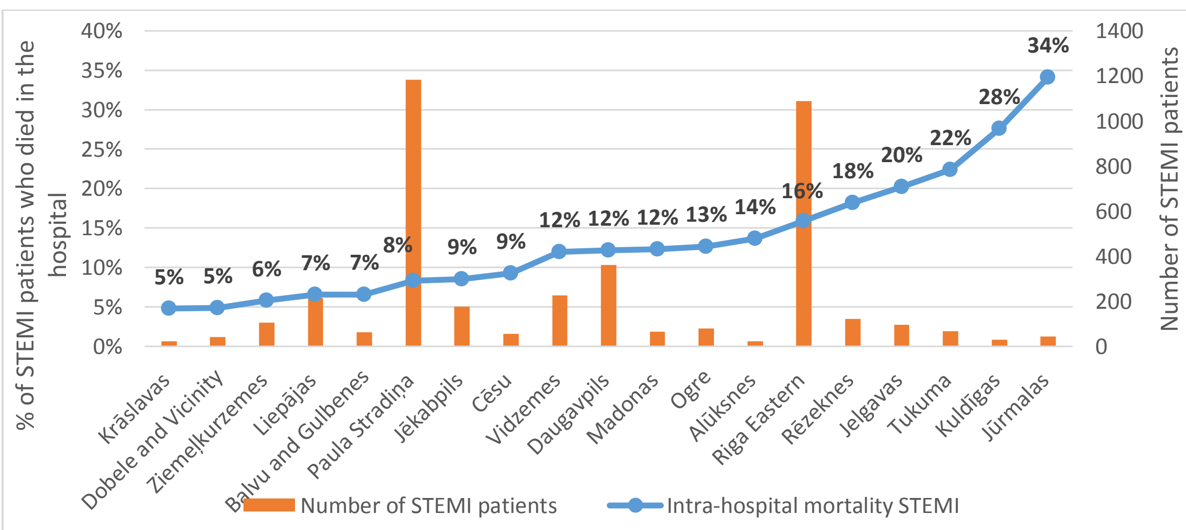
4.2.1 STEMI patients

57. According to the inpatient discharge data, Latvia's four interventional cardiology centers accounted for 2,846 out of 4,056 (70 percent) of all STEMI admissions in 2014. Thus, 30 percent of these patients were treated at hospitals without interventional cardiology capability. In 2014, 13 percent of STEMI patients died in the hospital. In-hospital mortality ranged from 5 percent in Kraslava hospital to 34 percent Jurmalas hospital. Mortality rates were three times higher in some non-PCI centers than in Pauls Stradins, a PCI and cardiology center (Figure 9).

58. Furthermore, some of the high-mortality hospitals were less than one hour from a PCI center. For instance, Jurmala, Jelgava, Ogre, and Tukums, all with mortality rates over 20 percent, are located less than 50 km from Riga. The recommended time from door to balloon (PCI) is 90 minutes, thus some of these patients could have accessed a PCI center. However, some STEMI patients were treated at hospitals located more than 100 km from any PCI center such as Balvu and Gulbenes, Alūksnes in the Vidzeme region, or Kuldīgas, which may indicate the need for better EMS coordination or adherence to selective referral guidelines.

59. A number of other indicators suggest that STEMI management needs to be improved. Primary PCIs accounted for 92 percent of all PCIs included in the analysis - that is, only 8 percent patients were transported from another hospital.[25] Yet the analysis indicates that about 45 percent of STEMI patients admitted at any of the 4 PCI centers did not undergo a PCI. These patients also did not receive hospital-initiated thrombolytic therapy, indicating an area were STEMI management needs improvement.

Figure 9: Number of STEMI patients by hospital and in-hospital mortality (2014)

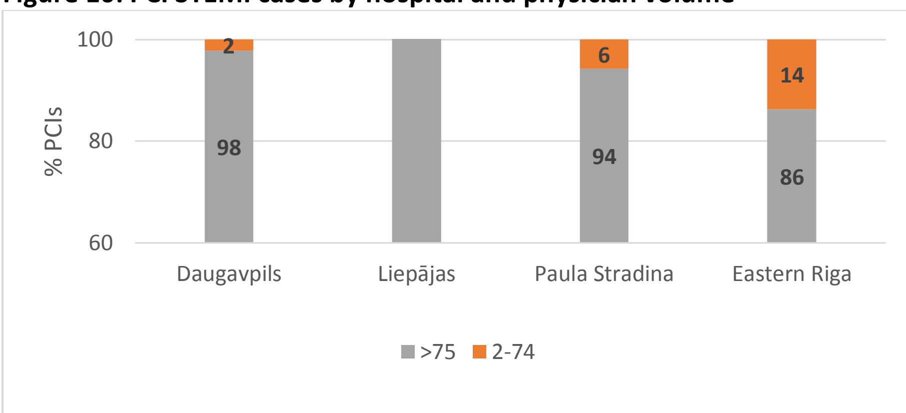


*Hospitals with <20 cases of STEMI not included.

25 Because 30% of STEMI patients were treated at hospitals with no PCI capabilities, we expected a higher number of patients to be transferred to PCI hospitals for a primary or rescue PCI. However, this was not the case, indicating either a high rate of successful fibrinolysis in small hospitals or delays in the referral process that increased the risk of death after acute myocardial infarction.

60. There are some differences across hospitals in the assignment of STEMI patients to high and low volume physicians and mortality. On average, 6 percent of STEMI patients who underwent a PCI died in a hospital between 2012 and 2014.[26] The crude in-hospital mortality rate ranged from 3.7 percent in Daugavpils to 7.5 percent in Eastern Riga. The 30-day mortality ranged from 6.5 to 8.5 percent across the same hospitals. Results for a multivariable logistic regression showed that STEMI patients in Pauls Stradins and Daugavpils had statistically lower in-hospital mortality than patients in Eastern Riga Hospital. Further, 92 percent of PCIs for STEMI cases were performed by high-volume surgeons (>75 PCIs per year). Figure 10 shows that high-volume surgeons treated nearly all STEMI patients in Liepaja and Daugavpils, compared with Eastern Riga that had the highest share of patients treated by low-volume surgeons (14 percent). Daugavpils hospital has only one high-volume surgeon.

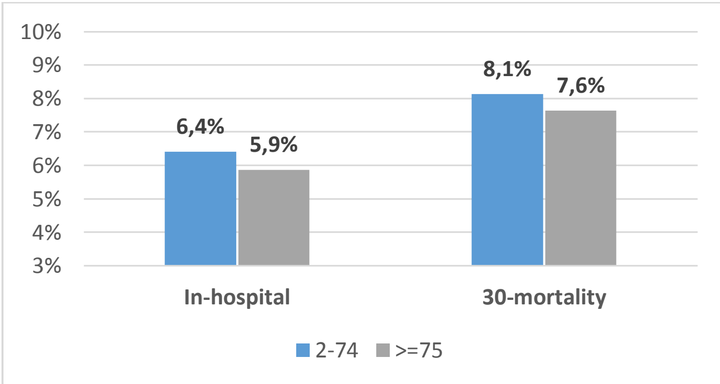
Figure 10: PCI STEMI cases by hospital and physician volume



61. High-volume physicians treating STEMI patients are associated with a lower risk of in-hospital mortality (Figure 11). Crude in-hospital mortality ranged from 10 percent among patients of low-volume physicians and 5.6 percent among patients of high-volume physicians. Once adjusted, the risk of death was 34 percent lower in patients treated by high-volume physicians than by low-volume physicians (adjusted relative risk 0.66; 95% CI 0.42–0.88). Similar to all PCIs, patients treated by very low-volume operators (<75 PCIs per year) had a 104 percent increase in the risk of dying in the hospital (adjusted relative risk 2.04; 95% CI 1.56–3.19).

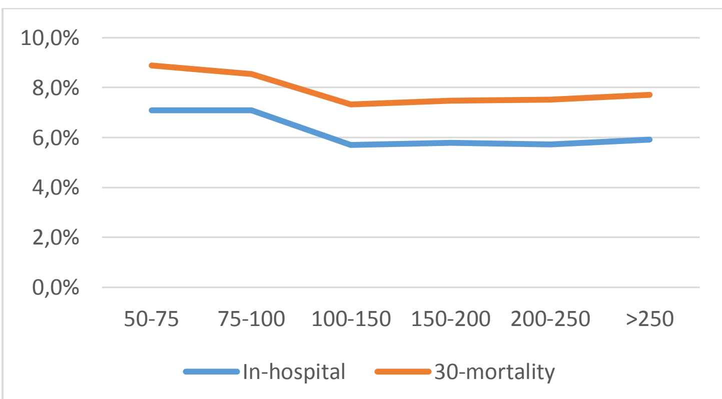
[26] These deaths correspond to 298 of the 336 patients who underwent a PCI who died in the hospital, once we exclude cases of physicians with only 1 PCI.

Figure 11: Adjusted in-hospital and 30-day mortality rates in STEMI patients, by physician volume



62. Figure 12 shows furthermore that mortality rates are higher even at volume levels over the minimum threshold, between 75 and 100 PCIS per year. Adjusted mortality rates are higher over the range 50-100, but remain constant after this. Thus, it is possible that Latvia could chose a higher volume surgeon threshold in order to reduce mortality rates after a PCI even more.

Figure 12: Adjusted mortality rates in STEMI patients, by physician volume group



4.2.2 Recommendations

63. In Latvia, interventional cardiology is concentrated in 4 PCI centers. All of these units met the minimum volume criterion of 400 PCIs per year established in international clinical guidelines, and half of physicians performing PCIs met the minimum threshold for physicians (PCI>=75 annually) yet, 94% of all PCIs were performed by a high-volume physician.

64. In Latvia, patients who underwent a PCI had an overall mortality rate of 2.8 percent which is relatively higher than other European countries, such as the United Kingdom (1.8 percent), or the United States (1.03 percent). As in other countries, low-volume physicians are associated with lower quality of care indicators and higher mortality rates overall and among STEMI patients. Patients treated by high-volume operators had a reduced risk of dying, ranging from 44 percent for patients of physicians performing more than 75 PCIs per year and 46 percent for patients whose physicians performed more

than 50 PCIs per year. Accordingly, low-volume operators were associated with a 103% or 2 times higher risk of a patient's dying in the hospital; these patients also had longer hospitals stays and higher readmissions rates.

65. Each of the four interventional cardiology centers would ideally ensure that only a dedicated team of trained physicians perform interventional cardiology procedures (planned and emergency cases). Because there are only four hospitals with PCI capabilities in Latvia, it is vital that each of the units provide round the clock service and have high-volume PCI physicians on call for emergencies. To this, these hospitals should reduce the number of physicians performing low volume of PCIs to a point that cases can be spread among remaining PCI physicians, allowing them to get closer to the minimum volume standard. At the same time, these hospitals should establish a specific number of doctors needed to perform the current cases requiring PCIs and thus discourage an increase in volumes of unnecessary procedures.

66. To improve the overall performance of interventional cardiology in Latvia, there are a number of initiatives that the Ministry of Health and its departments can undertake to identify facilities that may require assistance and to better coordinate care. First, it should be relatively easy to monitor physician volumes, along with the quality of care indicators presented in this report, with payment data received by the National Health Service. In collaboration with physicians, institutions for quality assurance, and the university, the Ministry of Health could promote a national annual clinic audit for PCIs as other countries do (for example, the United Kingdom).[27]

67. Second, both regional hospitals performing PCIs could benefit from additional high-volume physicians. Given that there are unserved areas in the Vidzemes region, it may be useful to do an assessment of need for additional PCI capabilities in that region to determine if volumes warrant it.

68. Third, clinical guidelines and pathways that include a definition of appropriate management of STEMI and emergency admissions may also decrease mortality. For instance, the European Society of Cardiology (ESC) and the European Association for Cardio-Thoracic Surgery (EACTS) Guidelines on myocardial revascularization indicate that PCI for STEMI patients should be considered a primary therapy if it can be performed in a timely manner in high-volume PCI centers with a 24-hour, 7-day catheterization laboratory and experienced physicians. In cases in which a primary PCI cannot be performed during the recommended time, fibrinolysis should be considered, particularly if it can be administered during pre-hospital care within the first 120 minutes (Windecker, Kolh et al. 2014).

69. Fourth, the Health Inspectorate may consider introducing a certification program that includes minimum volumes, or doctors' associations in Latvia can be encouraged to include this in their existing certification processes. Both the ESC and the American College of Cardiology (ACC) have incorporated volume standards in training and certification. For instance, the ACC established that interventional cardiologists should perform a minimum of 50 coronary interventional procedures per year (averaged over a 2-year period) to maintain competency (Harold, Bass et al. 2013). ESC guidelines recommend that

[27] The audit is commissioned by the Healthcare Quality Improvement Partnership (HQIP) in the United Kingdom. The audit provides information on: the structure of the provision of PCI services across the UK (for example the number of PCI centers, number of PCIs per center and population, number of physician); clinical care and treatment provided by each hospital, measured against national aggregated data and agreed national standards (for example indication for treatment, use of stents, arterial access routes); processes of care (for example delays in receiving treatments such as primary PCI), and outcomes for patients such as complications, adverse cardiac events, and death.

physicians training in interventional cardiology should have performed at least 200 PCI procedures under supervision as first or only operator, with one third of the PCI procedures being in emergency or Acute Coronary Syndrome (ACS) patients, before becoming independent (Windecker, Kolh et al. 2014).

5 Cancer care

70. Investigating the volume–outcome relationship can also be used to assess hospital performance in oncological services. Surgery is an essential element of cancer treatment, along with radiation and systemic therapy. Surgical resection of cancers remains the basis of treatment for many types of cancers, and it depends highly on availability of and access to onsite specialists (for example, oncologists and diagnostic radiologists) and, in some instances, complex technology. Surgical resection uses surgery to remove abnormal tissue. The type of resection is based on the tumor location, size, and type, as well as the patient's health prior to diagnosis. Resections are complex procedures that require a specially trained surgeon as part of a multidisciplinary team program and institutional capabilities to manage complications. These specialists and treatments are usually concentrated in relatively few medical institutions to maximize efficiency and resources (Farmer, Frenk et al. 2010). Additionally, effective surgical techniques, careful patient management, and supportive post-operative care are requirements for positive outcomes

71. This section focuses on four common cancers in Latvia: breast, ovarian, and colorectal, . Breast cancer accounts for the highest incidence of cancer and mortality rates in women in Latvia, and ovarian and cervical cancer rates are among the highest in Europe. Colorectal/prostate and lung cancers are two of the most commonly diagnosed malignancies in men. Latvia and other Baltic countries (Estonia and Lithuania) have some of the highest pancreatic and gastric cancer mortality rates among European countries (Bray, Lortet-Tieulent et al. 2010, Plonis, Bokums et al. 2014)

5.1 Breast cancer surgery

70. Mastectomies are a crucial aspect of breast cancer treatment. Mastectomy is the removal of the whole breast. There are different types of mastectomy: “simple” or “total” mastectomy, radical mastectomy, partial mastectomy, and subcutaneous (nipple-sparing) mastectomy. Radical mastectomy, which is the most extensive type of mastectomy, usually treats invasive breast cancer and involves axillary lymph node dissection and, in some instances, also affects the chest wall muscles under the breast.

71. Similar to low-volume, high-risk procedures, many studies have shown differences in quality of care and survival across hospital and surgeon volume in more common, low-risk procedures, such as the surgical treatment of breast cancer (Scharl and Göhring 2009, Peltoniemi, Huhtala et al. 2012, Vrijens, Stordeur et al. 2012, Siesling, Tjan-Heijnen et al. 2014, Köster, Heller et al. 2015). For instance, Gooiker, Van Gijn et al. (2010) systematically review 12 studies and show a strongly significant association between high-volume providers and improved survival in breast cancer treatment. Patients treated by high-volume surgeons (the most common volume cut-off was 50 operations per year) had a 15 percent higher survival rate than those of low-volume surgeons (RR 0.85; 0.80–0.91). Studies including in-hospital mortality had a pooled estimated odds Ratio of 0.40 (CI 0.22–0.74) in favor of high-volume

hospitals, where the volume cut-off was 70–88 operations. Low-volume hospitals also perform worse when it comes to process indicators. Köster, Heller et al. (2015) studied 939 hospitals in Germany and found that guideline adherence, including histologic confirmation of diagnosis before definite treatment and axillary dissection as recommended by the guidelines, was much lower in low-volume hospitals (with less than 105 cases per year).

