Available online at www.sciencerepository.org

Science Repository

Research Article

Variation in Hospital Length of Stay Based on Hospital Volume: A Retrospective Cohort Study of Emergency Abdominal Surgery in Ireland

Gintare Valentelyte[1], Deirdre Nally[2], Laura Hammond[3,4], Kenneth Mealy[5,6], Dara Kavanagh[7], and Jan Sorensen[8*]

[1]*PhD Scholar in Health Economics, Healthcare Outcomes Research Centre (HORC), Royal College of Surgeons in Ireland, Beaux Lane House, Mercer Street Lower, Dublin*

[2]*Research Fellow, Department of Surgical Affairs, Royal College of Surgeons in Ireland, 121 St. Stephen's Green, Dublin*

[3]*Chief Data Technician, National Clinical Programme in Surgery, Royal College of Surgeons in Ireland, 2 Proud's Lane, Dublin*

[4]*Research Officer, Healthcare Outcomes Research Centre (HORC), Royal College of Surgeons in Ireland, Beaux Lane House, Mercer Street Lower, Dublin*

[5]*President, Royal College of Surgeons in Ireland, 123 St. Stephen's Green, Dublin*

[6]*Clinical Lead and Advocate, National Clinical Programme in Surgery, Royal College of Surgeons in Ireland, 2 Proud's Lane, Dublin*

[7]*Senior lecturer in Surgery, Department of Surgical Affairs, Royal College of Surgeons in Ireland, 121 St. Stephen's Green, Dublin*

[8]*Professor of Health Economics, Healthcare Outcomes Research Centre, Royal College of Surgeons in Ireland, Beaux Lane House, Mercer Street Lower, Dublin*

ARTICLEINFO

Article history:
Received: 11 November, 2019
Accepted: 29 November, 2019
Published: 17 December, 2019

Keywords:
Length of stay
emergency abdominal surgery
hospital volume

ABSTRACT

Objectives: Emergency abdominal surgery (EAS) refers to high risk intra-abdominal surgical procedures associated with increased mortality risk and long length of hospital stay. The variation between hospital volume and hospital length of stay (LOS) of patients undergoing EAS is poorly understood. Our objective was to explore this relationship across public hospitals in Ireland.

Methods: Data for all adult episode discharges from public Irish hospitals in 2014-2017 were obtained from National Quality Assurance Improvement System (NQAIS) Clinical with EAS identified by primary procedure codes. Hospitals were categorised into low (n<200), medium (n=200-400), and high (n>400) volume groups based on the number of EAS episodes during the study period. Negative binomial regression models were applied to standardise for patient case mix. Several adjusted LOS measures were compared across the three volume groups. Sensitivity analysis was conducted to test the robustness of our findings.

Results: 8120 hospital episodes across 24 public hospitals providing EAS services were analysed. 7 were categorised as low, 9 as medium, and 8 as high-volume hospitals. High volume hospitals had a significantly longer adjusted LOS (24.7 days) relative to low and medium volume hospitals (18.2 and 18.6 days). Sensitivity analysis consisted of the exclusion of the following hospital episodes: in-hospital death, cancer diagnosis, Charlson comorbidity index (CCI) >0, admission from other hospitals, and discharge to other hospitals. No single variable influenced the observed LOS variation, although when the more complex episodes were excluded, the post-operative LOS at low and medium volume hospitals was significantly shorter compared to high volume hospitals (by 1.1-6.1 days). Intensive care unit (ICU) LOS was similar in all three hospital volume groups although low volume hospitals appeared to have more ICU admissions and longer stay (by up to 1.6 days).

Conclusions: Our findings indicate that patients treated at low volume hospitals have shorter LOS and may be discharged earlier than from high volume hospitals. This finding is surprising, suggesting that concentration of services to larger clinical departments may not necessarily reduce LOS and improve the efficiency of resource utilisation and service delivery.

