Appendix 1 (as supplied by the authors): Evaluation and reporting of wait times for surgery for hip fracture in Canada

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Appendix 1A 'Database codes for cohort inclusion'

Administrative data utilized:
Data were obtained from several administrative databases linked at the Institute for Clinical Evaluative Sciences (ICES; www.ices.on.ca). Databases included:

(A) the Ontario Health Insurance Plan (OHIP) billing databases, a single-payer universal health care system provider which identifies physician claims for services with high accuracy (96%)(1);
(B) the Discharge Abstract Database (CIHI-DAD) and the National Ambulatory Care Reporting System (NACRS), which contain detailed diagnostic and procedural information about all hospital admissions and ED visits;(2) and
(C) the Registered Persons Database (RPD) and the OHIP Physician Database (IPDB), containing demographic information about patients and physicians, respectively.

These data have been used previously to study hip fracture patients.(3-6) Sensitivity and positive predictive values for International Classification of Diseases 10th Revision (ICD-10) hip fracture diagnoses in these databases are 0.95 (95% CI: 0.93 to 0.97) and 0.95 (95% CI: 0.92 to 0.97), respectively.

Cohort inclusion (one of each):

A) International Classification of Diseases, Tenth Revision (ICD-10) diagnostic code:
    a. S72.0 (fracture of head and neck of femur); S72.1 (Pertrochanteric fracture); or S72.2 (Subtrochanteric fracture); and
B) OHIP Physicians Billings Database code:
    a. F100 (fixation); F096 (IMN); F101; R440; or R439 (arthroplasty); and
C) Canadian Classification of Health Interventions (CCI) code:
    a. 1VA53; 1VA74; 1VA80; 1VC74; or 1VC80
D) Not shaft or distal femur fracture: (ICD 10) S72.3, S72.4, S72.8, S72.9

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Appendix 1B 'Cohort exclusions'

Supplementary Table 1. Impact of the study entry criteria.

Inclusion criteria:	N=
Hip fracture surgical procedures in Ontario during study period	48,627
Exclusion criteria:	
Non-Ontario resident	31
Dead before or on index date	8
Non orthopaedic surgeon	351
Prior hip fracture	1,997
Missing emergency presentation time data	1,460
Hip fracture occurring in-hospital	440
Elective hospital admission	1,002
Low volume hospital (<5 hip fracture procedures during study period)	34
Age<45	746
Hip fracture surgery delayed > 10 days	328
Eligible hip fracture fixation procedures (total study cohort size)	42,230

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Appendix 1C 'Linear and Hierarchical Regression'

a) Linear regression assumptions

There were 1722 statistical outliers present in the cohort with 'rstudent' or 'Dffits' values greater than 2. We then assessed the extent to which our linear regression model adhered to important assumptions in cohorts (a) with and (b) without these outlier patients:

- R-square values were calculated to measure model fit.
- Residuals were graphically represented in Q-Q plots as well as statistically tested to confirm normality (skewness and kurtosis).
- Residual plots were also used to confirm each model's linearity and absence of heteroscedasticity.

Model parameters were improved by excluding the outlier patients (see next page, right versus left panel). The single-level linear regression (Table 2) was conducted among the remaining 40,508 patients (without outliers).

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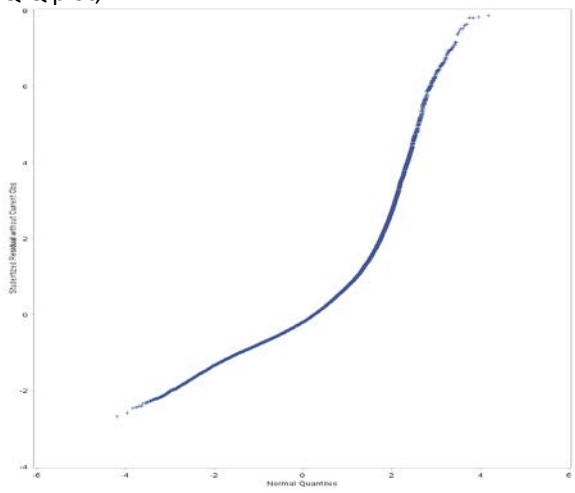
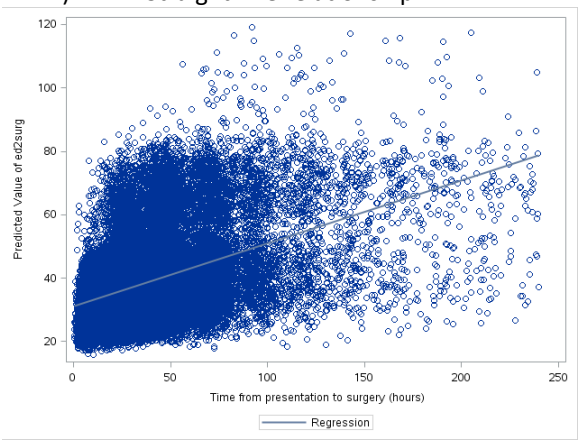
ENTIRE COHORT