72. Country studies in Europe demonstrate a similar advantage of high volume surgeons. Mikeljevic, Haward et al. (2003) studied a sample of surgeons and breast cancer patients in the United Kingdom and found that patients treated by surgeons with the highest workload (>50 cases per year) had better survival. Their 5-year survival rate was 68%, compared to 60% for patients of low-volume surgeons (<10 cases).[28]

73. High caseload and oncological specialization also are associated with other quality indicators. For instance, a study in Finland shows that surgeons with fewer than 60 cases per year were less likely to perform breast-conserving surgery and more likely to choose a more aggressive treatment, as they dissected more axillary nodes (Peltoniemi, Huhtala et al. 2012).

74. The European Society of Breast Cancer Specialists (EUSOMA) has established standards for breast cancer units that require 150 new breast cancer patients diagnosed per hospital as a minimum annual standard and a minimum surgical caseload of 50 cases per surgeon (Association of Breast Surgery at Baso 2009). The Netherlands developed its own guidelines, requiring 50 breast cancer operations per hospital per year. Since 2011, all hospitals in the Netherlands have met this volume standard (Siesling, Tjan-Heijnen et al. 2014). In Belgium, the volume stratification for the number of surgeries for invasive breast cancer per year is <50 (very low), 50–99 (low), 100–149 (moderate), 150-199 (high), and >200 (very high)(Vrijens, Stordeur et al. 2012). The French National Institute of Cancer requires a minimum of 30 procedures per year for surgeons. Similarly surgeons involved in publicly contracted services in the United Kingdom are expected to demonstrate an annual surgical workload of at least 30 treated breast cancers (Association of Breast Surgery at Baso 2009).

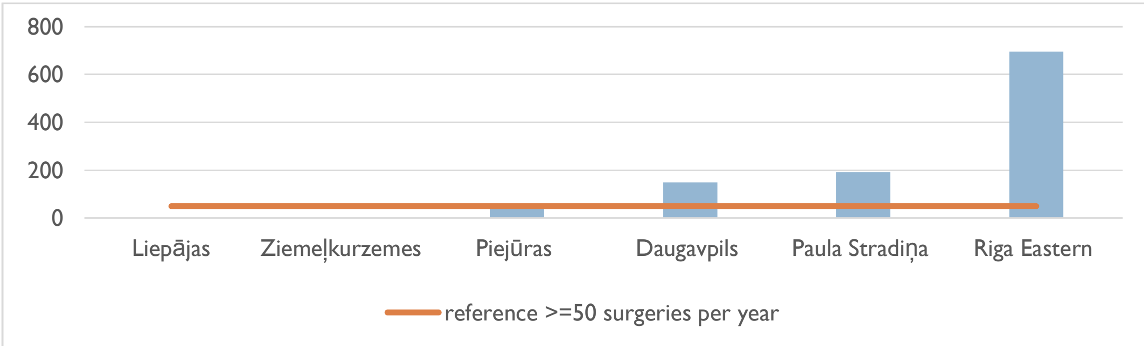
75. This study uses a minimum hospital volume of 50 breast surgeries per year and a minimum surgeon volume of 50 breast surgeries per year. The analysis includes all patients who underwent a mastectomy (partial and radical) between 2012 and 2014.[29]

76. To estimate the association between quality of care and provider volumes, the analysis examined the proportion of radical mastectomies among early-stage breast cancer patients, hospital length of stay, readmission rates, and mortality across volume categories. Because in-hospital mortality is rare for mastectomies, we considered 30-day, 60-day, and 90-day mortality rates adjusted by age, gender, comorbidity index, type of mastectomy, and cancer stage extracted from the Register of Patients with Particular Diseases, Patients with Cancer.[30]

[28] Currently, breast and other cancer treatments in the United Kingdom are based on the formation of multidisciplinary teams across the Latvia, and the assessment and treatment are concentrated among high-volume specialists.
[29] Manipulation codes 21022 and 21047.
[30] Five-year survival is considered a better indicator, but given the sample only cases from 2010 can be followed up.

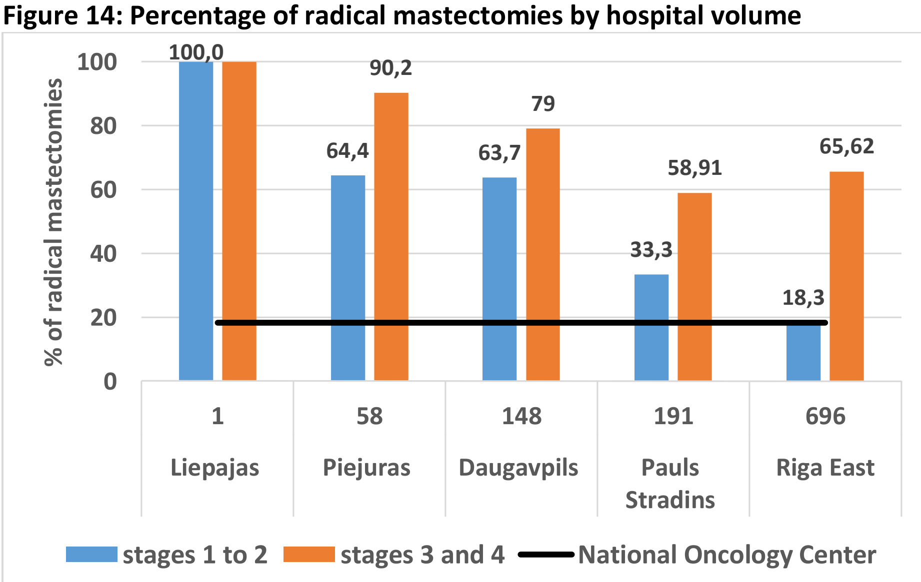
77. During the study period (2012-2014), four of the six hospitals performing mastectomies on cancer patients met the minimum volume threshold (Figure 12). Of the 4 hospitals that performed at least 50 surgeries, 3 were high-volume (>150 mastectomies annually) but Pierujas hospital was just at the threshold of 50 surgeries. The two low-volume hospitals performed between 1 and 2 mastectomies annually. 3,256 publicly funded mastectomies were performed on cancer patients by 40 surgeons at 6 hospitals**.** Riga Eastern Clinical University Hospital, which houses the National Oncological Center, had the highest caseload (more than 600 breast surgeries per year, or 64 percent of all breast surgeries in Latvia), followed by Pauls Stradins (197 surgeries, or 18 percent), Daugavpils Regional Hospital (150 surgeries, or 13 percent), and Piejuras (58 surgeries, or 5 percent). Ziemelkurzemes and Liepaja performed only 1-2 mastectomies.

Figure 13: Average annual number of mastectomies per hospital



78. A quality indicator associated with provider volume among breast cancer surgery is the use of breast-conserving therapy (partial mastectomies) on early-stage breast cancer patients (stages 1–2), and in Latvia, patients at low-volume hospitals were three times more likely to have a radical mastectomy during early stages of cancer (Figure 13). The use of breast-conserving therapy instead of radical mastectomies among these patients would have been recommended. Figure 13 also shows that the share of radical mastectomies for early-stage patients varied greatly by hospital volume, ranging from 18 percent at the highest-volume hospital (Riga Eastern) to 100 percent at the lowest-volume hospital (Liepaja).

Figure 14: Percentage of radical mastectomies by hospital volume



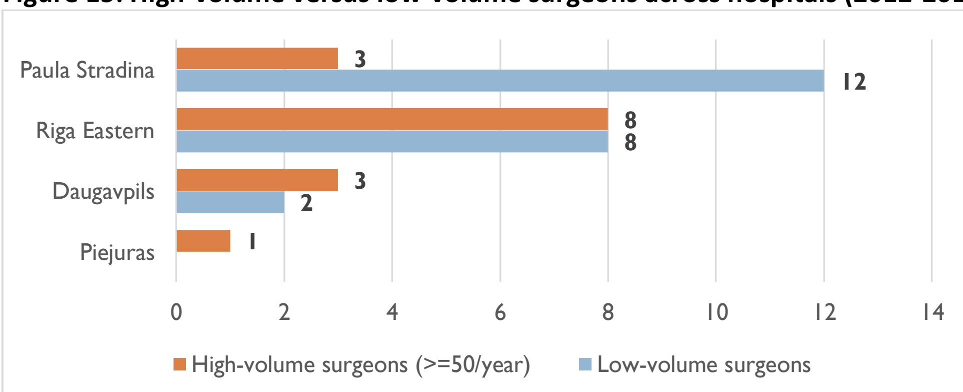
Note: patients in the discharge data who were not in the Cancer Register (528) are excluded. Riga Eastern and Pauls Stradins comprise 80% of these cases.

79. The results of a multivariable analysis indicate that early-stage breast cancer patients treated at Riga East were 79% less likely to have a radical mastectomy than patients at any of the other hospitals (OR 0.21 CI 0.17-0.26). Piejuras (5.26 CI 3.45–8.02), Daugavpils (OR 6.0, CI 4.4–8.2) and Pauls Stradins (OR 1.16, CI 1.04–1.29), had significantly higher adjusted odds of radical mastectomy than Riga East.

80. Similarly, a multivariable logistic model of the odds for 1-year survival for patients showed that patients treated at the highest-volume hospital, Riga East, had a 68 percent higher odds of surviving after one year (OR 1.68, CI 1.1 -2.6). Patients treated at the lowest-volume hospital (aside from Liepajas), Piejuras, on the other hand, had 73 percent lower odds of surviving at 1 year (OR 0.27, CI 0.14-0.51). There is no statistically significant difference between the other 2 hospitals and Riga East, but patients in Daugavpils and Pauls Stradins as in Riga East, had much higher odds of surviving than patients at Piejuras Hospital. This hospital had also significantly higher rates of readmissions within 30 days, compared to the other three hospitals (49% vs. 4%), (OR 29.2, CI 19.7–43.2).

81. Only 15 out of 40 surgeons (38 percent) met the minimum volume threshold of 50 or more breast cancer operations (mastectomies) per year.[31] Average surgeon volume per year ranged between 1 and 377. Figure 14 shows that Pauls Stradins had the lowest proportion of high-volume surgeons (20 percent), compared to over 50 percent in the other 3 hospitals.

Figure 15: High-volume versus low-volume surgeons across hospitals (2012-2014)



82. High volume surgeons performed 97 percent of all breast cancer surgeries. At Riga East, only 16 patients (<1%) were treated by surgeons with less than 50 mastectomies per year, compared to 16 percent at Pauls Stradins, where only 3 out of 15 surgeons were high-volume surgeons. Despite having only 3 high-volume surgeons, in Daugavpils and one in Piejuras hospitals, these surgeons treated more than 99 percent of their cases. All cases in the two regional hospitals that had only 1 or 2 cases were performed by low-volume surgeons (not shown).

83. The results of the analysis show that surgeon volume is associated with better outcomes for cancer patients who undergo a mastectomy. Table 7 shows crude rates and the results of the multivariate model for radical mastectomies and readmissions after 30 days. Patients treated by low-volume surgeons (<50 mastectomies per year) were significantly more likely than patients of high-volume surgeons to have had a radical mastectomy (45% vs. 28%, respectively), but the odds ratios for readmission were not statistically different across high and low-volume surgeons.

[31] There were 25 surgeons who did not met the volume standard, 14 of them had performed only one mastectomy per year. The number of surgeons who met the volume standard remained 15 even when we include mastectomies in patients with diagnoses other than cancer.

Table 7: Quality of care across low- and high-volume breast surgeons

	% radical	Odds ratio (high- vs. low-volume)*	30-day readmission	Odds ratio (high- vs. low-volume*
Low-volume surgeons (<50 surgeries/year)	45%	0.44 CI (0.26-0.73)	3.5%	1.4 CI (0.44-4.08)
High-volume surgeons (≥50 surgeries/year)	28%		6.0%	

*OR adjusted by age, year, cancer stage, comorbidities, and year. Sample limited to patients in stages 1 or 2.

84. Because very few patients were treated by low volume surgeons, and few patients died in the first 3 months after the surgery, it was not possible to analyze mortality rates among low- and high-volume surgeons.

85. To summarize, surgical therapy for breast cancer in Latvia is already concentrated in a few hospitals. Still, while rare, some surgeries are performed in very-low volume hospitals that do not provide specialized care. Moreover, despite having a large number of surgeons performing these procedures (40), 60 percent of them do not meet the minimum volume standard. A small number of surgeons (15) treated 97 percent of all mastectomies, which indicates good practice, but also the need to reduce the number of patients treated by low-volume surgeons. Low-volume surgeons were associated with higher rates of radical mastectomy.

5.2 Ovarian cancer surgery

86. According to data from the European Cancer Observatory (EUCAN) Latvia is the country with the highest ovarian cancer incidence and mortality in Europe (Ferlay, Steliarova-Foucher et al. 2013). Investigators in the United States and other European countries have demonstrated that patients treated by gynecological oncologists in large-volume tertiary institutions had the best outcomes. For instance Bristow, Zahurak et al. (2009) evaluate the impact of surgeon and hospital case volume on short-term outcomes after surgery for ovarian cancer. After controlling for other factors, they found that surgery performed by a high-volume surgeon was associated with a 69 percent reduction in the risk of in-hospital death, while high-volume hospital care was associated with an increased likelihood of optimal cyto-reduction, shorter hospital stay, and a lower hospital-related cost of care.

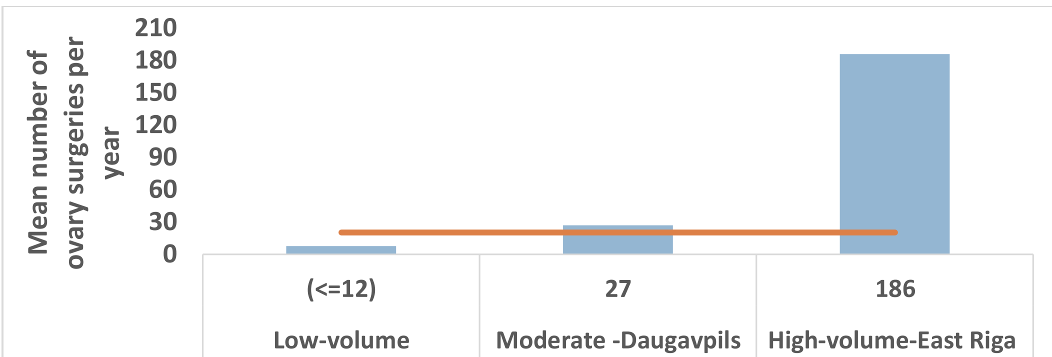
87. This study uses minimum volume standards recommended in the medical literature: a minimum volume of 20 ovary-cancer surgeries per year for hospitals and a minimum volume of 10 for surgeons (Goff, Matthews et al. 2007, Bristow, Palis et al. 2010). The analysis includes all patients with a primary diagnosis for ovary cancer (C56) who underwent a resection or surgery between 2012 and 2014.

88. To estimate the association between quality of care and provider volumes, the analysis first restricted the dataset to patients with a primary diagnosis of ovary cancer and identified ovary cancer-related surgeries, which included lymphadenectomy, hysterectomy, salpingo-oophorectomy, and other

resections.[32] Similar to procedures analyzed in previous sections, the associated between volume and in-hospital mortality was adjusted by age, gender, comorbidity index, and cancer stage extracted from the cancer register.

89. During the 2012- 2014 period, most of the 14 hospitals performing ovary-cancer surgeries were low-volume hospitals. Twelve of these hospitals performed between 1 and 12 surgeries a year (low volume), while the two larger-volume hospitals (Daugavpils and East Riga) performed on average 27 and 186 surgeries per year, respectively. In fact, Riga East performed the vast majority of ovarian cancer surgeries (80 percent). Daugavpils accounted for 12 percent, and low and very-low volume hospitals performed 8 percent of all ovary cancer surgeries (Figure 16).