[*]*Correspondence to: Jan Sorensen, Healthcare Outcomes Research Centre, Royal College of Surgeons in Ireland, Beaux Lane House, Mercer Street Lower, Dublin; Tel: 4028640; E-mail: jansorensen@rcsi.ie*

http://dx.doi.org/10.31487/j.SCR.2019.06.10

Introduction

Emergency abdominal surgery (EAS) is the collective term for a variety of urgent intra-abdominal surgical procedures undertaken for gastrointestinal conditions. This is high risk surgery associated with considerable rates of morbidity and mortality and increasing rates among older patient groups [1-3]. Patient and surgical system factors impact both resource use and outcomes for EAS patients. EAS patients represent a vulnerable group, as the acute nature of symptoms requires urgent care delivery, resulting in limited choice of hospital. Addressing the importance of providing high quality and safe EAS care and outcomes is an important public health concern, requiring considerable resources. Mean LOS, defined as the total number of days stayed by all in-patients during a year, divided by the number of hospital episodes (discharges), is often used as a proxy measure for hospital resource utilisation thus reflecting the efficiency of care delivery [4-6]. Reported variation in the risk-adjusted LOS between hospitals is often a reflection of the differences in the efficiency of hospital care delivery [7-9]. Variation in the risk-adjusted hospital LOS measures following high risk surgery, has been reported as the resulting impact of hospital volume [10, 11]. Shorter mean total LOS and post-operative LOS at high volume hospitals have been reported, yielding to improved outcomes for patients following high risk surgery [12-16]. Similarly, an Irish study investigating LOS among emergency colorectal surgery admissions found total LOS to be significantly shorter among patients admitted to higher volume hospitals, who were older and with co-morbidities [17]. A study evaluating the impact of surgeon volume, reported total LOS to be 1.3 days shorter among high-volume surgeons and post-operative LOS reduced by 0.92 days, when high volume surgeons were compared to low volume surgeons [18].

In the Republic of Ireland, current EAS practices and comparative LOS measures have not, to date been reported. Our objective was to perform such an analysis. Specifically, this study explores the variation in hospital LOS and hospitals categorised by the volume of hospital episodes. LOS was the primary outcome used, as a proxy measure for resource utilisation. Results from such analysis can inform policy decisions and provide important contributions to the debate about future planning and quality and efficiency improvements of EAS services in Ireland.

Methods

I Healthcare Context

In the Republic of Ireland, all residents are entitled to receive publicly funded health care, organised and delivered by the Health Service Executive (HSE). Public hospitals are divided into seven hospital groups with geographically defined catchment areas, with each group designated to at least one Cancer Centre and other hospitals, classified into 4 levels ("models"), providing increasing complexity care at each level. Model 3 hospitals provide acute surgical services to undifferentiated surgical patients, and model 4 hospitals, additionally, accept tertiary referrals [19]. Twenty-four hospitals provide acute surgical services, with 24-hour on-call operations for emergency services. In each hospital, data from patient medical records is coded by trained coders and submitted to the national Hospital In-Patient Enquiry (HIPE) System. The National Quality Assurance & Improvement System (NQAIS) is a data extraction system by which HIPE data can be retrieved and analysed [20]. This study is reported according to the RECORD Guidelines, an extension to the STROBE Guidelines [21].

II Data Material and Extraction

Each HIPE discharge record holds demographic, clinical and administrative data for completed in-patient episodes. All procedures and diagnoses are coded according to the Australian Classification of Health Interventions (8th Ed.), and the International Classification of Diseases (ICD-10-AM, 2013) [22]. All public hospitals reporting data to HIPE were included in this study. From the NQAIS Clinical database 2014-2017, primary procedure codes representing EAS were identified by general and colorectal surgeons, delivering emergency intra-abdominal surgery (Appendix I). Appendicectomy was excluded, as it represents different risk and complexity relative to other intra-abdominal procedures. Data relating only to emergency hospital discharges for patients over 16 years were included, and no restriction was imposed on clinical specialty. Children's hospitals and hospitals with a volume of less than 10 annual EAS procedures were also excluded. For each hospital episode, the following variables were available: sex, age, medical card status (indicates entitlement to receive free public health services based on socio-economic indicators), cancer diagnosis (based on primary diagnosis), source of admission (home, other hospital, nursing home), intensive care unit (ICU) admission, length of stay measures, discharge destination, Charlson comorbidity score index (CCI) categorization (0 (no comorbidity), 1-3, 4-6, 7-9, 10+ (high comorbidity)).