R-SQUARE: .198

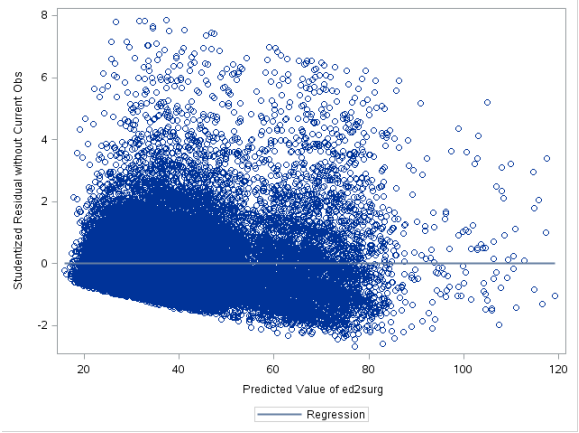
i) Normality of residuals:
SKEWNESS: 2.1
KURTOSIS: 8.2
Q-Q plot,



ii) Straight-line relationship:



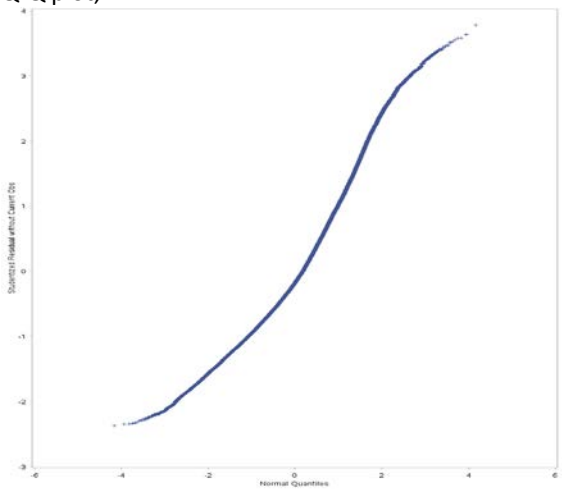
iii) Heteroscedasticity:



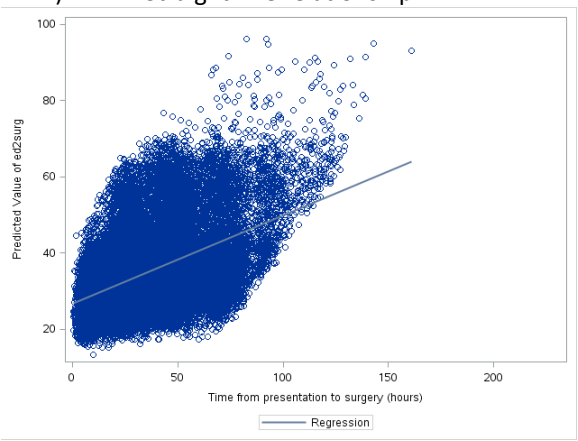
ENTIRE COHORT WITHOUT 1722 OUTLIERS

R-SQUARE: .231

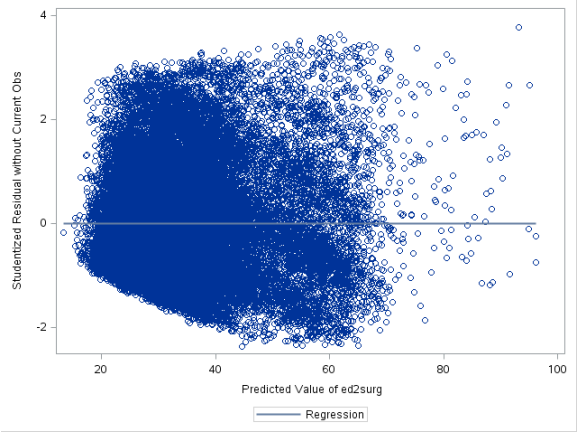
i) Normality of residuals:
SKEWNESS: 0.7
KURTOSIS: 0.2
Q-Q plot,



i) Straight-line relationship:



ii) Heteroscedasticity:



*ed2surg; Time from hospital arrival to surgery

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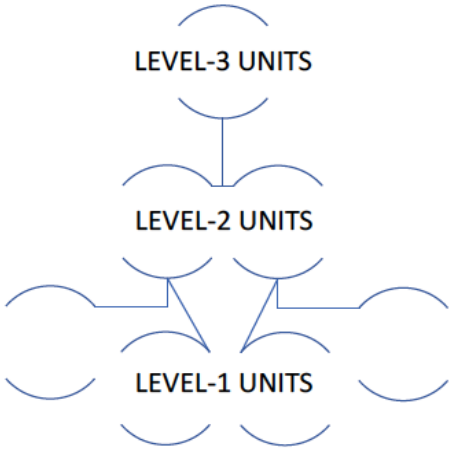
b) Hierarchical regression

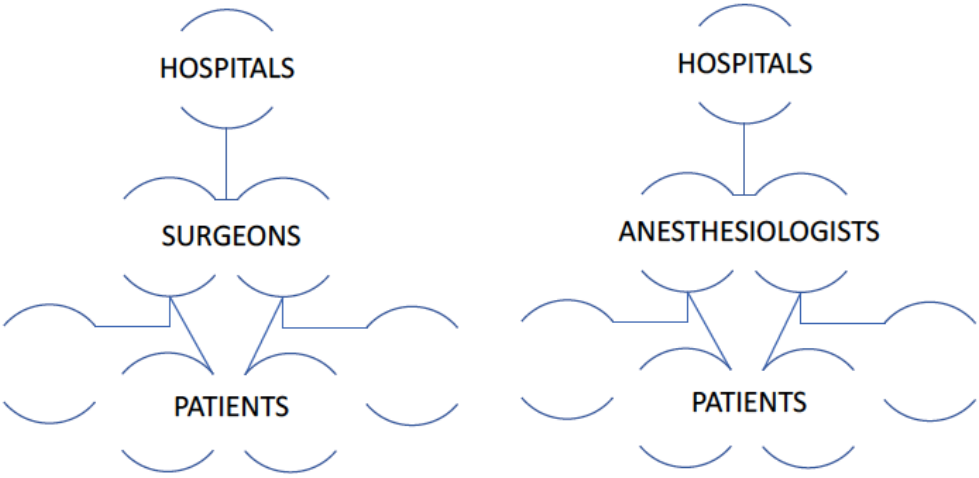
To further explore the impact of individual providers and hospital systems on wait time variability, we also developed three-level hierarchical linear regression models. The random effects output from this model provided each provider's and hospital's unique beta coefficient (in hours) and 95% CI, after adjusting for patient case mix. The following patient-level fixed effects were adjusted for in the models: age, sex, year of surgery, income quintile, Charlson group, history of frailty, diabetes, coronary artery disease, COPD, coronary artery disease, pre-admission institutionalization, ISS, fracture and surgery type.

Hospital estimates were adjusted for patient case mix and physician random effects (reported from the hospital-surgeon-patient model). Physician estimates were adjusted for both patient case mix and hospital random effects.

Hierarchical data generally can be displayed as follows:



The two provider scenarios we considered were:



Surgeons and anesthesiologists were considered in separate models as 'physicians'. No observations, except those with missing values, were excluded from these analyses to assess the full impact of variation. Individual surgeon wait time estimates were thus calculated amongst 522 surgeons treating 42,025 patients. The anesthesiologist conducting the preoperative anesthetic consultation, when one occurred, was the 'anesthesiologist' considered in this analysis. Individual anesthesiologist wait time estimates were calculated amongst 963 anesthesiologists treating 11,343 patients who had preoperative anesthetic consultations. Cross-classified hierarchical models were used to account for surgeons and anesthesiologists working at more than one hospital.

Appendix 1D 'Adjusted Mortality, Complications and Costs by Hospital and Surgeon'