Figure 16: Average number of ovary cancer surgeries by hospital volume



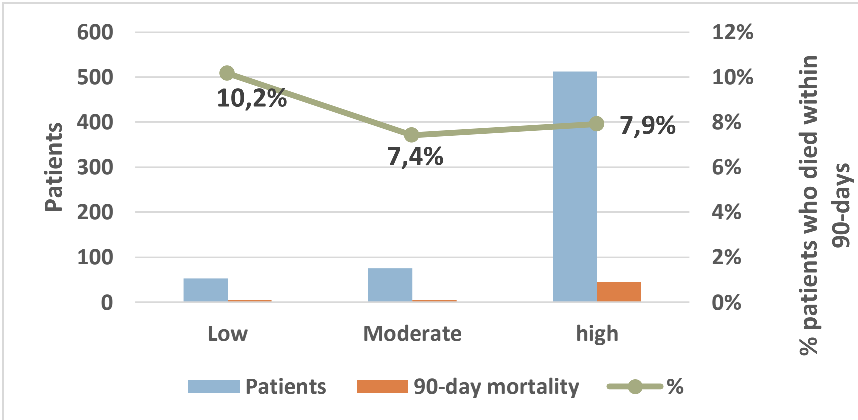
Note: Median hospital volume Low volume= Dobele, Cēsu,Jēkabpils , Jelgavas, Jūrmalas, Piejūras, Riga Maternity, Rēzeknes, Ziemeļkurzemes, and Tukuma; Liepājas and Pauls Stradiņa.

90. Mortality was 1.5 times higher for ovarian cancer surgery patients in low-volume hospitals compared with the high-volume center (Figure 17). During 2012-2014, 56 of the 640 ovary cancer patients, (9 percent) who underwent an ovary surgery died in the hospital or within 90 days. Crude mortality rates ranged from 10 percent in low volume hospitals (6 deaths) to 8 percent (44 deaths) in East Riga. In addition, patients treated at low, and moderate volume hospitals had higher likelihood of survival than those treated in very low-volume hospitals (Figure 18:). Very-low hospitals have the lowest one-year survival rates for patients who underwent an ovary cancer surgery (67 percent), however East Riga has lower survival rates.[33]

[32] Manipulation codes 16140, 16044,16053,16061,16064,16071,16082,16088,21017,21041,21042,21043,21045,21062, 21063, 21065, 21068, and 21069.

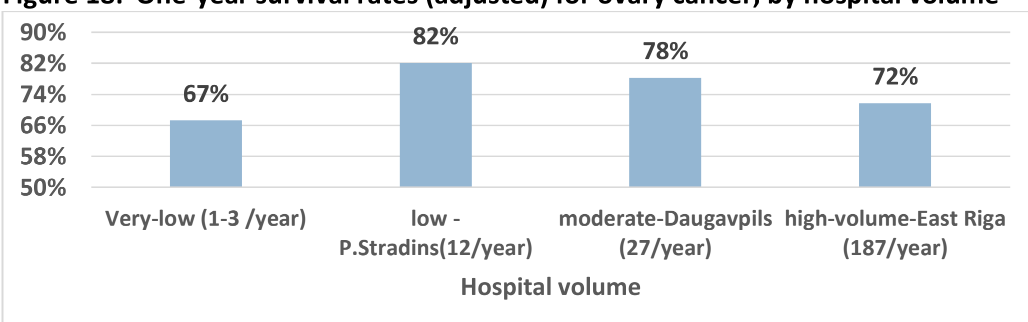
[33] Adjusted survival rates by age, year, type of surgery (resections versus gynecological), comorbidity index and cancer staging. Yet, it is possible that cancer staging does not control adequately by severity. The model also excludes one third of observations that did not have cancer staging information or were treated in 2014. In addition, a survival model instead of a logistic model would provide a more precise estimate.

Figure 17: Fraction of ovary cancer patients who died within 90 days, by hospital volume



Note: Low volume= Dobele, Cēsu,Jēkabpils , Jelgavas, Jūrmalas, Piejūras, Riga Maternity, Rēzeknes, Ziemeļkurzemes, and Tukuma; Liepājas and Pauls Stradiņa

Figure 18: One-year survival rates (adjusted) for ovary cancer, by hospital volume

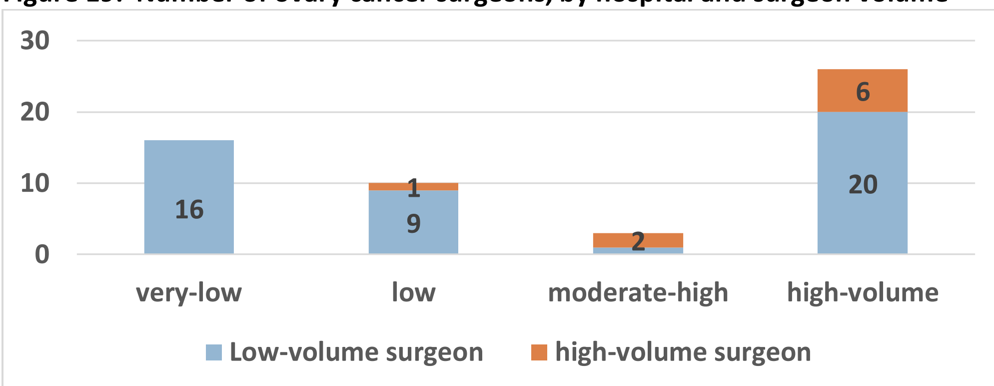


Note: Low volume= Dobele, Cēsu,Jēkabpils , Jelgavas, Jūrmalas, Piejūras, Riga Maternity, Rēzeknes, Ziemeļkurzemes, and Tukuma. Only 210 patients with cancer register information. Excludes 2014.

A large majority - about 84 percent - of ovary surgeries are performed by surgeons that met the minimum volume standard of at least 10 surgeries per year (on average). Overall, 55 surgeons performed 640 procedures during the study period. Average surgeon volume per year ranged and 47. Only 9 out of 55 surgeons (16 percent) performed 10 or more ovary cancer operations and 8 of 9 (90 percent) of these high-volume surgeons are in moderate and high-volume hospitals. Daugavpils is the only hospital where all surgeons meet the minimum volume, although this hospital only two surgeons performing these surgeries (

91. Figure 19:).

Figure 19: Number of ovary cancer surgeons, by hospital and surgeon volume



Note: Average annual surgeon volumes

92. The results of the analysis show that surgeon volume appears to be associated with better outcomes for ovary cancer patients who undergo an operation**.** Table 8 presents the proportion of patients who died within 90 days, where patients treated by low-volume surgeons (<10 ovary surgeries per year) were 2.5 times more likely to die in low-volume than in high-volume hospitals. This result is based on a small number of observations, so while qualitatively similar to results for other procedures, caution is warranted in their interpretation

Table 8: Quality outcomes by surgeon volume (2012-2014)

	Patients	Comorbidity index	ALOS	Died	% died*
Low-volume (<10)	107	4.9	12.2	15	15%
High-volume (>=10)	533	4.4	11.7	41	8%

*Proportions with less than 20 observations

93. To summarize, the results suggest that surgery for ovary cancer in Latvia is already concentrated in a few hospitals, but some surgeries (8 percent) are performed at very-low volume hospitals without access to specialized care. These surgeries were associated in the study with lower one-year survival and higher mortality. Thus, it should be reasonable to assume that referring these cases to higher-volume centers can improve quality of care and survival. Despite having a large number of surgeons performing these procedures (55), 46 do not meet the minimum volume required, as most of them perform only one operation per year. Therefore, few surgeons (9) treated 84 percent of all ovary

surgeries, which indicates good practice, but also a need to increase the number of high-volume surgeons. This is particularly important for the two larger volume hospitals.

5.3 Colorectal Cancer

94. Colorectal cancer is one of the most common cancers in Latvia, where more than 150 physicians were performing colorectal cancer related surgeries during the study period. Clinical guidelines developed in Latvia specify minimum volumes and training requirements. Specifically, the colorectal cancer guidelines (2013) from the National Oncological Center in Latvia indicate that hospitals performing these surgeries have at least two surgeons with appropriate training and adequate experience or specialization in colon and rectal cancer surgery. The guidelines also recommend that each surgeon independently carries out at least 20 colon and rectum resections.[34]

95. In the medical literature, colorectal cancer surgery demonstrates a volume–outcome relationship for both hospitals and surgeons. Patients in high-volume hospitals are associated with better survival rates, lower postoperative morbidity, and fewer permanent colostomies than those treated in low-volume hospitals (Borowski, Kelly et al. 2007, Iversen, Harling et al. 2007, Archampong, Borowski et al. 2011). The most recent systematic review of studies found that overall five year survival was significantly higher for patients with colorectal cancer treated in high-volume hospitals (HR=0.90, 95% CI 0.85 to 0.96), by high-volume surgeons (HR=0.88, 95% CI 0.83 to 0.93), and colorectal specialists (HR=0.81, 95% CI 0.71 to 0.94). Operative mortality was significantly lower for high-volume surgeons (OR=0.77, 95% CI 0.66 to 0.91) and specialists (OR=0.74, 95% CI 0.60 to 0.91), but there was no significant association with higher hospital caseload (OR=0.93, 95% CI 0.84 to 1.04) when only case-mix adjusted studies were included (Archampong, Borowski et al. 2011). Volume thresholds for low hospital caseloads ranged between 10 and 61 and for high hospital caseloads between 19 and 201.

96. Similarly, surgeons who perform high volumes of colorectal resections also are associated with lower in-hospital mortality rates than surgeons with low volume. For instance, Karanicolas, Dubois et al. (2009) found that the surgeons with higher volumes of colorectal resections achieved significantly lower mortality rates. Patients of surgeons in the bottom decile (1 case per year) had an adjusted mortality rate of 5.6 percent compared with 4.5 percent for surgeons in the top decile (greater than 43 cases per year). Rogers Jr, Wolf et al. (2006) suggests that patients would benefit from treatment by surgeons who perform at least 13 colorectal operations over 4 years and in hospitals with at least 84 of these operations over this time.

97. The current analysis divides hospitals into three volume groups: low volume (less than 12 resections per year), medium-volume (12-60 resections per year), and high volume (more than 60 resections per year).[35] Surgeons were classified as low-volume if they performed less than 5 resection per year (<=5 per year), and high if they performed >=10 resections per year. The analysis includes colorectal cancer patients who underwent a gastric or colon resection that are found in the NHS

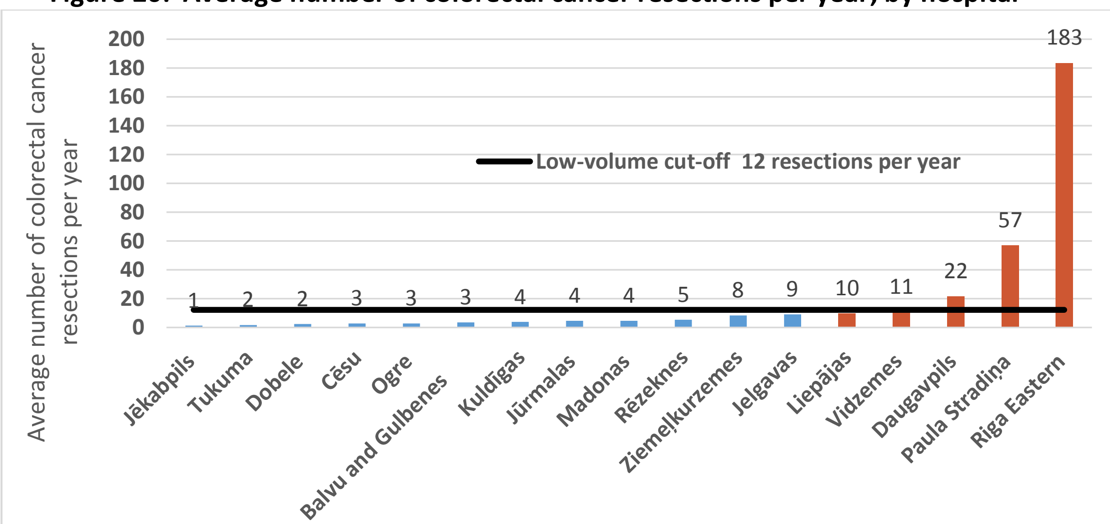
[34] These guidelines, however, needs to clarify the surgeon volume standards period, usually per year or biannual.

[35] Manipulation codes 21042, which includes stomach resections gastrectomy and colostomy. Restricted to patients with a primary diagnostic for colorectal cancer (C18-C20).

payment inpatient dataset from 2012 to 2014. The study assesses the association of surgeon and hospital case volumes with the short-term outcomes of in-hospital death and 30-day mortality for resection of colorectal carcinoma presenting both crude and adjusted mortality rate, again adjusting estimates by age, sex, year, cancer stage, type of resection, a comorbidity index, and type of admission (for example, emergency).

98. More than half of resections during 2012-2014 were performed at high-volume hospitals (57 percent), and by high-volume surgeons (51 percent). Low-volume hospitals treated 170 of the 930 patients during the period (18 percent), and medium accounted for 228 patients (25 percent). The average number of resections per hospital ranged from 1 in Jekabpils to 183 in Riga East (Figure 20). Three hospitals (Riga East, Pauls Stradins, and Daugavpils) treated 80 percent of colorectal resection patients during this period. Figure 20 shows that most of the hospitals are classified as low-volume (<12 resections per year). A hospital is considered high-volume when hospital volume is about >=60 per year.

Figure 20: Average number of colorectal cancer resections per year, by hospital



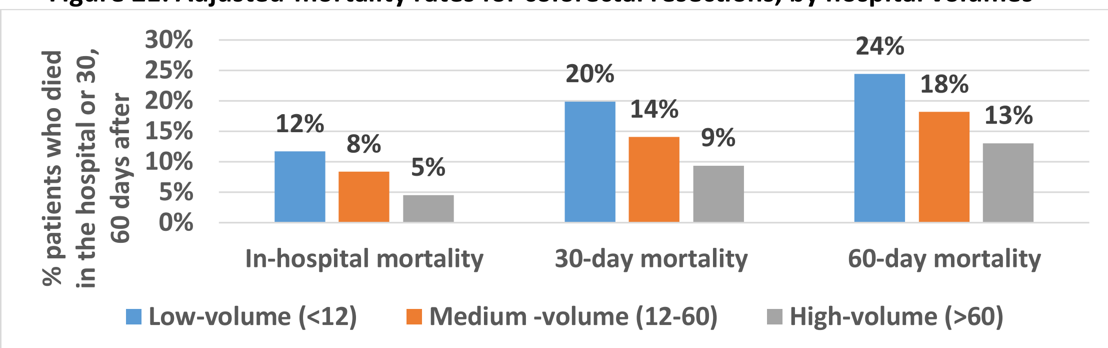
99. With the exemption of Riga East, none of the other hospitals adhere to Latvia's clinical guidelines that specify a minimum surgeon volume of 20. Low-volume surgeons (defined here as less than 5 colorectal cancer resections per year) operated on 312 of the 930 patients (34 percent) at an average rate of 2.6 cases per year. A hospital's share of resections performed by high-volume surgeons (>=10 resections per year) ranged from 0 in small district hospitals and Cēsu Clinic to 24 percent in Pauls Stradins, 33 percent in Daugavpils, and 77 percent in East Riga.

Both higher hospital and surgeon volumes were associated with lower mortality rates. Over the three years, 86 of the 930 colorectal cancer patients who underwent a resection (9.2 percent) died in the hospital and 140 died within 30 days (15 percent). Although low-volume hospitals only treated 18 percent of patients, 55 percent of all in-hospital deaths occurred in these centers. Conversely, East treated 57 percent of all patients, with about 21 percent of all in-hospital deaths. Crude in-hospital

death rates ranged from 3 percent in East Riga to 28 percent in low-volume hospitals, and from 8 percent to 32 percent in terms of 30-day mortality rates.[36]

100. Figure 21: shows adjusted-mortality rates by hospital volume group, and a similar relationship holds. Patients in low-volume hospitals had had a higher risk of dying than those in high-volume hospitals (12 percent vs 5 percent), as well as a higher 30-day mortality (20 percent vs 9 percent).

Figure 21: Adjusted-mortality rates for colorectal resections, by hospital volumes



101. These results persist in a multivariate logistic model. After risk-adjustment, medium-volume hospitals (Daugavpils and Pauls Stradins) that performed 12-60 resections per year had 57 percent lower odds of in-hospital mortality than lower-volume hospitals (Odds ratio 0.42, 95% Confidence interval 0.23-0.78).[37] The high-volume hospital (Riga East) had 93 percent lower odds of mortality than low-volume hospitals (Odds ratio 0.07, 95% Confidence interval 0.03-0.17). Patients treated at low-volume hospitals had risk of dying that was 13 times higher than patients treated at Riga East (odds ratio 13.1, 95% Confidence interval 5.9-32.1). It is important to note, however, that there are large variability in the share of patients who died over the years and hospitals.