The primary outcome measure was LOS, and we used four readily available variables in the NQAIS system:

1. Total LOS - duration from admission to discharge.
2. Pre-operative LOS - duration from admission to first surgery.
3. Post-operative LOS – duration from first surgery to discharge.
4. ICU LOS –time spent in intensive care.

III Volume Categorisation

To explore the variation between hospital volume and LOS, hospital volume was categorised by the total number of episodes of care during the study period into: low volume (n<200), medium volume (n=200-400), and high volume (n>400). The 25th and 75th percentile volumes were identified as cut-off points. One of the 8 designated national cancer centres was re-categorised from the medium to the high-volume group, to ensure all specialist regional centres represented this grouping. The medium volume group was used as the reference category.

IV Analysis

Variation of LOS associated with hospital volume was assessed. There was no substantial variation in patient case-mix, crude or adjusted LOS measures in the single years, thus, to increase statistical power, all four years of data were analysed together. Negative binomial regression models were used, often recommended for count data containing over dispersed variables [23, 24]. The predicted mean LOS measures for each hospital volume group are reported along with 95% confidence intervals (CI). We standardized patient case-mix by sex, age categories, medical card status, cancer diagnosis, CCI score, admission source, and ICU admission. The robustness of our findings was validated through sensitivity analyses on the following hospital episode exclusions: (1) Dead during hospital stay, (2) Primary cancer diagnosis, (3) Comorbidities, (4) Admission from other acute hospitals, and (5) Discharged to other acute hospitals. Additional sensitivity analysis, based on the dependent variable, was undertaken, excluding all LOS measures above the 95th percentile. Statistical analyses were performed using Stata 15.1. A p-value <0.05 was considered significant.

V Research Ethics and Patient Consent

All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards. For this type of study formal patient consent is not required. Ethical approval was granted by the Research Ethics Committee of the Royal College of Surgeons in Ireland (REC 001534).

Results

I Descriptive Analysis

During the study period (2014-2017), 8120 EAS episodes occurred at 24 public Irish hospitals. 7 hospitals were categorized as low, 9 as medium, and 8 as high-volume hospitals. The variation in patient case mix between all hospital volume groups was not profound, as indicated in Table 1. The majority of patients were female, 55.2%, 52.4% and 52.1% in low, medium and high volume, respectively. Patients admitted to high volume hospitals were 1.7 years older relative to the other hospitals. More patients in high volume hospitals had medical cards which entitles older citizens with incomes below a threshold or with a chronic or expensive condition free or reduced rate medical treatment. (44% vs 36%). The proportion of patients with cancer diagnosis was similar for the three groups. High volume hospitals had more patients admitted from other hospitals and more patients with comorbidities (CCI>10), although low and medium volume hospitals also had patients admitted from other hospitals. The proportion of patients who died during hospital admission was similar for all three hospital groups (7%). Total mean length of stay was 20.7 days and 23.2 days in low and high-volume hospitals, respectively.

II Volume Analysis

Table 2 summarises the adjusted mean LOS measures classified by hospital volume. Statistically significant differences across all LOS measures was observed. The mean total LOS was significantly longer in high volume hospitals, 24.7 days (CI 24.1-25.4) relative to low and medium volume (18.2 days; CI 17.3-10.1, and 18.6 days; CI 17.9-19.2). Similarly, the mean pre-operative LOS and post-operative LOS was significantly longer at high volume hospitals, 5.2 days (CI 4.9-5.4), and 19.5 days (CI 19.9-20.1), respectively. In contrast, the mean ICU LOS was significantly higher at low volume hospitals, 5.7 days (CI 4.8-6.4), and similar for medium and high-volume hospitals at 3.4 (CI 3.0-3.7) and 2.4 days (CI 2.2-2.6), respectively.

III Sensitivity Analysis

We validated the robustness of our results through sensitivity analysis, by comparing the results after excluding certain hospital episodes. Table 3 summarises these results, reporting the difference in adjusted days between the three volume groups. Additional analysis excluding patient cases with extremely long length of stay was performed, to determine whether cases with extreme LOS influenced the variation.