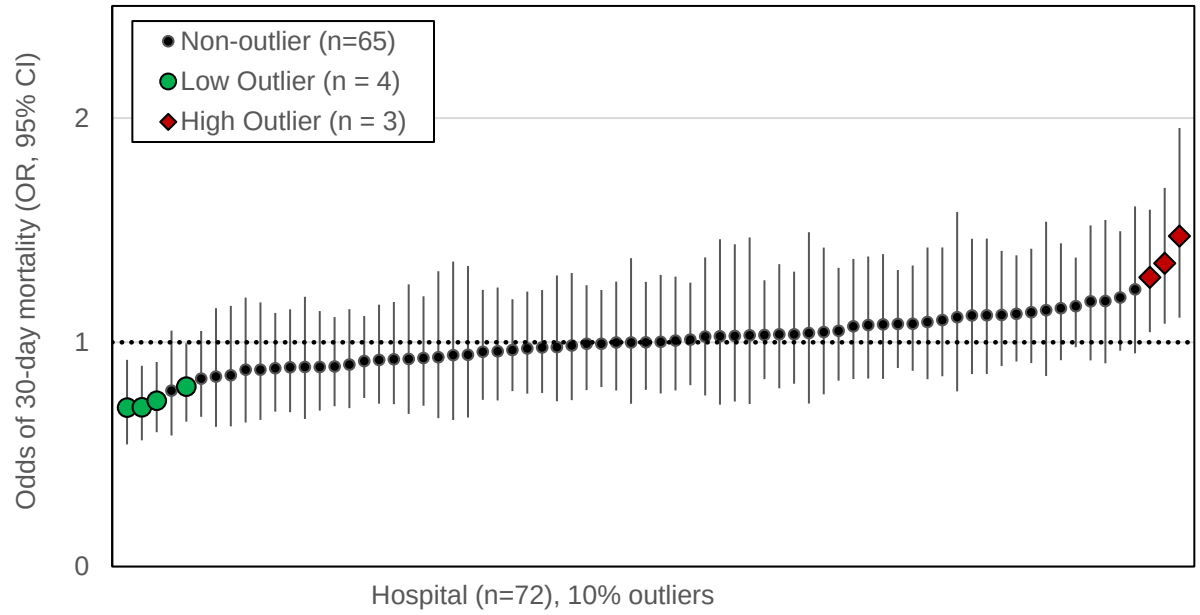
We repeated the process described in Appendix C to assess the adjusted (i) odds of 30-day mortality, (ii) odds of inpatient surgical complications, and (iii) medical costs of hip fracture care at each hospital and surgeon in the Province.

"Inpatient surgical complications" included intra-operative surgical complications and significant medical complications (urinary tract infection, DVT, MI, confusion, pneumonia), among others, and were chosen based upon their clinical relevance and reduced risk of misclassification. The set of specific codes identifying these complications have been used several times previously and are published elsewhere.(3, 6, 7) Multilevel logistic regression models were then fit for 30-day mortality and surgical complications.(8) The random effects output from this model provided each provider's and hospital's unique adjusted outcomes compared to the average, after adjustment for the covariates discussed in Appendix C [i.e. adjusted odds ratio (OR) and 95% CI]. The random effects output from this model provided each provider's and hospital's unique odds ratio (OR) with 95% CI for patient 30-day mortality and surgical complications, after adjustment for case-mix and the hospital / physician random effects. The proportion of providers and hospitals that were 'outliers' compared to their peers were then described: 'low outliers' were those with the upper limits of the 95% CI less than 1 and 'high outliers' were those with a lower limit of their 95% CI greater than 1.(9, 10)

Medical costs (inflated to 2013 Canadian dollars) in the year before and after admission for hip fracture were calculated for each patient using previously established methods.(4) "Hip fracture attributable costs" were modeled and defined as the difference between the baseline cost for the year prior to the injury and the costs accrued in the first year following. A multilevel, linear regression model was then fit for medical costs. 'Low outliers' and 'high outliers' were again identified.

The results of these multilevel regression analyses are displayed in Supplementary Figures 1, 2 and 3. Zero surgeon and anesthesiologist outliers were identified in terms of their adjusted odds of mortality, odds of complications or medical costs and thus were not plotted. In contrast, and similar to wait times, adjusted odds of mortality, surgical complications and medical costs varied significantly between hospitals (10%, 17%, and 39% were 'outliers' for each outcome, respectively).

Supplementary Figure 1. Patient odds (OR, with 95% CIs) of **30-day mortality** at each hospital in Ontario were estimated in a multilevel logistic regression model that adjusted for patient case mix and physician random effects.