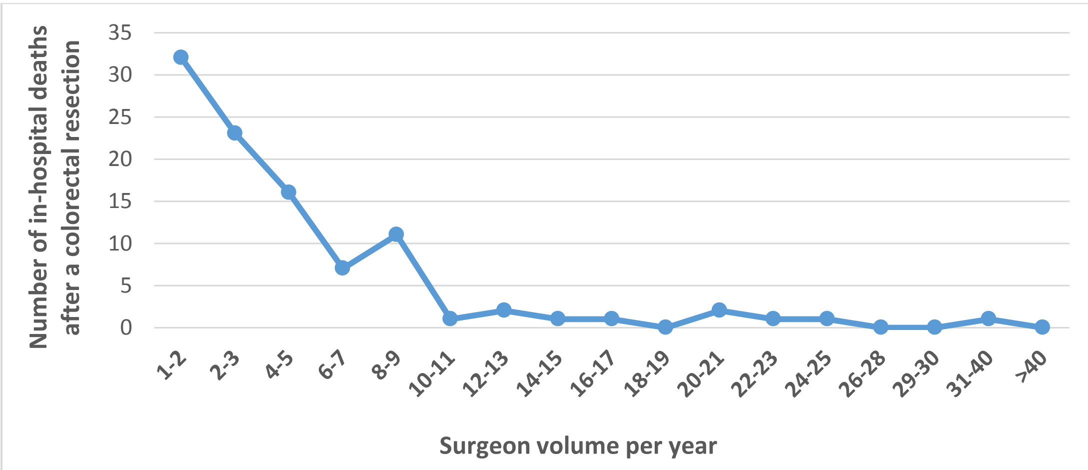
102. Surgeon volume was also negatively associated with mortality rates before and after risk adjustment. **Error! Reference source not found.** clearly shows that most of the patients who died after

[36] Some of these hospitals treated very few patients, which prevents estimation of hospital-specific mortality rates.

[37] This model does no control for cancer staging as there were 215 patients missing in the cancer register. The results with the restricted model shows a similar coefficient (0.47) but it was not statistically significant. Cancer stage was not significant in the restricted model.

a colorectal cancer resection were treated by surgeons who performed less than 10 resections. These are concentrated among very low-volume surgeons (1-5 resections).

Figure 22: Mortality rates by surgeon volume (2012-2014)



103. Low-volume surgeons (<10 resections per year) had also higher adjusted short-term mortality rates (18 percent) than surgeons with higher-volumes (8 percent); as well as higher 90-day mortality rates (26 percent versus 16 percent).

Table 9: Adjusted-mortality rates by surgeon volume (2012-2014)

Surgeon volume	In-hospital mortality	30-day mortality	60-day mortality	90-day mortality
Surgeon low-volume<=5	11%	18%	22%	26%
Surgeon volume >5	5%	9%	13%	16%

104. To summarize, the results indicate that on average low-volume hospitals (<12 per year) and surgeons (<10 per year) were associated with higher mortality rates (in-hospital and 30-day mortality). Although low-volume hospitals only treated 18 percent of patients, 55 percent of in-hospital deaths occurred in these centers. Moreover, patients treated at low–volume hospitals had a risk of dying that was 13 times higher than patients treated at the highest volume hospital, Riga East. Low-volume surgeons treated about 34 percent of all resections among colorectal cancer patients. Surgeon volume was negatively associated with higher mortality rates, even after controlling by hospital of treatment, which suggests that patients treated by low-volume surgeons are at a higher risk of dying regardless of which hospital admits them. As a result, referring cases from low-volume hospitals to higher-volume centers and high-volume surgeons can improve quality of care and survival.

5.4 Recommendations for cancer resections

105. From the evidence presented on the association between resection volumes of both hospitals and surgeons and outcomes related to quality of care and mortality, it is clear that cancer patients in Latvia would benefit from the enforcement of minimum volume standards. The Ministry of Health, the National Health Service, professional associations, and hospitals and physicians themselves can support such enforcement in a number of ways. First, all of these actors would ideally work together to develop clinical guidelines and clinical pathways for each of the cancers studied that specify location of surgical treatment based on minimum volume standards for both hospitals and surgeons but do not reduce access to care outside of Riga. Guideline and pathway development would naturally need to follow an exchange of good-practices between East Riga and the other hospitals performing cancer resections to discuss a shift to a more multidisciplinary organization of cancer care and how this ought to be incorporated into guidelines and pathways.

106. Second, such guidelines and pathways could in turn be enforced were they to be incorporated into the contracts that the National Health Service writes with hospitals. Again, it would be critical that physicians, hospital managers, emergency services, and associations of both physicians and patients be consulted in such a process.

107. Finally, as suggested earlier, the Health Inspectorate or any other institution with a mandate of quality assurance would ideally develop a system for monitoring volumes and quality of care indicators in cancer, both through data analysis and through national clinical audits.

6 Obstetric Care

108. In a well-functioning referral system, obstetric patients are treated according to their underlying risk of pregnancy and delivery complications to reduce the probability of morbidity and mortality among mothers and newborns. Low-admissions are usually treated at lower levels of care, while high-risk pregnancies and deliveries who are expected to have a complicated birth should be carried out in specialized levels of care.

109. In Latvia, guidelines for obstetric care are relatively well-articulated. Mothers can choose to give birth in any center providing obstetrics services. Cabinet Regulations 611 outline key processes, services (for example, labs and tests), and providers required for treating pregnant women and newborns in Latvia. According to Latvia's referral guidelines for pregnant women and women in labor [38] there are three designated levels of care,[39] and referrals from Level I/II to Level II and Level III are considered in

[38] */Līguma* par stacionāro veselības aprūpes pakalpojumu sniegšanu un apmaksu 7.1.7 .*punkts/*

[39] Hospitals are grouped based on the current regulations. Maternity Riga was assigned to a different category to account for differences in capacity between Maternity Riga and the regional perinatal centers.
Level I: all district hospitals, plus Daugavpils, Jelgava Rezekne , Ziemeļkurzeme regional hospitals
Level II: Jēkabpils, Liepaja, Pauls Stradins, and Vidzemes
Level II.2 Maternity Riga,
Level III: Pauls Stradins Clinical University Hospital

cases of pathological delivery and complications requiring specialist care.[40] The Level III hospital also provides regular obstetric services for a segment of Riga's population according to the referral guidelines.

110. This section presents results from an analysis that assesses whether patients were treated according to their underlying risk of pregnancy and delivery complications during the 2012-2014 period – in particular, how normal and low-risk admissions and high-risk pregnancies were distributed across the different levels of hospitals, among hospitals providing NHS-contracted inpatient services. As in previous sections, the analysis also estimates the association between hospital-level obstetric quality indicators (such as elective deliveries at between 37 and 39 weeks of gestation and cesarean delivery performed in low-risk mothers) and maternal health outcomes. The analysis covers all births that were both registered in the Medical Birth Register and included in the inpatient payment dataset.[41] The Birth register provides information on maternal factors such as pregnancy and delivery complications. The inpatient data allow the estimation of a comorbidity index and the identification of pathological deliveries.

6.1 Trends in obstetrics volumes

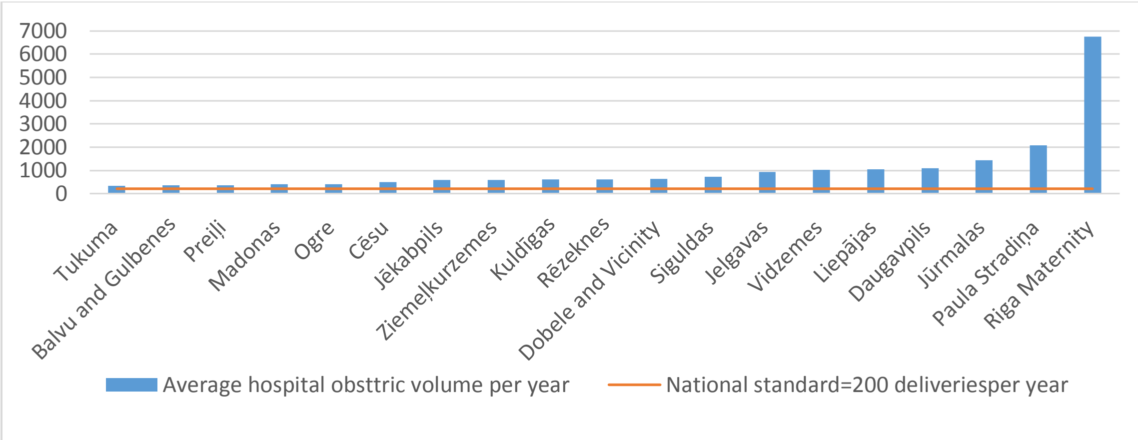
111. In Latvia, during the 2012-2014 period, there were 61,195 publicly-financed deliveries at 21 hospitals - that is, about 20,398 deliveries annually.[42] Annual delivery per hospital ranged between 329 in Tukums Hospital to 6750 deliveries in Riga Maternity hospital. All hospitals in Latvia met the national minimum standard of 200 deliveries per year (Figure 23).

Figure 23: Average annual number of births per hospital

[40] The Level III maternal care is provided by P.Stradins to the following indications: 1) severe systemic pathology mother whose treatment requires specialists such as urologist, cardiologist, neurologist, nephrologist, endocrinologist, oculist, surgeon, therapist), 2) the need for specialized technology applications (for example, invasive cardiology, magnetic resonance); 3) severe genital abnormalities or malignant tumors

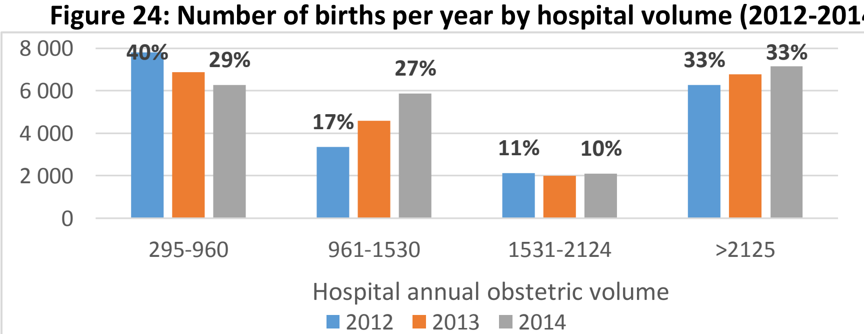
[41] About 721 births (1% of all deliveries) included in the inpatient payment data were not found in the Birth register. 1253 (2%) were found in the register but not in the inpatient payment dataset. These cases were excluded given that it would be a challenge to identify complications and comorbidities in a comparable way.

[42] The total number of births in this period excludes 994 out-of-hospital births (delivered at home, during transport etc.), 35 deliveries for which information on institution of delivery was missing, and 134 deliveries in the following hospitals: Eastern Riga (4), Gimenes (43) and Saldus (81). These hospitals do not report any births in 2014.



112. Figure 24 show that during 2012-2014 there has been a shift away from treating patients at low-volume hospitals. Hospitals were classified in four groups based on their annual delivery volume. Out of a total of 21, 14 hospitals were classified as low-volume (260-960 deliveries per year). All of these were Level I hospitals. Five hospitals (Daugavpils, Jūrmalas, Jēkabpils, Jelgava, and Vidzemes)- all regional hospitals except one - are medium volume (961-1530). Pauls Stradins had a medium-to-high delivery volume (1531-2124), and Maternity Riga had the highest volumes with more than 2,125 deliveries per year (about 6,750 deliveries per year).

Figure 24: Number of births per year by hospital volume (2012-2014)



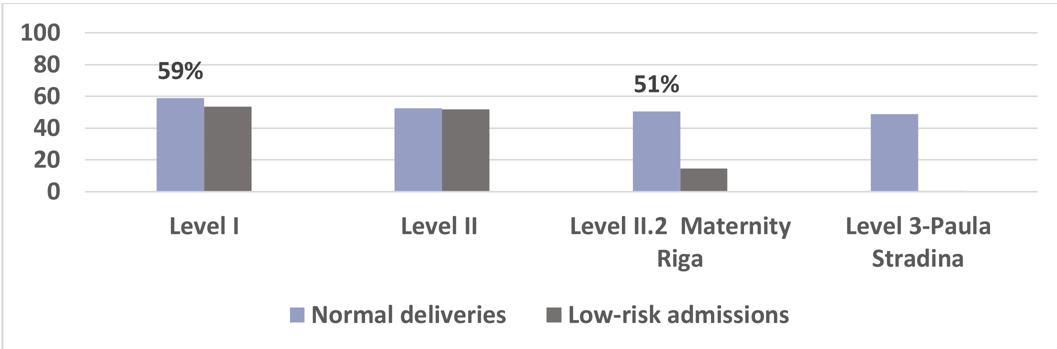
6.2 Management of normal and high-risk pregnancies and deliveries

113. During the study period, normal deliveries (spontaneous single, full- term, unassisted deliveries (vertex or breach) accounted for half of all deliveries and were evenly distributed across all levels of care (54 percent).[43] Figure 25: shows that higher levels of care (Level II and Level III hospitals) treated similar

[43] At least 66 percent of these deliveries did not present any of the following major complications: preexistent and gestational diabetes, diseases of the circulatory system (e.g. preeclampsia, eclampsia), STIs, multiple births, placenta Previa, renal and liver conditions, premature break of membranes or congenital malformations. The

shares of normal deliveries. Similarly, about 57 percent of deliveries at low and medium volume hospitals were normal, as were 50 percent at higher volume centers.

Figure 25: Percentage of normal deliveries and low-risk admissions, by hospital level



114. Low-risk admissions (normal deliveries of full-term singleton vertex births without any pregnancy complications) accounted for 35 percent of all deliveries, about 21,409 births, and few low-risk admissions were treated at higher level hospitals (Figure 25:).[44] On average, 68 percent of low-risk admissions were treated in Level I hospitals during 2012-2014. Only 15 percent of deliveries in Maternity Riga were low-risk admissions compared with 54 percent and 52 percent in Level I and II. The difference in Maternity Riga between normal and low-risk admission suggest that a large share of the normal deliveries treated at that hospital had one or more complications.

115. Although Level I hospitals were more likely to treat low-risk admissions, large differences exist in the proportions between hospitals. Low-risk admissions ranged from only 14 percent in Cēsu Clinic to 76 percent in Dobeles District hospital **(**

116.

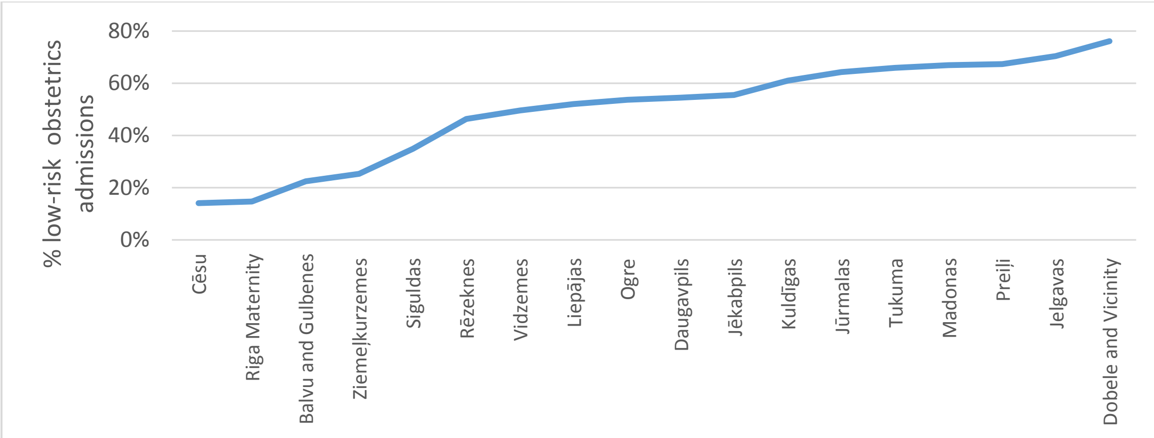
117.

118. Figure 26:**).** This indicates that a number of Level I hospitals treated primarily complicated births contrary to what is recommended in the current referral guidelines.