IV Excluding Episodes Discharged as Dead

622 hospital episodes were related to death during hospital stay. Excluding these episodes did not change the difference between the volume groups seen in the full data set. Total mean LOS was 7.1 and 6.6 days shorter at low and medium volume hospitals, respectively, relative to high volume (p<0.01). Pre-operative LOS was 0.8 (p=0.01) and 1.3 (p<0.01) days shorter at low and medium volume hospitals, respectively, compared to high volume hospitals. Similarly, post-operative LOS was shorter at low and medium volume hospitals compared to high volume (6.1 days; p<0.01; 5.0 days; p<0.01). ICU LOS at low volume hospitals was longer by 1.4 days (p<0.01), relative to medium volume. No significant differences were observed for high volume hospitals.

V Excluding Episodes with Cancer Diagnosis

After excluding episodes with cancer diagnoses the mean total LOS was 6.7 (p<0.01) and 6.3 (p<0.01) days shorter in low and medium vs high volume hospitals. Compared to all episodes, the difference between low and high-volume hospitals changed in pre-operative LOS from 5.7 to 0.6 days longer, and the difference in post-operative LOS expanded; episodes at high volume hospitals stayed 5.8 days longer compared to low volume hospitals. The longer ICU stay at low volume hospitals did not change.

VI Excluding Episodes with Comorbidity

3,011 patient episodes with CCI>0 were reported. Episodes with no registered comorbidity indicated shorter total LOS at low and medium volume hospitals, relative to high volume (5.5 days; p<0.01; 5.1 days; p<0.01), with a reduction of approximately 1 day, between all groups. Pre- and post-operative LOS was shorter at low and medium volume hospitals, and the exclusion reduced the difference between total and pre-operative LOS and increased the difference in post-operative stay.

VII Excluding Episodes Admitted and Discharged from Other Hospitals

Exclusion of episodes admitted from or discharged to other hospitals reduced the difference between low and medium volume hospitals relative to high volume hospitals with shorter post-operative stays at low and medium hospitals. Finally, after excluding patient cases with LOS measures above the 95th percentile, we saw a substantial reduction in LOS difference between the three volume groups. However, these differences were not statistically significant, and did not influence the LOS variation.

Table 1: Descriptive analysis of hospital episodes included in the study.

		Low Volume	**Medium Volume**	**High Volume**
n		1129	2427	4564
Sex (%)	Male	506 *(44.8%)*	1156 *(47.6%)*	2186 *(47.9%)*
Age group (%)	<30 yrs	70 *(6.2%)*	153 *(6.3%)*	356 *(7.8%)*
	30-39 yrs	90 *(7.9%)*	208 *(8.6%)*	436 *(9.6%)*
	40-49 yrs	143 *(12.7%)*	289 *(11.9%)*	507 *(11.1%)*
	50-59 yrs	152 *(13.5%)*	344 *(14.2%)*	733 *(16.1%)*
	60-69 yrs	234 *(20.7%)*	437 *(18.0%)*	934 *(20.5%)*
	70-79 yrs	246 *(21.8%)*	599 *(24.6%)*	927 *(20.3%)*
	>79 yrs	194 *(17.2%)*	397 *(16.4%)*	671 *(14.6%)*
Medical Card (%)	Yes	414 *(36.7%)*	880 *(36.3%)*	2008 *(44.0%)*
Cancer Diagnosis (%)	Yes	175 *(15.5%)*	389 *(16.0%)*	687 *(15.1%)*
Admission Source (%)	Home	1067 *(94.5%)*	2299 *(94.7%)*	4150 *(90.9%)*
	Other Hospital	26 *(2.3%)*	74 *(3.1%)*	363 *(7.9%)*
	Nursing Home	36 *(3.2%)*	54 *(2.2%)*	51 *(1.2%)*
Charlson comorbidity index score (%)	0	764 *(67.7%)*	1620 *(66.7%)*	2822 *(61.8%)*
	1-3	41 *(3.6%)*	109 *(4.5%)*	169 *(3.7%)*
	4-6	43 *(3.8%)*	115 *(4.7%)*	251 *(5.5%)*
	7-9	56 *(4.9%)*	99 *(4.1%)*	281 *(6.2%)*
	10+	225 *(20.0%)*	484 *(20.0%)*	1041 *(22.8%)*
ICU admission (%)	Yes	698 *(61.8%)*	1124 *(46.3%)*	1396 *(30.6%)*
Discharge destination (%)	Home	826 *(73.2%)*	1871 *(77.1%)*	3397 *(74.4%)*
	Nursing Home	141 *(12.5%)*	275 *(11.3%)*	527 *(11.6%)*
	Transfer	75 *(6.6%)*	92 *(3.8%)*	294 *(6.4%)*
	Death	87 *(7.7%)*	189 *(7.8%)*	346 *(7.6%)*
Total LOS	Mean [SD]	20.7 [24.2]	19.3 [24.3]	23.2 [30.4]
Pre-operative LOS	Mean [SD]	4.5 [8.4]	3.8 [8.2]	5.1 [10.1]
Post-operative LOS	Mean [SD]	16.2 [21.5]	15.4 [21.7]	18.1 [26.8]
ICU LOS	Mean [SD]	4.5 [8.0]	2.9 [6.7]	2.6 [9.7]