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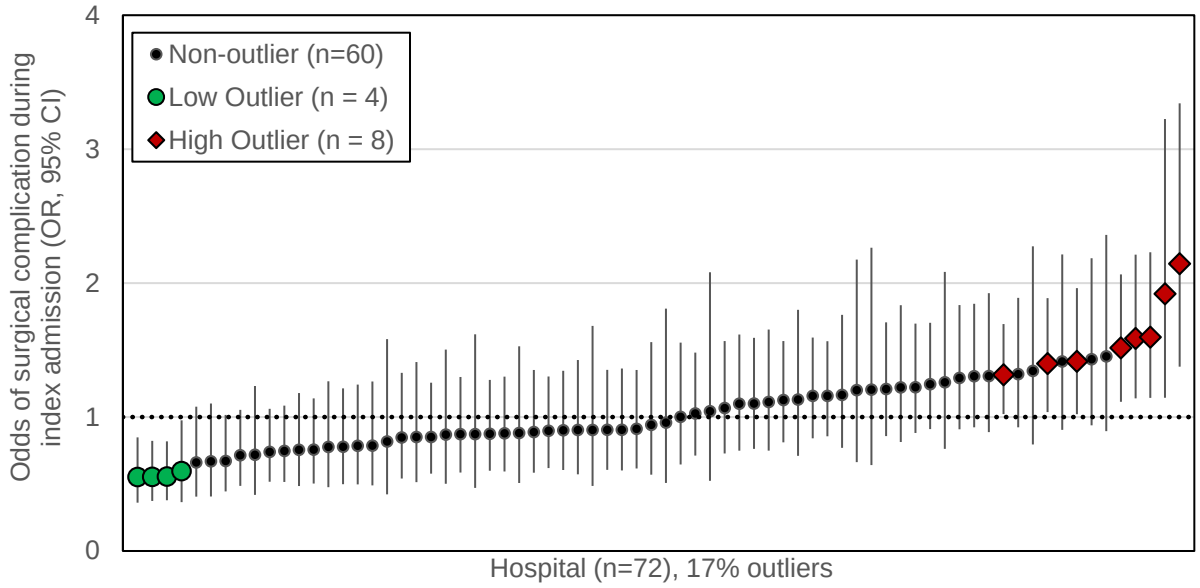
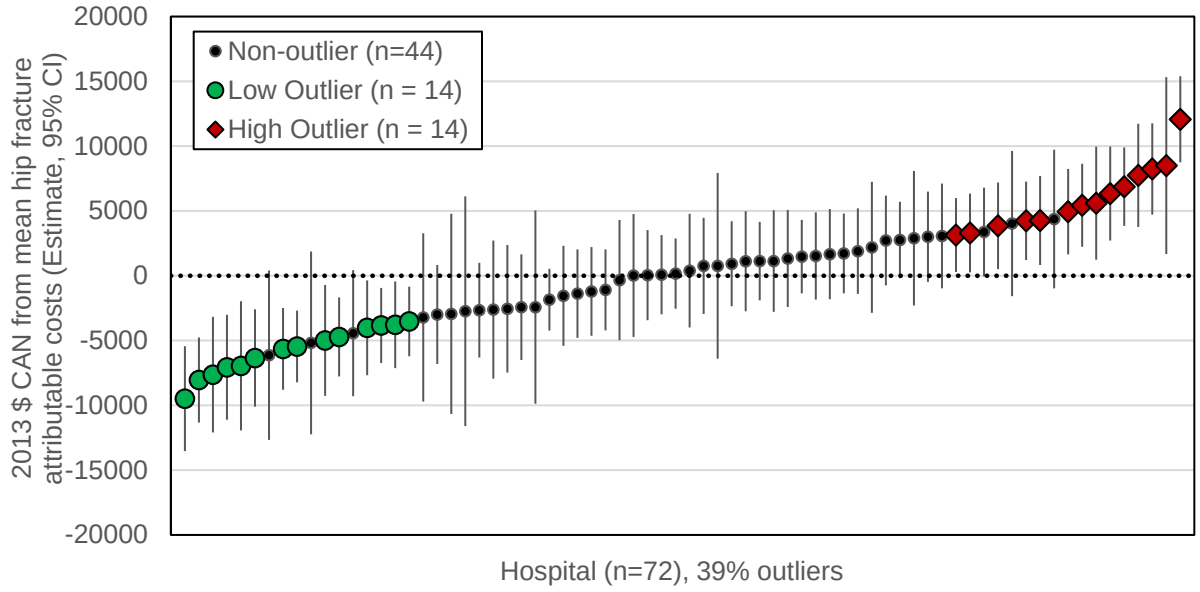
Supplementary Figure 2. Patient odds (OR, with 95% CIs) of suffering a **surgical complication during their index admission** at each hospital in Ontario were estimated in a multilevel logistic regression model that adjusted for patient case mix and physician random effects.



Supplementary Figure 3. Each hospital's mean difference (in 2013 $ CAN, with 95% CIs) from the average 1-year hip fracture attributable **health care costs** in the cohort was estimated in a multilevel linear regression model that adjusted for patient case mix and physician random effects.



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