Figure 26: Percentage of low-risk admissions, by hospital

remaining 34% of deliveries had a complication – e.g. perineal tear – but were still considered normal (Diagnosis codes O80x)

[44] Low-risk admissions refers to full-term normal delivery of a single, healthy infant without any complications antepartum, during the delivery, or postpartum during the delivery episode (only O80 excluding O.80.1, O80.8 and O80.9 codes).



119. The analysis also suggest that delivery complications among low-risk obstetrics admissions were higher when treated at low-volume hospitals. About 30 percent of low-risk admissions had at least one delivery complication such as post-partum hemorrhage, perineal lacerations, intrauterine hypoxia, or issues related to the umbilical cord**.** Table 10 below shows that although post-partum hemorrhage and intrauterine hypoxia were rare, patients at Level I and Level II regional hospitals had higher rates of these complications than those at Maternity Riga (1.5% versus 0.2%, and 1.2% versus 2.1%). Low-volume hospitals also exhibited higher rates of (1^{st} and 2^{nd} degree) perineal lacerations (13%) compared with Maternity Riga (0.4%). Moreover, 33 newborns *Regulation 631* among all low-risk admissions died in the first 7 days of life, mostly as stillbirths, and 66% of these early deaths occurred in a Level I hospital. Level I and Level II had higher crude early mortality rates than Maternity Riga.

Table 10: Delivery complications among low-risk admissions

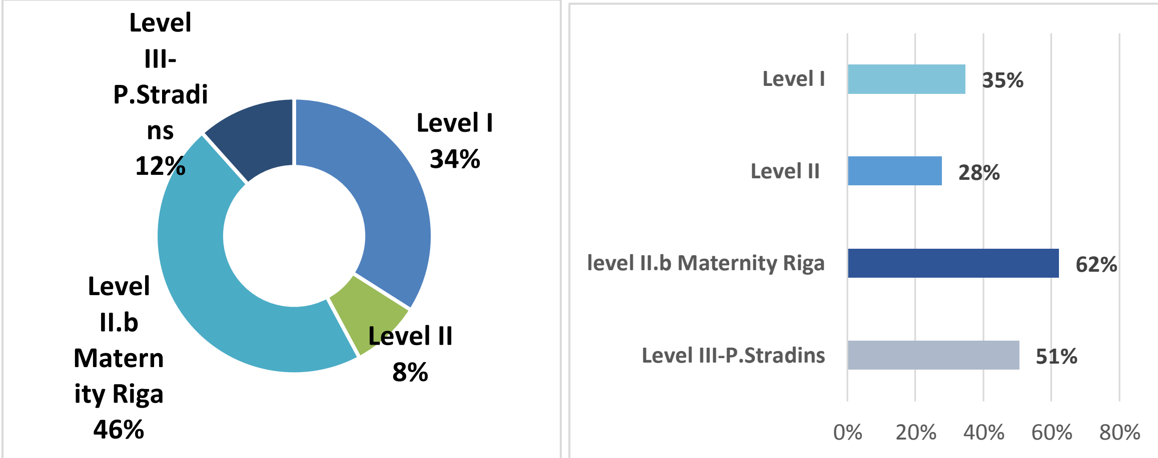
Level of Care	Postpartum hemorrhage	Perineal lacerations (1^{st} and 2^{nd} degree)	Umbilical cord	Intrauterine hypoxia or birth asphyxia	Any complication	Early Neonatal Mortality
Level I	1.5%	13%	6.6%	1.2%	27%	0.2%
Level II	1.4%	14%	1.4%	2.1%	29%	0.3%
Level II.2						
Maternity Riga	0.2%	0.5%	35.4%	0.4%	50%	0.1%

120. During the study period, high-risk deliveries were carried out at every level of care. More than a third of these high-risk deliveries were carried out at Level I hospitals, and about half were treated at level II hospitals (54%) (Figure 27).[45] High-risk pregnancies expected to result in a complicated birth should be carried out in specialized levels of care to prevent negative maternal and newborn outcomes. In Latvia, however, high-risk pregnancies accounted for 35 percent of all births at Level I hospitals- a

[45] During 2012-2014, about 45% of all deliveries had one or more pregnancy complication or risk factor. These included preexistent and gestational diabetes, diseases of the circulatory system (for example, hypertension), sexually transmitted infections, multiple births, placenta previa, renal and liver conditions, premature break of membranes and congenital malformations.

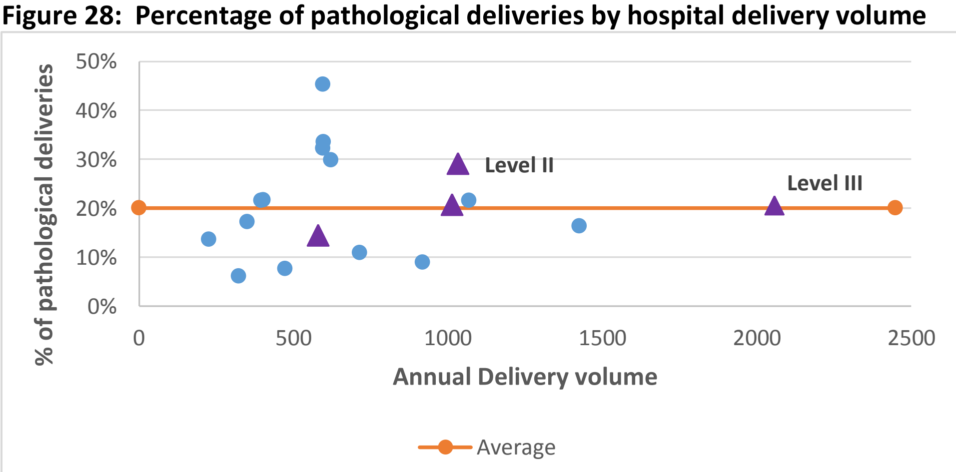
higher rate compared with 28 percent in level II hospitals, which might reflect better referral practices of regional hospitals and suggest more generally that high-risk pregnancies require better referral practices.

Figure 27: High-risk pregnancies by level of hospital



121. Despite the referral guidelines, a high proportion of low-volume hospital deliveries are pathological.[46] Pathological deliveries above the national average (20%) are concentrated in a group of low volume hospitals including Kuldīgas (34%), Rezekne (32%) and Ziemeļkurzemes (45%) (Figure 28:) All levels of care treated on average similar rates of pathological deliveries, 20% in Level I and Level III hospitals, 23% in Level II and, 30% in Maternity Riga. Rates of pathological deliveries in Level I and Level II hospitals have declined markedly from 30% in 2012 to 13% and 16% respectively in 2014.

Figure 28: Percentage of pathological deliveries by hospital delivery volume

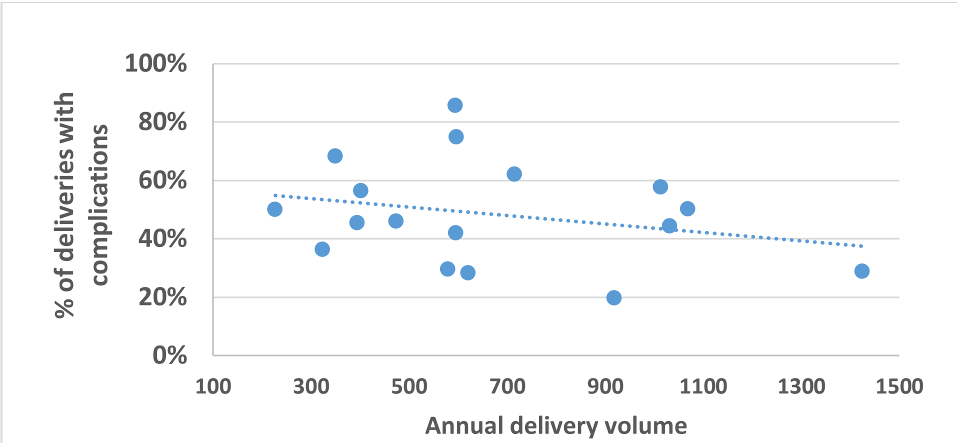


Note: Maternity Riga, where 29%of deliveries were pathological, is not included in the graph.

[46] The risk of neonatal intra-hospital mortality is much higher among pathological deliveries (0.5% versus 2.3%).

122. Deliveries complications in general are slightly more likely in low-volume hospitals (Figure 29).

Figure 29: Percentage of births experiencing delivery complications, by hospital delivery volume



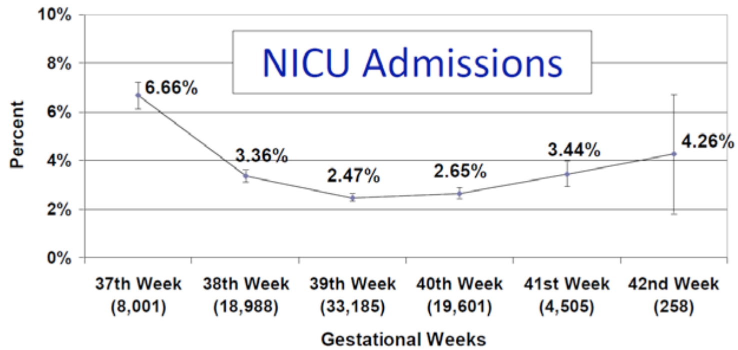
123. To summarize, guidelines for obstetric care are relatively well-articulated in Latvia. However, these guidelines could be linked to specific clinical pathways or/and to Cabinet Regulations 611 for pregnant women and newborns. The analysis finds that low-risk admissions are appropriately treated in Level I and II hospitals, but delivery complications among low-risk admissions were higher at low-volume hospitals. High-risk pregnancies, on the other hand, where carried out at every hospital level, which indicates the need for better referral practices and among Level I hospitals.

6.3 Non-medically Indicated deliveries before 39 weeks gestational age

124. Elective deliveries before 39 weeks gestational refers to non-medically indicated deliveries associated with medical induction or cesarean delivery at more than 37 weeks and prior to 39 weeks gestational age. These deliveries carry significant increased risk for the newborn and are associated with the numerous complications (NICU admissions, transient tachypnea of the newborn, respiratory distress syndrome (RDS), need for ventilator support, suspected or proven sepsis, newborn feeding problems, and other transition issues). Figure 30 shows the association between early elective deliveries and NICU admissions in the United States.

125. The American College of Obstetricians and Gynecologists (ACOG) recommends that no elective delivery should be performed before the gestational age of 39 weeks. Thus, elective deliveries between 37 and 39 weeks have been used as an obstetric quality of care indicator.

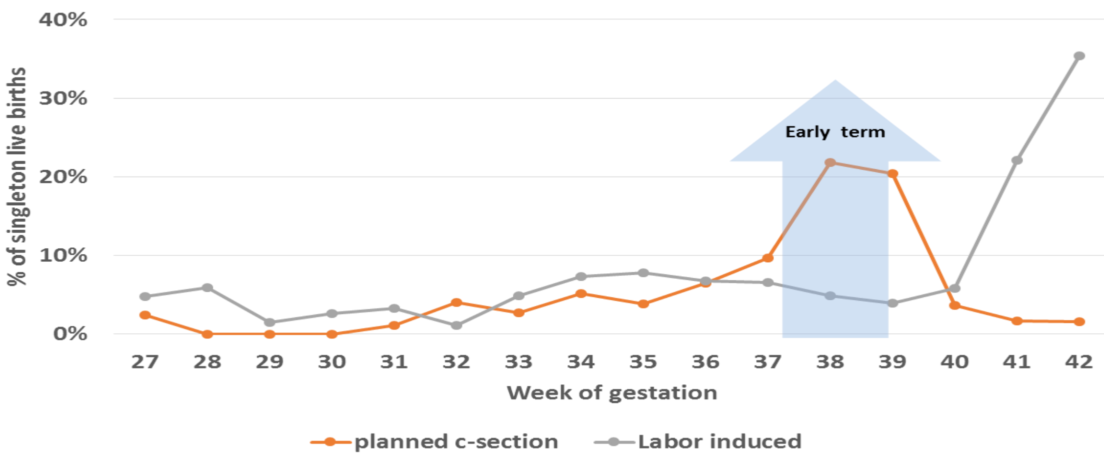
Figure 30: Elective early deliveries and NICU admissions in the United States



Source : *Oshiro, B. et al. 2009.*

126. In Latvia, about 2,447 of 10, 239 (24%) singleton live births delivered between 37 and 39 weeks were elective (Figure 31). This proportion is much higher compared to other countries (US 4.7%). Half of these early deliveries did not have conditions that could justify elective delivery prior to 39 weeks gestation. [47]

Figure 31: Cesarean section and labor induction rates among singleton live births by week of gestation



127. Hospital rates of early scheduled deliveries were frequent at each level of care **(**Figure 32: **)**, and as in the previous figure, these rates exclude conditions that could justify elective delivery prior to 39 weeks gestation. During the 2012-2014 period, non-medically early deliveries ranged between 19

[47] Among these are placental abruption, placenta previa, rupture of membranes prior to labor (term or preterm), gestational hypertension, preeclampsia, eclampsia, chronic hypertension, preexisting diabetes, gestational diabetes, renal disease, liver diseases (including cholestasis of pregnancy), cardiovascular diseases (congenital and other), HIV infection, fetal-maternal hemorrhage, fetal malformation, chromosomal abnormality, or suspected fetal injury, IUGR, oligohydramnios, polyhydramnios, fetal distress, abnormal fetal heart rate. These conditions were coded using the inpatient payment data diagnosis codes following the algorithm in the Manual for Joint Commission National Quality Core Measures (20101a); Perinatal Care Core Measure Set. 2009 [cited November 21, 2009].

percent in Level I hospitals and 35 percent in the Level III hospital. Level I hospitals where 43 percent of singleton live births were born accounted for 35 percent of these cases, compared to 13 percent of the Level III hospital. These proportions vary by hospital ranging from 6 percent in Dobeles to 36 percent in Cēsu Clinica (Figure 32 and Figure 33).

Figure 32: Non-medically indicated early deliveries

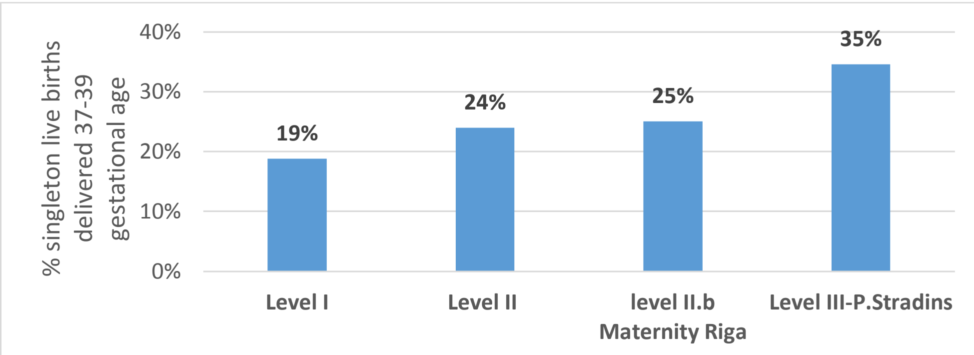
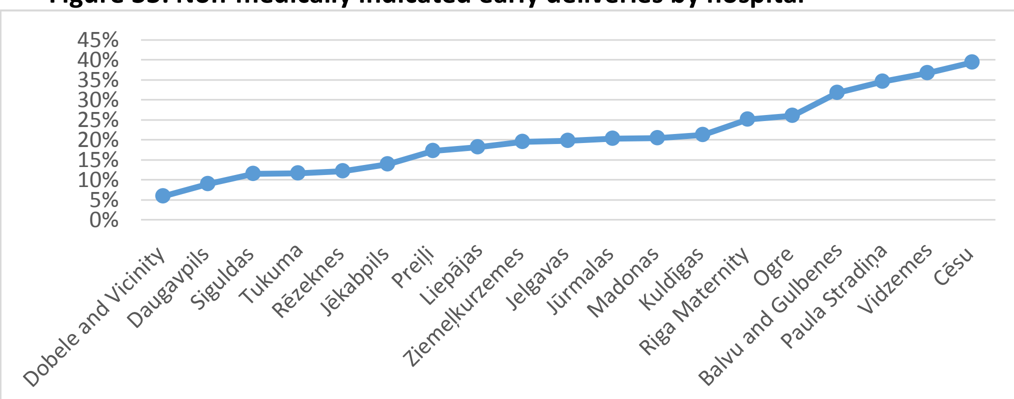


Figure 33: Non-medically indicated early deliveries by hospital



128. These non-medically indicated elective early deliveries in Latvia are associated with higher neonatal transfer rates for singleton live births, as well as longer lengths of stay (Table 11).