n number of patients, *%* percentage of the total number of patient cases within the specified hospital volume group

Table 2: Adjusted mean Length of Stay (LOS) Measures by Hospital Volume.

	Low Volume [95%CI]	**Medium Volume [95% CI]**	**High Volume [95% CI]**
Total LOS	18.2 [17.3–19.1]	18.6 [17.9-19.2]	24.7 [24.1-25.4]
Pre-operative LOS	4.4 [4.0-4.8]	3.8 [3.6-4.0]	5.2 [4.9-5.4]
Post-operative LOS	13.8 [13.1-14.5]	14.9 [14.4-15.4]	19.5 [18.9-20.0]
ICU LOS	5.6 [4.8-6.4]	3.4 [3.0-3.7]	2.4 [2.2-2.6]

All LOS measures are adjusted for sex, age, medical card status, admission source, Charlson comorbidity index, cancer diagnosis, ICU admission. All measures represent the adjusted mean number of days

Discussion

Our results indicate EAS patients have shorter adjusted LOS at low and medium volume Irish public hospitals in comparison to high volume hospitals. No substantial difference in total LOS between low and medium volume hospitals was observed. These results are different to those of previous studies, reporting statistically shorter LOS at high volume hospitals for patients post high-risk surgery [12, 14, 25, 26]. The total LOS difference between low and medium volume hospitals was insignificant, however patients at low volume hospitals stayed longer pre-operatively and shorter post-operatively. The adjusted post-operative LOS estimates in our study are shorter to those in the UK, with post-operative LOS for EAS patients estimated at 15 days [27]. In contrast, shorter post-operative LOS among high volume hospitals has been reported in other studies [28].

Pre-operative LOS across all volume groups was relatively long, considering all patients were admitted as emergency patients, reflecting potentially restricted access to diagnostics and operating theatres. It has been proposed that by developing acute surgical assessment units, the pathway for selected acute surgical patients would be shortened, thus leading to reductions in pre-operative LOS [29]. Furthermore, we observed that low volume hospitals admitted more patients to ICU who also had longer ICU stays, compared to medium and high-volume hospitals. This could reflect higher capacity and availability of ICU resources at low volume hospitals and could be explained by better availability and less demand of ICU capacity at low volume hospitals, relative to high volume hospitals. Our sensitivity analyses confirm the robustness of our primary analysis. After excluding episodes with different characteristics, no single factor influenced the difference in

LOS between all volume groups. Post-operative stays at low and medium volume hospitals were shorter versus high volume hospitals, in contrast to the literature [13]. Similarly, after the exclusion of extremely long LOS measures, no statistical differences were observed, and could be a reflection of the unequal distribution of long LOS between all volume groups.