Table 11: Neonatal transfer rates and length of stay, by hospital level and type of delivery

	Neonatal transfer		Length of stay	
	Normal birth	**Elective birth**	**Normal birth**	**Elective birth**
Level I	1.1%	4.8%	3.5	4.6
Level II	9.5%	14.9%	3.5	5.4
Level II Maternity Riga	1.5%	4.3%	3.3	4.8
Level III-Pauls Stradins	2.5%	4.4%	3.5	4.6

6.4 C-sections among low-risk women

129. C-section among low-risk women refers to a situation in which nulliparous women, or first-time mothers, with a term, singleton baby in a vertex position is delivered by cesarean section. The American College of Obstetricians and Gynecologists has set a target of 15 percent for this low-risk group. Reducing C-section rates in low-risk, first-time pregnancies can have many benefits, as it would decrease the need for repeat C-sections in the future, lessen risks to mothers and babies, and lower the costs of delivery and post-partum care.

130. General C-section rates in Latvia area high, even in low-volume hospitals, ranging between 16 and 35 percent with an average of 21 percent during the 2012 -2014 period. At least two low-volume hospitals (around 400 deliveries per year) had C-section rates close to 30 percent, and both of these hospitals are close to both regional and tertiary care hospitals (Figure 34). Maternity Riga hospital's C-section rate was 22 percent, while Pauls Stradins has the highest C-section rate (35 percent) (Figure 35).

Figure 34: C-section rates by annual delivery volume

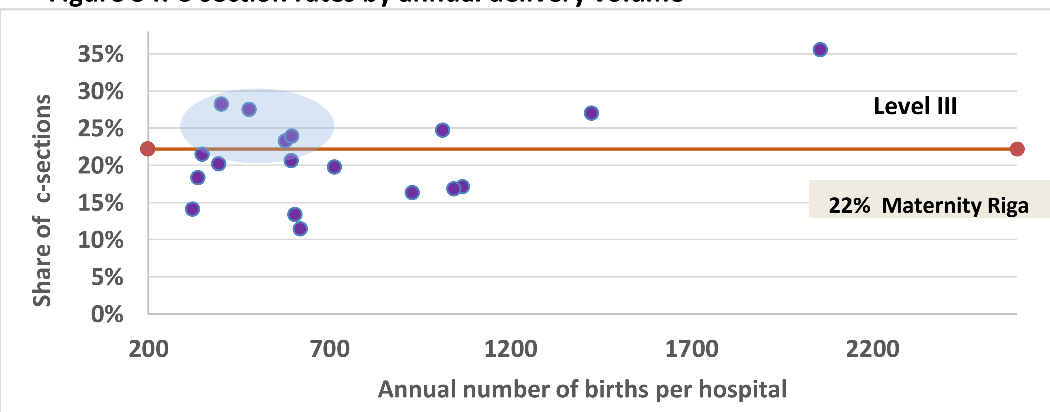
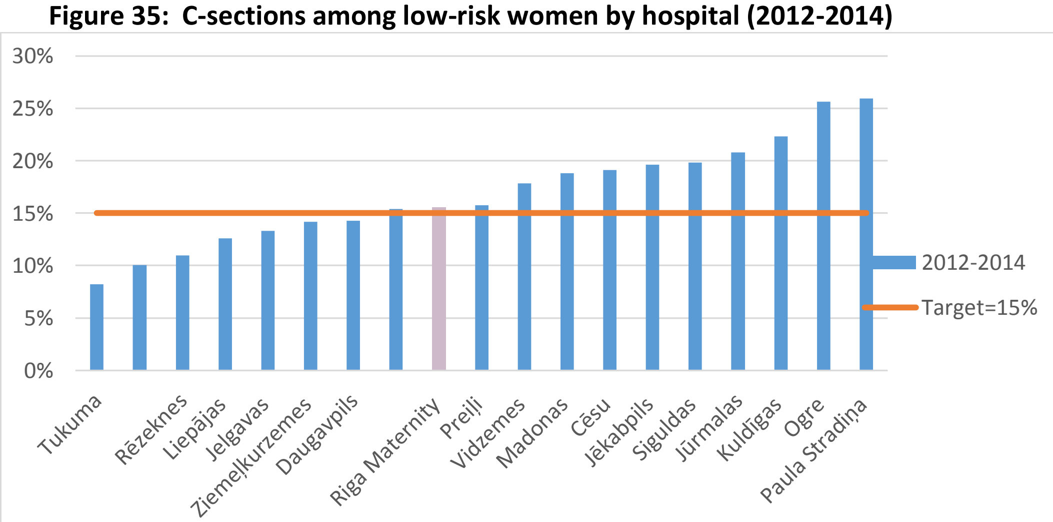


Figure 35: C-sections among low-risk women by hospital (2012-2014)



131. In Latvia, 17 percent of low-risk first-mothers had a C-section between 2012 and 2014. Many hospitals are above the international target of 15% for C-section among low-risk women (Figure 35). At least three hospitals had C-section rates above 20%.

6.5 Recommendations

132. To minimize the delivery of high risk pregnancies in low level hospitals and reduce non-medically indicated early deliveries and C-sections, a first step could be the development clinical guidelines and clinical pathways for both low and high-risk pregnancies that specify each hospital level of care and what care should be provided at each level. These pathways should include a clear definition for high-risk pregnancies as well as pathological deliveries and ensure consistency with previous regulations (for example, Cabinet Regulation 611). These guidelines and pathways can be supported by routine quality monitoring of admissions and adherence to referrals guidelines through clinical audits - for instance, an audit of appropriate and timely referral and access for women who develop complications.

133. Given that some practices are demanded by patients themselves, adopting quality indicators, such as the fraction of non-medically indicated early deliveries and C-section rates in low-risk first-time mothers, will not be sufficient. Further engagement of physicians and patients will be required. It is important that the adverse effects of these practices are communicated.[48]

134. The Ministry of Health and National Health Service may also consider adding financial incentives to contracts with hospitals to reduce the rate of early elective deliveries and C-sections among low-risk women.

7 Management of high-risk newborn cases

123. Access to risk-appropriate neonatal and obstetric care are critical for preventing perinatal mortality. As a result, regionalization of neonatal care and referrals of high-risk newborn cases are standard practice. Premature and low-birth weight babies are usually treated at Neonatal Intensive Care Units (NICUs) to improve birth outcomes and decrease infant mortality. High-risk pregnancies (for example, multiple births, congenital defects, or hypertension disorders) that place newborns at a higher risk of mortality also tend to be concentrated in hospitals with adequate equipment and personnel skilled in high risk perinatal care. (Stark, American Academy of Pediatrics Committee on et al. 2004, Phibbs, Baker et al. 2007, Lasswell, Barfield et al. 2010).

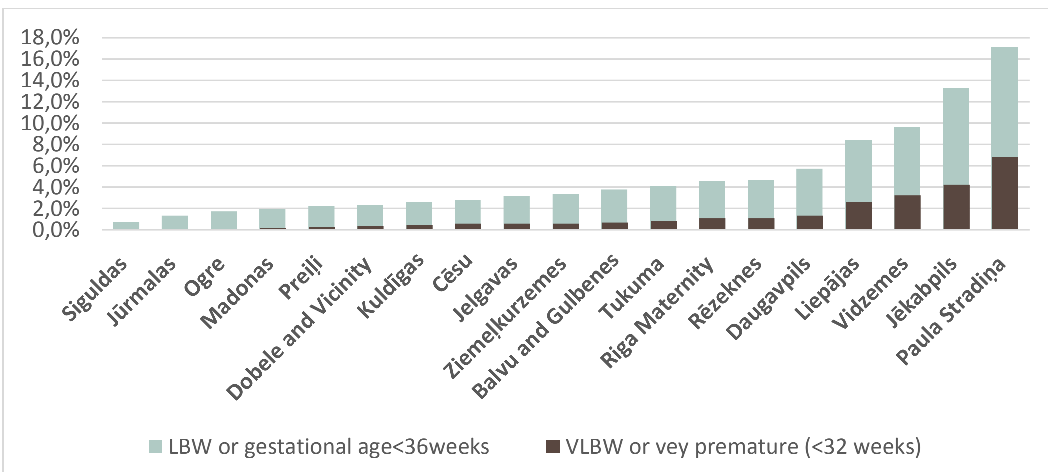
124. Current Newborn Transfer Guidelines in Latvia stipulate three designated hospital levels for newborn care and outline where high-risk cases such as premature births should receive care.

[48] A good example of a program implemented to reduce elective early deliveries which decreased elective scheduled early-term deliveries to less than 5% in a group of hospitals in the United States is described in Oshiro, B. T., E. Henry, J. Wilson, D. W. Branch and M. W. Varner (2009). "Decreasing elective deliveries before 39 weeks of gestation in an integrated health care system." Obstetrics & Gynecology 113(4): 804-811.

- Level I –Full term uncomplicated births (gestational age>36 weeks)
- Level II- Perinatal centers (3 regional hospitals- Jekabpils, Liepaja, and Vidzemes hospitals): gestational age>28
- Level III- tertiary-level neonatal care. Maternity Riga and Pauls Stradins hospitals: gestational age 22-28 weeks.
- Neonates in need of specialized surgeries, technologies and investigations (for example, echocardiography), or in need of longer treatment are referred to the Children's Hospital.

125. Despite these guidelines, that high-risk newborns were born at each level of care. According to the Medical Birth Register, there were 19,287 (2012), 20,011 (2013), and 21,145 (2014) live births in NHS-contracted hospitals.[49] From 2012 -2014, 3,500 of the nearly 60,400 infants born in these hospitals (6 percent) were either low-birth weight (LBW) (<2500 gr) or preterm infants (<36 weeks). About one third (29 percent) of these were very-high risk (very low-birth weight (VLBW) (<1500gr)) or very premature (born at <32 weeks). The fraction of cases that were low-birth weight or preterm in hospitals ranged from 0.7 percent in Siguldas hospital to 17.1 percent in Pauls Stradins (Figure 36). High-risk neonates born in Maternity Riga, the highest delivery volume hospital, accounted for 4.6 percent of all births in that hospital. Regional hospitals in the Latgale region (Daugavpils and Rezekne), which are not designated perinatal centers, had similar rates of high-risk newborns than Maternity Riga (4.7%-5.7%).

Figure 36: Percentage of high-risk newborns, by hospital



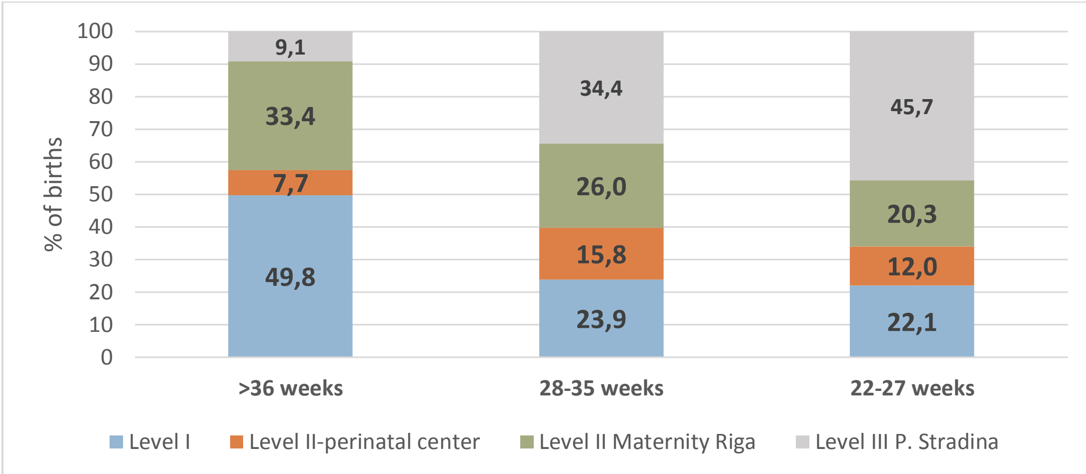
Note: LBW- Low-birth weight (<2500 gr), VLBW=Very low birth-weight baby (<1500gr)

126. In fact, the analysis indicates that 24 percent of premature (<36 weeks) and 22 percent of very-premature babies (22-27 weeks) were born in Level I hospitals, instead of being treated or transferred to Level II or III hospitals (Figure 37:). A majority of very premature babies delivered in Level I hospitals are concentrated in the Latgale region (67 percent), where hospitals are on average 100 km away from the assigned perinatal center. But others in the Zemgale region (20 percent) that are only about 40 minutes

[49] The total number of births in this period excludes 994 out-of-hospital births (delivered at home, during transport etc.), 35 deliveries for which information on institution of delivery was missing, and 134 deliveries in the following hospitals: Eastern Riga (4), Gimenes (43) and Saldus (81). These hospitals did not have any deliveries in 2013 or/and 2014.

away from Riga also did not refer these high-risk cases. The Level III hospital, Pauls Stradins, accounted for 46 percent of all very premature babies.

Figure 37: Newborns by gestational age and hospital level



127. Transfers from perinatal centers to tertiary care also do not always happen according to the Latvian referral guidelines, which stipulate that premature births from 24 to 28 gestational weeks are expected to be transferred from Level II to tertiary care. The analysis indicates that 14 percent of these high-risk cases born in a perinatal center were not transferred to the Children's Hospital or other higher hospital.

128. There is a large variation in transfer and perinatal mortality[50] rates of high-risk newborns by hospital volume. Rates of perinatal mortality in Level I hospitals for premature births ranges between 0 percent in Siguldas and Madonas[51] to 56 percent in Preili hospital. Higher volume hospitals have mortality rates between 5 percent in Liepaja and Jēkabpils and 15 percent in Daugavpils. The two hospitals without any newborn death transferred between 40 percent and 75 percent of these cases. Pauls Stradins and Maternity Riga transferred between 55-67 percent of their premature newborns to Children's Hospital, but it was puzzling that none of the perinatal centers (Liepaja, Jēkabpils or Vidzemes) transferred any of these cases to the Children's Hospital (Figure 38).

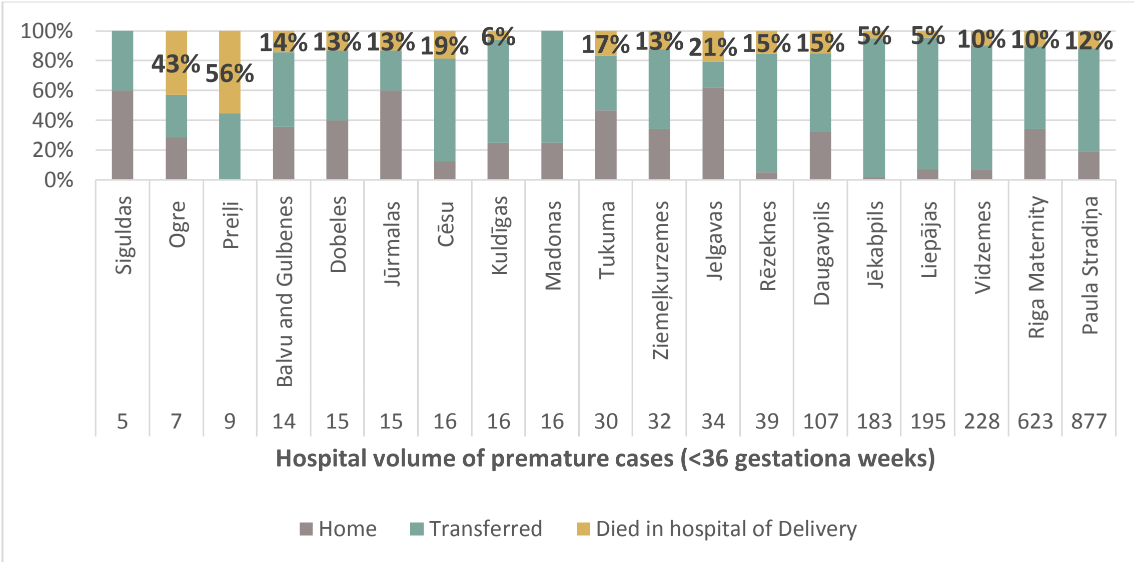
129. In Latvia, premature births (24-36 weeks) admitted to lower level hospitals had higher perinatal and neonatal mortality rates than those admitted in Level II (Liepaja, Jēkabpils or Vidzemes) and Level III (Maternity Riga and Pauls Stradins) hospitals. As shown .