Our analysis demonstrates a considerable LOS advantage when patients are treated in low volume hospitals. However, it is possible that variation in case selection between hospitals exists, although our data fails to demonstrate differences between patients based on available measures of co-morbidity. Additionally, this study illustrates that reconfiguration of resources for high-risk emergency surgery may be necessary, through improved governance for EAS. In the UK, the implementation of the National Emergency Laparotomy Audit (NELA) recommendations, has observed relative improvements in the quality of EAS care provision, through increased resource use [30]. Such national audits providing benchmark indicators for improved quality of service delivery, are important for ensuring that well-informed and efficient resource allocation decisions are made. Implementation of a NELA-like audit process could allow for analysis of specific factors contributing to more efficient resource allocation, and shorter LOS, in high-volume hospitals. However, this would be both financially and logistically difficult in the Irish context.

Table 3: Sensitivity Analysis - Difference in days between LOS measures for all hospital volumes after episode exclusion.

	All episodes n=8120	Excl. Dead n=7498	Excl. Cancer n=6869	Excl. Charlson>0 n=5109	Excl. Hosp. admissions n=7657	Excl. Hosp. discharges n=7659
LOS						
Low vs High	-6.6 (<0.01)	-7.1 (<0.01)	-6.7 (<0.01)	-5.5 (<0.01)	-6.2 (<0.01)	-6.4 (<0.01)
Medium vs High	-6.2 (<0.01)	-6.6 (<0.01)	-6.3 (<0.01)	-5.1 (<0.01)	-6.0 (<0.01)	-6.3 (<0.01)
Low vs Medium	-0.4 (0.58)	-0.5 (0.42)	-0.4 (0.60)	-0.5 (0.46)	-0.1 (0.84)	-0.2 (0.80)
Pre-op LOS						
Low vs High	-1.4 (<0.01)	-0.8 (0.01)	-0.7 (0.02)	-0.8 (0.01)	-0.7 (0.01)	-0.8 (0.01)
Medium vs High	0.7 (0.01)	-1.3 (<0.01)	-1.3 (<0.01)	-1.4 (<0.01)	-1.4 (<0.01)	-1.5 (<0.01)
Low vs Medium	-5.7 (<0.01)	0.5 (0.05)	0.6 (0.02)	0.6 (0.01)	0.7 (0.01)	0.7 (0.01)
Post-op LOS						
Low vs High	-1.1 (0.06)	-6.1 (<0.01)	-5.8 (<0.01)	-4.6 (<0.01)	-5.3 (<0.01)	-5.5 (<0.01)
Medium vs High	0.3 (0.49)	-5.0 (<0.01)	-4.7 (<0.01)	-3.5 (<0.01)	-4.4 (<0.01)	-4.7 (<0.01)
Low vs Medium	-1.0 (0.02)	-1.1 (0.05)	-1.0 (0.11)	-1.0 (0.06)	-0.9 (0.12)	-0.9 (0.13)
ICU LOS						
Low vs High	0 (<0.01)	0.3 (0.58)	0 (0.98)	0.4 (0.41)	0.6 (0.25)	0.5 (0.32)
Medium vs High	0 (<0.01)	-1.2 (<0.01)	-1.4 (<0.01)	-0.8 (0.06)	-0.7 (0.08)	-1.1 (0.01)
Low vs Medium	0 (<0.01)	1.4 (<0.01)	1.4 (0.01)	1.2 (0.01)	1.3 (<0.01)	1.6 (<0.01)

All measures represent adjusted mean difference in the number of days; *p*-values are represented in parenthesis

Centralisation of EAS services has occurred to a variable extent in Ireland, with higher-risk patients transferred to larger hospitals in some, but not all, hospital groups. Our health system lacks unique patient identifiers, and one limitation of our dataset is incomplete information about transferred patients. Shorter LOS in low volume hospitals may be due to more complex patients being transferred to other institutions. Similarly, longer LOS in high volume hospitals may be due to the limited available capacity at step-down facilities, resulting in patients 'bed blocking' until discharge. The limitations of this study are those inherent to the interpretation of administrative databases. Data accuracy is critically dependent on coding performed at hospital level from clinical records. HIPE consists of administrative data at the time of discharge, not clinical data. Therefore, all hospital episodes extracted from the NQAIS Clinical system using the principal procedure code for each patient admitted to hospital as an emergency patient, does not take into consideration any prior elective procedure. The lack of information about secondary and subsequent procedures may influence some of the LOS measures, thus affecting the total LOS and making it longer.

Furthermore, the volume per hospital does not, and should not be interpreted as a reflection of the volume of surgical teams at these hospitals. Our data suggests that these procedures are carried out by a high number of surgeons at each hospital. Not all high-volume surgical teams were located across all high-volume hospitals. However, given the complex coding nature of surgical teams within the NQAIS Clinical system, surgical team volume may appear to be higher among certain hospitals, than the actual volume.

Conclusion

EAS patients are discharged earlier from low volume hospitals, than larger volume hospitals. This suggest that service concentration to larger clinical departments may not necessarily reduce LOS and therefore may have little influence on improving the efficiency of resource consumption. Reconfiguration of EAS services and more efficient resource allocation may reduce the observed variation in adjusted LOS measures. However, large specialised hospitals may have better opportunities to retain and recruit staff, particularly surgical specialists, to high-volume departments. These departments may also have better opportunities to provide more efficient services and explore economies of scale to provide less costly, high quality care. Better analyses of these aspects are needed to support the debate about restructuring emergency surgical services.

Conflicts of Interests

The Authors declare that there is no conflict of interest.

Funding

This research received no specific grant from any funding agency in the public, commercial, or not-for-profit sector.

Acknowledgements

The authors acknowledge the Healthcare Pricing Office as the source of HIPE (Hospital In-Patient Enquiry) data which is utilised in NQAIS Clinical. The authors also acknowledge the Clinical Leads of the National Clinical Programme in Surgery, the NQAIS Clinical Steering Group, the HORC-NCP research group, and the Acute Hospital Division (HSE) for providing access to NQAIS Clinical