130. Figure 39: perinatal mortality rates between Levels I and II ranged from 8 percent to 16 percent, and 9 percent to 17 percent (neonatal mortality).

Figure 38: Rates of transfer and in-hospital mortality for premature newborns by hospital

[50] Includes prenatal, intrapartum and early neonatal deaths of babies delivered in a hospital

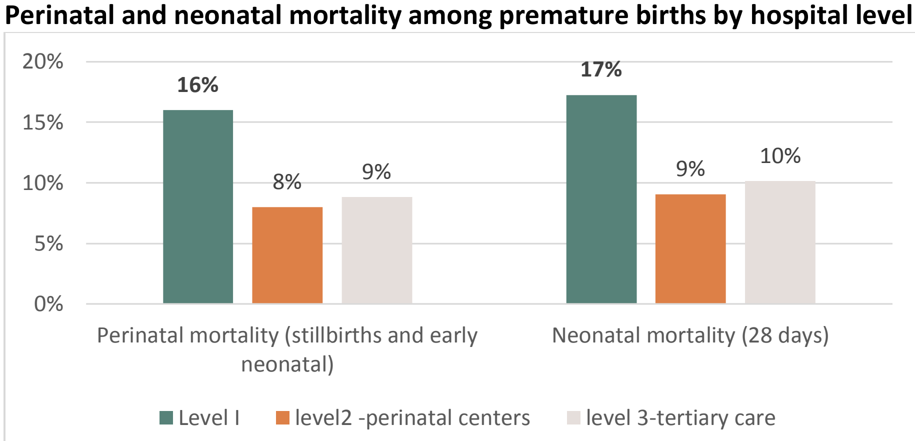
[51] Because of the low number of cases, it is not possible to ensure that hospitals with zero deaths would have the same rates if they were to admit more cases.



Note: Transfers in Liepaja, Jekabpils and Vidzemes refer to in-hospital transfers. Based on information from the Birth registry

131. After controlling by maternal and delivery factors, premature births born in Level I hospitals had 89 percent higher odds of perinatal death (stillborn and early neonatal) compared with Level II and Level III hospitals (Odds ratio (OR), 1.88; 95% confidence interval, 1.38-2.58; P=.0001).[52] Similarly, premature births born in Level II perinatal centers had 69% lower odds of death compared with Level I hospitals (Odds ratio (OR), 0.31; 95% confidence interval, 0.18-0.55; P=.0001). Level III hospitals had 41 percent lower odds of perinatal death compared with Level I hospitals (Odds ratio (OR), 0.59; 95% confidence interval, 0.43-0.82; P=.0001). There was no statistically significant difference between Level II and Level III mortality risks among preterm and VLBW.

Figure 39: Perinatal and neonatal mortality among premature births by hospital level



Note: premature births (24-36 gestational weeks).

[52] The multivariate logistic model include controls for adolescent mother, mother >35 years, singleton birth, type of delivery (urgent and planned c- section, induces labor), newborn sex, and year. Includes premature births >= 24 and <36 gestational weeks.

132. Similarly, the proportion of high-risk cases (very premature <32 weeks or very low-birth weight <1500)) outside of perinatal centers or Level III neonatal care is 22 percent, which indicate a relatively low level of identification and referral. The results of the analysis indicate a significant elevated risk of perinatal mortality among these births born in Level I hospitals (89 percent), while perinatal centers were associated with a 41 percent reduction in risk for perinatal mortality, suggesting that centralization of high-risk services in these centers can bring important benefits. However, only 15 percent of these high-risk cases were treated at regional perinatal centers.

133. A number of hospitals with high volume of deliveries in the Latgale region (Daugavpils, Rezekne and Preili) appear to have lower transfer rates of high-risk babies to perinatal centers, and higher than average neonatal mortality rates. These hospitals are a more than 100kms from the nearest perinatal center which reduces the possibility of high-risk cases to timely access to perinatal care.

7.1 Recommendations

134. As in the previous sections, the evidence of the current study suggests room for strengthening the identification and referral of high-risk cases before birth through the development of clinical guidelines and a pathway for low-birth weight and very low-birth weight babies.

135. Moreover, current referral guidelines do not have full compliance (some high risk cases, even those close to a more appropriate care setting, are not referred to higher level hospitals). This suggests that clinical guidance alone may not be sufficient. The connection between hospitals and their assigned perinatal center could be strengthened, both physically through neonatal transport services but also financially by writing contracts that specify where certain types of care should be performed.

136. Finally, the functional capabilities of facilities in Level 1 hospitals should be adequate to deal with complications that arise prior to transfer – for example, personnel and equipment to perform neonatal resuscitation and stabilize newborns born at less than 36 weeks gestational age. The Ministry of Health may also consider strengthening and upgrading to perinatal centers the regional hospitals that currently accept high-risk newborn cases but do not have timely access to a perinatal center (for example, Daugavpils).

8 Conclusions

137. A large number of studies have investigated the relationship between volumes and better quality of care and outcomes in a broad range of procedures. These studies vary in their quality, methodologies and magnitude of effect, but they consistently show a strong volume-outcome link for certain complex procedures and patients groups. These results have led national quality assurance organizations and police-makers to use volume standards as tools to improve quality of care. Primarily

by reporting volume indicators, supporting selective referral to high-volume centers, certifying physicians and regionalization of certain procedures.

138. This report examined the volume-quality relationship in a set of publicly funded procedures and conditions in Latvia performed during 2012-2014 across four clinical areas: cardiovascular, cancer, obstetrics and newborn care. It identified areas where volume standards may contribute in improving quality of care and lowering mortality rates. Overall, the report findings aim to motivate discussion between NHS, hospital managers, providers, and patients regarding volume standards and selective referral guidelines.

139. The analysis findings suggest that in Latvia high hospital and surgeon volumes are associated with better quality of care and survival in number of procedures and indicate areas where selective referral could be beneficial. These are aortic vascular surgery, interventional cardiology, and surgical therapy for breast, ovarian and colorectal cancer. For instance, patients treated by physicians who performed more than 75 PCIs per year exhibited 44 percent lower risk of in-hospital mortality compared to patients treated by physicians who performed less than 75 PCIs per year. This translates to 19 potentially avoidable deaths over three years if these patients had been referred to a high-volume surgeon. Similarly, colorectal cancer patients who underwent a resection had 92 percent lower risk of dying if they were performed at East Riga University Hospital, compared with patients in any of the 14 low-volume hospitals performing the procedure (with less than 25 resections per year). This means that potentially 43 of the 86 patients who died in the hospital after a resection for colorectal carcinoma over these three years might have been saved.

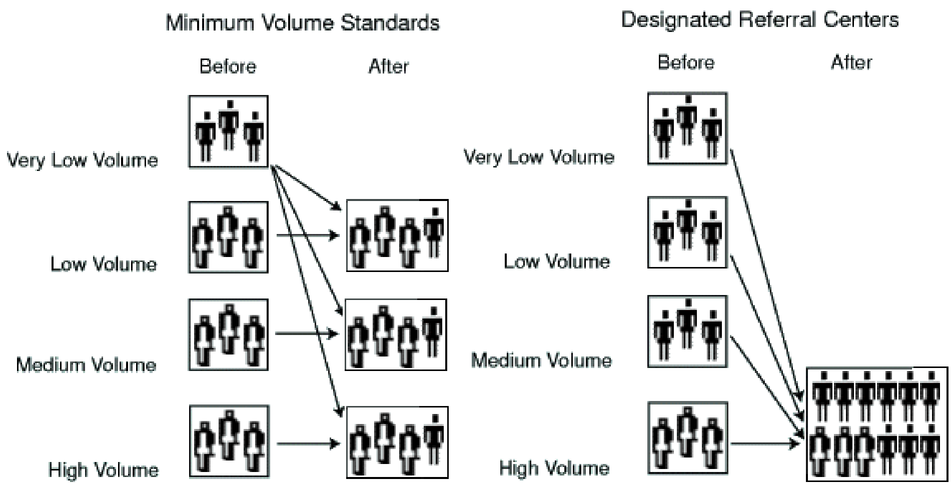
135. The study also examined the association between volume or designated level of care and health outcomes for high-risk obstetrics and newborn cases. The findings indicate low referral compliance of high-risk pregnancies and newborn cases, resulting in higher rates of perinatal mortality at Level I hospitals. Over the three year period, premature births born in Level I hospitals had 89 percent higher odds of perinatal death compared with those born in Level II and Level III hospitals. In addition, non-medically indicated elective early deliveries in Latvia were carried out at every hospital level of care, and they were associated with higher neonatal transfer rates for singleton live births, as well as longer lengths of stay. Finally, the analysis indicated high rates of unnecessary C-sections among low-risk women.

140. Latvia has already concentrated interventional cardiology services in four centers, and most cancer resections are treated at the two university hospitals in Riga. However, smaller hospitals and low-volume surgeons are still performing some complex cancer resections or elective AAA and PCI procedures. These cases had significantly higher mortality risks if performed by low-volume providers. Volume-based referrals

80. Thus, implementing minimum volume standards is likely to save lives in Latvia. Two general approaches can be used when setting referral pathways (Figure 39). First, patients currently at hospitals below a specified procedure volume threshold (very-low-volume hospitals) could be “redistributed” to hospitals above the threshold. A second approach uses designated referral centers, where all patients are directed to selected (high-volume) hospitals. The choice between these two options depends on the overall need for surgical services (that is, the number of services within a given population). For instance, in the United Kingdom an ideal oeosphago-Gastric unit consist of 4-6 surgeons each carrying out a minimum of 15-20 resections per year serving a population of 1-2 million.

81. In selecting procedures for selective referral, however, it will be necessary to develop fairly complex protocols for emergency cases that first enter the health system in a low-volume hospital. In addition, adequate geographic access to referral hospitals is essential for a minimum volume standard policy to be effective. Regionalization needs to take into account the trade-off between the numbers of patients needed to be transferred versus the benefits on the number of deaths averted. On the other hand, regionalization/centralization can encourage municipalities to establish cooperation schemes with neighboring municipalities to provide high quality procedures, or high-volume hospitals can establish similar arrangements with smaller hospitals to treat low-risk pregnancies[53]. In particular, low-volume hospitals geographically close to high-volume hospitals with poor outcomes should be scrutinized. If these hospitals are located in isolated areas, regionalization needs to be considered carefully.

Figure 40: Minimum volume standards approaches



Source: Hentschker and Mennicken 2014

82. It is important to note that volume is only one component of the components in the production of health outcomes. Using procedural volume then as quality indicator calls for the need of considering other components of care along with procedural volume indicators (Pennsylvania Health Care Cost Containment Council 2002). The association between volume and outcomes reflects underlying differences in structural and process components of care such as specialized staff, dedicated operating rooms, high-intensity intensive care units, effective prevention and managing of complications, or better nurse staffing between low and high volume hospitals (Tol, van Gulik et al. 2012).

[53] The volume of patients or cases can also be used as a basis for the concentration or centralization of services. This can result in a local reconfiguration of health services or reorganization of hospital networks.· Concentrating volume and expanding the variety of cases (by increasing catchment areas) is believed to reduce geographical inequalities. Providing certain services in a smaller number of regional, specialist centers rather than in a large number of low-volume institutions allows technological advances to reach more patients in a cost-effective manner (Meadows, Rattenberry et al. 2011). In these processes, however, concerns related to social costs represented in patient access to nearby care, disruptions of service menus, and disruptions of individual and institutional income need to be taken into consideration (Smith, Hillner et al. 2003)

141. The implementation of volume standards and referrals thus would require further analysis, including consultations with providers, hospital managers, and patients, as reorganization of services driven by a focus on volume may exert adverse effects on access to care and cause disruptions to health services. For instance, the movement of low-volume patients to high-volume centers imply that these centers have the capacity to absorb more patients and offer care in a timely manner. The results showed that these high-volume centers have a large number of low-volume surgeons treating complex procedures. The analysis also show that low-volume surgeons have lower quality of care and outcomes regardless of the hospital where the patient was admitted. A possible explanation could be these centers face understaffing to treat these complex procedures when they are admitted in emergency care, compared to elective services. Patient safety and the quality and efficiency of emergency care services needs to be addressed and improved before any movement of patients can be planned.

142. Also, it is important to note that there always be a number of cases in low-volume hospital and low-volume surgeons either because emergency cases or because isolated areas cannot risk access to essential care even if their volumes are not optimal. The current study found several instances where equity with respect access to essential care can be improved - for instance, underserved areas in terms of PCI in Vidzemes and necessary perinatal capacity in the Latgale region. In addition, it identified cases where low-volumes units very close to a high-volume center or a specialized center provided complex surgical procedures (for example, premature births close to a perinatal center, or STEMI admissions to hospitals near Riga without PCI capabilities). Referring these cases to a high-volume center should be straightforward and potentially less disruptive to hospital services.

143. In general, the analytical findings of this report suggest the need for reform in four broad areas:

1. Regulation which complex surgical procedures hospitals are certified to provide and which cases they can handle
2. Development clinical guidelines and pathways with selective referral for
3. Incorporation of volume standards into the specialization training and certification programs of physicians
4. Monitoring and reporting of volumes for certain procedures and cases.

144. The report identified a number of surgical procedures that had lower quality of care and worse outcomes when performed at low-volume hospitals. To improve quality of care and ensure patient safety, it will be necessary to regulate when a hospital is certified to provide certain cardiovascular and complex cancer resections. This process can be done during licensing and accreditation of hospitals, or through NHS contracts with individual hospitals. For example, in the Unites States, some states' health administration agencies use volumes as a requirement for hospitals accreditation. Similarly, in France regional health agencies certify healthcare facilities and authenticate healthcare professionals and their authorization to practice.

145. Developing clinical pathways that integrate minimum volume standards will also be critical. Both disease-specific national pathways that guide patient referrals to adequate units and hospital-specific pathways of care that identify specific processes of care, such as surgeon volumes, would very likely enhance quality of care in the conditions studied. Clinical pathways[54] are commonly develop by doctors,

[54] "Integrated care pathways are structured multidisciplinary care plans which detail essential steps in the care of patients with a specific clinical problem. They have been proposed as a way of encouraging the translation of

nurses, and other health care professionals based on approved clinical guidelines. Although some clinical guidelines in Latvia mention surgeon volume recommendations (for example, colorectal cancer guidelines), it will be necessary to develop clear recommendations with professional societies and organizations to strengthen the role of case volume on certification of surgeons and hospitals. Professional organizations such as medical and nursing associations can play a leading role in promoting quality in health care. For example in Germany, the medical chamber, the nursing society, and the health insurance funds began a consortium, later including the society of all hospitals, to develop healthcare accreditation (Shaw, Kalo et al. 2002).

146. Integrating volume standards with training and certification could also be beneficial in Latvia. An effective certification program can improve quality of care by introducing volumes standards in the training and certification of surgeons and specialists. The results of this report indicate that case volume is a better indicator of competency than the current interventional cardiology certificate. Certification programs that include volume thresholds by construction reduce the number of low-volume surgeons and could motivate medium-volume surgeons to work towards higher volumes. Implementing minimum volume standards without having in place a surgeon certification program, however, can cause negative incentives to increase volume without appropriate improvement in quality of care. An example, of a certification program is the American Board of Internal Medicine's interventional cardiology initial certificate that establishes a minimum of 250 interventional cardiac procedures performed during an accredited 12-month interventional cardiology fellowship-training program. This certification lasts for 10 years when recertification is needed. To maintain certification, candidates are required to participate in several learning programs or modules, pass a secure recertification examination, and meet a procedural volume target of a minimum of 150 PCIs during the two years prior to the expiration of their certificate (Bass 2012).

147. Public reporting of hospital case volumes for surgical procedures and conditions and associated case-mix adjusted outcomes such as surgical mortality would be a useful tool to create accountability and provide patients and providers with relevant information. It would be key to elicit inputs from professional societies and providers when choosing measures for public reporting and determining how to standardize them across hospitals and physicians. The indicators that this report used can be easily replicated at individual hospitals. A working group can be formed to establish which hospital and surgeon indicators would be publicly reported.