REFERENCES

1. Tolstrup MB, Watt SK, Gogenur I (2017) Morbidity and mortality rates after emergency abdominal surgery: an analysis of 4346 patients scheduled for emergency laparotomy or laparoscopy. *Langenbecks arch of surg* 402: 615-623. [Crossref]
2. Saunders DI, Murray D, Pichel AC, Varley S, Peden CJ (2012) Variations in mortality after emergency laparotomy: the first report of the UK Emergency Laparotomy Network. *Br J Anaesth* 109: 368-375. [Crossref]
3. Green G, Shaikh I, Fernandes R, Wegstapel H (2013) Emergency laparotomy in octogenarians: A 5-year study of morbidity and mortality. *World J of Gastrointes Surg* 5: 216-221. [Crossref]
4. Philbin EF, McCullough PA, Dec GW, DiSalvo TG (2001) Length of stay and procedure utilization are the major determinants of hospital charges for heart failure. *Clin Cardiol* 24: 56-62. [Crossref]
5. Zhu HF, Newcommon NN, Cooper ME, Green TL, Seal B (2009) Impact of a stroke unit on length of hospital stay and in-hospital case fatality. *Stroke* 40: 18-23. [Crossref]
6. Fleming I, Monaghan P, Gavin A, O'Neill C (2008) Factors influencing hospital costs of lung cancer patients in Northern Ireland. *Eur J of Health Econ* 9: 79-86. [Crossref]
7. Walsh T, Onega T, Mackenzie T (2014) Variation in length of stay within and between hospitals. *J Hosp Admin* 3: 53-60.
8. Lorenzoni L, Marion A (2017) Understanding variations in length of stay and cost: Results of a pilot project. Paris: OECD Publishing.
9. Morgan M, Beech R (1990) Variations in lengths of stay and rates of day case surgery: implications for the efficiency of surgical management. *J Epidemiol Community Health* 44: 90-105. [Crossref]
10. Chattha A, Muste J, Patel A (2018) The impact of hospital volume on clinical and economic outcomes in ventral hernia repair: an analysis with national policy implications. *Hernia* 22: 793-799. [Crossref]
11. Kuo EY, Chang Y, Wright CD (2001) Impact of hospital volume on clinical and economic outcomes for esophagectomy. *Ann Thorac Surg* 72: 1118-1124. [Crossref]
12. Philip P Goodney, Therese A Stukel, F Lee Lucas, Emily VA Finlayson, John D Birkmeye (2003) Hospital volume, length of stay, and Readmission Rates in High-Risk Surgery. *Ann Surg* 238: 161-167. [Crossref]
13. Giwa F, Salami A and Abioye AI. Hospital esophagectomy volume and postoperative length of stay: A systematic review and meta-analysis. *Am J Surg* 2018; 215: 155-162. [Crossref]
14. Baek JH, Alrubaie A, Guzman EA, Choi SK, Anderson C et al. (2013) The association of hospital volume with rectal cancer surgery outcomes. *Int J Colorectal Dis* 28: 191-196. [Crossref]
15. Nugent E, Neary P (2010) Rectal cancer surgery: volume-outcome analysis. *Int J Colorectal Dis* 25: 1389-1396. [Crossref]
16. Mehta A, Efron DT, Canner JK, Dultz L, Xu T et al. (2017) Effect of Surgeon and Hospital Volume on Emergency General Surgery Outcomes. *J Am Col Surg* 225: 666-675. [Crossref]
17. Kelly M, Sharp L, Dwane F (2012) Factors predicting hospital length-of-stay and readmission after colorectal resection: a population-based study of elective and emergency admissions. *BMC Health Serv Res* 12: 77. [Crossref]
18. Yi D, Monson JRT, Stankiewicz CC, Atallah S, Finkler NJ et al. (2018) Impact of colorectal surgeon case volume on outcomes and applications to quality improvement. *Int J Colorectal Dis* 33: 635-644. [Crossref]
19. Mealy K, Keane F, Kelly P, Kelliher G et al. (2017) What is the future for General Surgery in Model 3 Hospitals? *Ir J Med Sci* 186: 225-233. [Crossref]
20. Royal College of Surgeons in Ireland (RCSI). NQAIS (National Quality Assurance and Improvement System), (2017, accessed 17 Aug 2018).
21. Benchimol EI, Smeeth L, Guttmann A, Harron K, Moher D et al. (2015) The REporting of studies Conducted using Observational Routinely-collected health Data (RECORD) statement. PLoS med 12: e1001885. [Crossref]
22. Healthcare Pricing Office (2019) Irish Coding Standards (ICS) Dublin, Ireland.
23. Deb P, Norton E Manning W (2017) Health Econometrics Using Stata. Stata Press, 2017.
24. Moran JL Solomon PJ, ANZICS Centre for Outcome and Resource Evaluation (CORE) of the Australian and New Zealand Intensive Care Society (ANZICS) (2012) A review of statistical estimators for risk-adjusted length of stay: analysis of the Australian and New Zealand Intensive Care Adult Patient Data-Base, 2008-2009. BMC Med Res Methodol 12: 68. [Crossref]
25. Kim W, Wolff S, Ho V (2016) Measuring the Volume-Outcome Relation for Complex Hospital Surgery. *Appl Health Econ Health Policy* 14: 453-464. [Crossref]
26. Borowski DW, Bradburn DM, Mills SJ (2010) Volume-outcome analysis of colorectal cancer-related outcomes. *Br J Surg* 97: 1416-1430. [Crossref]
27. Stephens N, Dolan R, Dorrance H (2015) The emergency laparotomy; post-operative mortality and length of stay in hospital. Int J Surg 23.
28. Enomoto LM, Gusani NJ, Dillon PW, Hollenbeak CS (2014) Impact of surgeon and hospital volume on mortality, length of stay, and cost of pancreaticoduodenectomy. *J Gastrointest Surg* 18: 690-700. [Crossref]
29. Flynn M, Logan J, Ridgway P (2017) Minimum Standards for Acute Surgical Assessment Units. 2017. Dublin: Royal College of Surgeons in Ireland.
30. National Emergency Laparotomy Audit Project Team (2017) Third Patient Report of the National Emergency Laparotomy Audit. Royal College of Anaesthetists, London.