148. The following table summarizes the problems identified through the report and juxtaposes them with some of the recommendations just described and enabling actions that might be necessary prior to reform.

national guidelines into local protocols and their subsequent application to clinical practice. They are also a means of improving systematic collection and abstraction of clinical data for audit and of promoting change in practice".Campbell, H., R. Hotchkiss, N. Bradshaw and M. Porteous (1998). "Integrated care pathways." BMJ **316**(7125): 133-137.

Table 12: Recommendations for Latvia

Component	Problems	Potential solutions	Enabling actions
Cardiovascular procedures			
Abdominal Aorta Aneurism (AAA) repair	• Surgical repairs performed by low-volume surgeons. • Lower-volume hospitals and surgeons associated with lower quality of care and higher mortality for both unruptured and ruptured AAAs	1. Clinical pathways with selective referral to (and transfers) to high-volume hospital and high-volume surgeons. a. Unruptured AAAs should be done only in high-volume centers (>=50 per year). b. High-volume surgeons should perform ruptured and unruptured AAA. 2. Incorporation of pathways into NHS contracts in a way that satisfies volume targets but does not reduce access to care outside of Riga. 3. Hospital benchmarking by AAA volumes 4. Incorporation of volume standards into the training and certification process for vascular surgery.	1. Development of clinical guidelines and pathways for AAA repair. 2. Consultations with physicians performing this procedure, high-volume hospitals, low-volume hospitals, and SEMS to draft a strategy for incorporating volume standards in NHS contracts. 3. Consultations with medical education institutions, university hospitals, and physicians' association to develop a strategy for incorporating volume-standards in training and certification process. 4. Development of reporting process for hospitals to report total volumes, physician-specific volumes, and quality indicators for certain procedures. 5. AAA screening program for males over 65 years.
Percutaneous	• Regional PCI centers have	1. Strengthening regional hospitals' PCI service by increasing the number of	1. Consultations with medical education

Component	Problems	Potential solutions	Enabling actions
Coronary Intervention (PCI)	few doctors who met the recommended minimum threshold for physicians.	high-volume physicians working in these hospitals. 2. Establishment of a certification program with a minimum physician performance level (for example, 75 interventions per year).[55] 3. Clinical pathways with selective referral to high volume physicians 4. Monitoring of physician volumes, along with quality of care indicators.	institutions, university hospitals, and physicians' association to develop strategy for incorporating volume-standards in training and certification process. 2. Development of reporting processes for hospitals to report total volumes, physician-specific volumes, and quality indicators procedures. 3. Pilot a national clinical audit for PCI
	• Low-volume physicians associated with higher mortality and quality indicators		
	• Unequal access to PCI for STEMI cases	1. Clinical guidelines and pathways that include appropriate management of STEMI and emergency admissions. ○ Pathway should redirect all STEMI cases from low-volume hospitals close to Riga (e.g. Jūrmalas) to a PCI center 2. Ensuring underserved areas are properly linked to a PCI center or enhanced so they provide 24 h/7-day PCI service and have high-volume PCI physician(s) on call for emergencies.	1. Development of clinical guidelines and pathways for STEMI cases. 2. Needs assessment for additional PCI capabilities in the undeserved region (Vidzemes).
	• No unified registry of acute coronary syndrome	• To develop a unified register, which would include ambulatory, pre-	3. Establishment and maintenance of a national ACS register

[55] Volume threshold suggestions based on the volume-outcome literature. However, this may not be the optimal cut-off points for Latvia.

Component	Problems	Potential solutions	Enabling actions
	or PCI	hospital EMS and hospital stage treatment episodes of patients with acute coronary syndrome	
Cancer procedures			
Cancer Resections	• Resections performed in very low-volume hospitals with no access to specialized care, or by low-volume surgeons. • Lower volumes associated with lower survival and worse quality of care	1. Clinical pathways for cancers that specify location of surgical treatment based on minimum volume standards and that ensure access to care outside of Riga. 2. NHS contracts that incentivize adherence to such pathways 3. Ensure that current national clinical guidelines are followed (e.g. guidelines regarding colon and rectal surgery issued by the National Oncological Center in Latvia). 4. Service delivery model based on breast cancer units in each of the four bigger hospitals with a minimum of 100 breast surgeries per year. 5. Monitoring the number of radical mastectomies in patients with early-stages of cancer, in particular performed by low-volume surgeons and hospitals.	1. Development of clinical guidelines and pathways for cancer patients that include volume standards for surgeons and units. 2. Consultations with surgeons performing this procedure, high-volume hospitals, and low-volume hospitals, to draft a strategy for incorporating volume standards in NHS contracts. 3. Convening an exchange of good-practices between East Riga and the other hospitals performing cancer resections to discuss a shift to a multidisciplinary organization of cancer care. 4. Development of reporting process for volumes and quality of care indicators.
Obstetric care			
Obstetric care	• Low-risk admissions treated	1. Clinical pathway for pregnancy that	1. Consultations with patients and

Component	Problems	Potential solutions	Enabling actions
	at the highest levels of care.	directs low-risk admissions and uncomplicated births to Level I and Level II hospitals, rather than to higher levels of care.	obstetricians to develop clinical pathways.
	• Higher adverse outcomes among low-risk admissions at low-volume hospitals.	1. Clinical guidelines for emergency complications in labor and delivery 2. Monitoring labor, delivery, and post-partum quality of care	1. Development of clinical guidelines and pathways for emergency obstetric complications. 2. Development of a clinical pathway for pregnancy that specifies hospital level of care and what care should be provided at each level for both low-risk and high-risk deliveries. 3. Clinical audits of appropriate and timely referral and access for high-risk pregnancies and delivery complications
	• Low referral compliance of high-risk pregnancies resulting in higher rates of neonatal mortality	1. Clinical pathway for pregnancy that incorporates existing referral guidelines for high-risk pregnancies and deliveries. 2. Link between adherence to pathways and NHS reimbursement. 3. Quality monitoring of admissions and adherence to referral guidelines.	
	• High proportion of non-medically indicated early deliveries that are associated with higher neonatal transfer rates for singleton live births and longer hospital stays.	1. Clinical guidelines for the management for elective early deliveries that include contraindications for C-section and induced labor procedures in low-risk women. 2. Identification and tracking of elective deliveries by gestational age 3. A quality incentive program in	1. Development of clinical guidelines for the management for elective early deliveries 2. Outreach among physicians and patients to educate them on the dangers of early elective delivery and content of clinical guidelines. 3. Consultations among hospitals and
	• Hospital C-section rates that exceed international target of 15% for C-section among		

Component	Problems	Potential solutions	Enabling actions
	low-risk women.	hospitals that includes financial incentives to reduce rate of early elective deliveries and C-sections among low-risk women.	obstetricians to develop incentive program
Newborn care			
Newborn care- Management of high-risk cases	• Low referral compliance of high-risk neonatal cases	1. Clinical pathways for neonatal cases that incorporate existing referral guideline for high-risk pregnancies and deliveries. 2. Link between adherence to pathway and NHS reimbursement. 3. Quality monitoring of admissions and adherence to referral guidelines.	1. Development of clinical guidelines to strengthen the identification and referral of high-risk neonatal cases. 2. Consultation with hospital managers to identify factors affecting the compliance of the referral regulations, in particular, high-risk cases occurring at hospitals closer to a perinatal center. 3. Development of a clinical pathway for very-low-birth weight infants. 4. Clinical audits of high-risk neonatal cases
	• Unequal regional access to perinatal centers (in particular in the Latgale region)	1. Strengthening and upgrading regional hospital in Daugavpils to perinatal center	1. Assessment of the equipment and personnel needed for upgrading.

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10 Technical Annex

This annex describes the main variables included in the volume –quality statistical analyses and summarizes the empirical approach.

Data Sources

The study used primarily data from the NHS payment inpatient dataset from 2012 and 2014. The analysis followed longitudinally patients using an encrypted unique identification number. This permits following patients across different providers, over time, and across different datasets over the three years of study. The analysis use ICD-10 diagnosis codes, as well as procedural codes (manipulation codes) to identify procedures and patients. Hospital and surgeon codes were available and encrypted for confidentiality. For each episode, it was possible to identify whether the patient was discharged home, transferred to another hospital, or died before being discharged.

Three population registries managed by Center for Disease Prevention and Control were used in conjunction with the payment dataset Register of Causes of Death, Register of Patients with Particular Diseases, Patients with Cancer, and Medical Birth register. The Death register information was used to estimate short-term mortality rates (30, 60, 90 days) of patients in the payment datasets. The Cancer Register provided key information on cancer staging, and the Birth Register was used as a base for both obstetric and newborn care analysis. The analysis of obstetric care used information from both datasets to define delivery complications and comorbidities. Finally, the outpatient dataset allowed quantifying the number of PCIs performed by hospitals and surgeons in both ambulatory and inpatient settings.

Study population

The study included hospital discharges for each disease / intervention under consideration included in the inpatient payment dataset or the Birth Register.

Study Period: 2012 - 2014.

Volume-based indicators

Procedure volume or volume refers to the number of procedures of a given type a hospital or surgeon performed each year and can be defined in relation to any type of surgical procedure. Both hospital and physician volumes were evaluated as categorical variables based on procedure-specific minimum recommended thresholds.

Hospital volume: Hospital volume was defined as the aggregate number of publicly funded procedures performed in a hospital per year. Hospital volume was estimated as the mean number of discharges included in the study at a given hospital per year.

Surgeon volume: annual number of public-funded procedures performed by a surgeon/physician in any NHS-contracted hospitals.

Outcome measures

In-hospital mortality: In-hospital mortality was defined as death occurring during the hospital stay.

30-day, 60-day, 90-day mortality: Short-term mortality is defined as death occurring during the first 30, 60, 90 days from being admitted in the hospital. To estimate these indicators the inpatient payment dataset was merged with the death register to follow the patients during that period. When possible, one-year survival was estimated using exclusively data from 2012 and 2013.

Perinatal mortality refers to stillbirths and deaths in the first week of life (early neonatal mortality). To reduce neonatal deaths not susceptible to institutional factors such as hospital volume, the analysis considered a perinatal period starting at 24 completed weeks of gestation until seven completed days after birth.

Neonatal mortality refers to the deaths of a newborn in the first 28 days of life

Quality Measures

Average-length-of Stay (ALOS) refers to the average number of days that patients spend in the hospital. It was defined as the total number of days stayed by patients who underwent a specific procedure.. When a patient was transported to another hospital after the procedure, the entire length of stay was considered.

30-day readmissions: refers to the number of patients who underwent select procedures that were readmitted within 30-days at any hospital for any cause.

Statistical analysis measuring the link between volume and health outcomes

The measure of association used for the analysis of the relationship between volume and health outcomes was the odds ratios (OR). The OR is a relative measure of association that compares the odds of disease of those exposed to some attribute to the odds of disease of those unexposed. Here an exposed group refers to either a volume hospital/provider category or a level of care. An OR of 1 would suggest that there is no difference between the groups. An OR > 1 suggests that the odds of exposure are positively associated with adverse outcomes. For example, an OR of 3, indicates that the patients treated at a low volume/providers died 3 times more often than patients in high-volume centers.

The RR is calculated as the ratio of two rates / proportions and it expresses the excess risk in the numerator rather than the denominator group. For example, a RR of 2, indicates that patients treated at a low-volume hospital have a risk of death twice as high as that treated at a high-volume hospital.

Econometric specification

Multivariate logistic regressions[56]

[56] The analysis does not account for clustering of outcomes that occur within a hospital. Few clusters (hospitals) prevent us to include a cluster correction.

$$y*_{ih} = \alpha_0 + vol'_h \beta_1 + x'_{ih}\beta_2 + k'_h\beta_3 + \varepsilon'_{ih}$$
$$y_{ih} = 1 \; if \;\; y*_{ih} \geq 0$$

$y_{ih} = whether\ patient\ i\ died\ in\ hospital\ h\ (y_{ih} = 1) or\ not\ (y_{ih} = 0)$, vol=case volume, x patient characteristics, and $\varepsilon = error\ term$

- **Case mix adjustment**: risk adjustment was performed using patients' characteristics known to be associated with differential mortality rates, including age, sex, emergency admission, year of admission, and comorbidities (e.g. diabetes, hypertension, CVD, pulmonary disease and renal disease) see below. Specific covariates were included as was deemed relevant for each condition. For instance, newborn care analysis includes maternal or structural factors (age<18, age>35, type of delivery), and newborn sex. In cancer resections models, cancer staging information from the Cancer Register was also included.

- **Subgroup analysis:** subgroups analysis was performed on the following cases: ruptured vs unruptured AAA, STEMI PCI patients, high-risk newborn cases defined by prematurity, low-risk admissions, and low-risk deliveries.

- **Severity:** the analysis include emergency admissions as a proxy for disease severity in the model, and when possible type of procedure: for example ruptured vs unruptured AAA, or STEMI vs non-STEMI patients

- **Comorbidity Index**: the analysis used the Charlson index[57]. The Charlson Comorbidity Index is a method of categorizing comorbidities of patients based on the International Classification of Diseases (ICD) diagnosis codes found in administrative data, such as hospital abstracts data. Each comorbidity category has an associated weight (from 1 to 6), based on the adjusted risk of mortality or resource use, and the sum of all the weights results in a single comorbidity score for a patient. A score of zero indicates that no comorbidities were found. The higher the score, the more likely the predicted outcome will result in mortality.

  It includes the following conditions:

Condition	**ICD-10/SSK-10**
AIDS/HIV	B20.x–B22.x, B24.x
Cerebrovascular disease	G45.x, G46.x, H34.0, I60.x–I69.x
Congestive heart failure	I09.9, I11.0, I13.0, I13.2, I25.5, I42.0, I42.5–I42.9, I43.x, I50.x, P29.0
Chronic pulmonary disease	I27.8, I27.9, J40.x–J47.x, J60.x–J67.x,J68.4, J70.1, J70.3
Dementia	F00.x–F03.x, F05.1, G30.x, G31.1
Diabetes without chronic complication	E10.0, E10.1, E10.6, E10.8, E10.9, E11.0, E11.1, E11.6, E11.8, E11.9, E12.0, E12.1, E12.6, E12.8,

[57] The index was calculated using stata command by Stagg, V. (2015). "CHARLSON: Stata module to calculate Charlson index of comorbidity." Statistical Software Components., based on a SAS program written by Dr. Hude Quan (Quan H et al. Coding algorithms for defining comorbidities in ICD-9-CM and ICD-10 administrative data. Medical Care 2005 Nov; 43(11):1073-1077.) The list of codes

	E12.9, E13.0, E13.1, E13.6, E13.8, E13.9, E14.0, E14.1, E14.6, E14.8, E14.9
Diabetes with chronic complication	E10.2–E10.5, E10.7, E11.2–E11.5, E11.7, E12.2–E12.5, E12.7, E13.2–E13.5, E13.7, E14.2–E14.5, E14.7
Hemiplegia or paraplegia	G04.1, G11.4, G80.1, G80.2, G81.x, G82.x, G83.0–G83.4, G83.9
Mild liver disease	B18.x, K70.0–K70.3, K70.9, K71.3–K71.5, K71.7, K73.x, K74.x, K76.0, K76.2–K76.4, K76.8, K76.9, Z94.4
Moderate or severe liver disease	I85.0, I85.9, I86.4, I98.2, K70.4, K71.1, K72.1, K72.9, K76.5, K76.6,K76.7
Any malignancy, including leukemia and phymphoma	C00.x–C26.x, C30.x–C34.x, C37.x–C41.x, C43.x, C45.x–C58.x, C60.x–C76.x, C81.x–C85.x, C88.x,C90.x–C97.x
Metastatic solid tumor	C77.x–C80.x
Myocardial infarction	I21.x, I22.x, I25.2
Peripheral vascular disease	I70.x, I71.x, I73.1, I73.8, I73.9, I77.1, I79.0, I79.2, K55.1, K55.8, K55.9, Z95.8, Z95.9
Peptic ulcer disease	K25.x–K28.x
Rheumatologic disease	M05.x, M06.x, M31.5, M32.x–M34.x, M35.1, M35.3, M36.0
Renal disease	I12.0, I13.1, N03.2–N03.7, N05.2– N05.7, N18.x, N19.x, N25.0, Z49.0– Z49.2, Z94.0, Z99.2

Source: Quan H, Sundararajan V, Halfon P, et al. Coding algorithms for defining Comorbidities in ICD-9-CM and ICD-10 administrative data. *Med Care.* 2005 Nov; 43(11): 1130-9