**Use of failure to rescue to identify international variation in postoperative care:**

**Analysis of data from a seven day cohort study of elective surgery**

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**Supplementary table 1. Complications after surgery.**

**Output of the three level hierarchical generalised mixed modelling (mixed effect logistic regression). Patients were entered in the first level, hospitals in second level and countries in the third level. Population average was used as a reference for the countries. Country was added as a random effect in the model. Odds ratios and 95% confidence intervals (CI) for each country were produced by using the random effects estimates of each country. ASA, American Society of Anesthesiologists physical status score; COPD, chronic obstructive pulmonary disease.**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  | **Complications n (%)**  | **Unadjusted OR (95% CI)** | **Adjusted OR (95% CI)** | **p-value** |
|  |  |  |  |  |
| **Age** mean (SD) | 61.8 (16.0) | --- | --- | --- |
| Age spline 1 | --- | 1.01 (1.00 - 1.02) | 1.00 (0.99 - 1.01) | 0.63 |
| Age spline 2 | --- | 1.08 (1.04 - 1.12) | 1.04 (0.99 - 1.08) | 0.09 |
| Age spline 3 | --- | 0.77 (0.65 - 0.91) | 0.88 (0.73 - 1.06) | 0.18 |
| Age spline 4 | --- | 1.35 (0.99 - 1.83) | 1.25 (0.89 - 1.76) | 0.20 |
| **Current smoker** | 1305 (17.5) | 0.98 (0.92 - 1.04) | 1.02 (0.95 - 1.1) | 0.57 |
|   |   |   |   |   |
| **ASA score** |  |  |   |   |
| I | 848 (11.3) | Reference | --- | --- |
| II | 3005 (40.1) | 1.91 (1.76 - 2.07) | 1.38 (1.25 - 1.52) | <0.01 |
| III | 3090 (41.2) | 5.32 (4.91 - 5.78) | 2.39 (2.13 - 2.68) | <0.01 |
| IV | 554 (7.4) | 14.01 (12.17 - 16.12) | 4.30 (3.55 - 5.21) | <0.01 |
|   |   |   |   |   |
| **Severity of surgery** |  |  |   |   |
| Minor | 672 (8.9) | Reference | --- | --- |
| Intermediate | 2494 (33.2) | 1.62 (1.48 - 1.77) | 1.76 (1.59 - 1.94) | <0.01 |
| Major | 4336 (57.8) | 4.22 (3.87 - 4.60) | 4.12 (3.71 - 4.56) | <0.01 |
|   |   |   |   |   |
| **Surgical procedure** |  |  |   |   |
| Orthopaedics | 1556 (20.9) | Reference | --- | --- |
| Breast | 128 (1.7) | 0.46 (0.38 - 0.55) | 0.66 (0.54 - 0.81) | <0.01 |
| Obstetrics & gynaecology | 554 (7.4) | 0.55 (0.49 - 0.60) | 0.84 (0.75 - 0.95) | <0.01 |
| Urology & kidney | 720 (9.6) | 0.87 (0.79 - 0.96) | 0.98 (0.88 - 1.09) | 0.67 |
| Upper gastro-intestinal | 485 (6.5) | 1.63 (1.45 - 1.83) | 1.59 (1.4 - 1.82) | <0.01 |
| Lower gastro-intestinal | 748 (10.0) | 1.62 (1.47 - 1.79) | 1.73 (1.55 - 1.93) | <0.01 |
| Hepato-biliary | 366 (4.9) | 0.96 (0.85 - 1.09) | 1.15 (1 - 1.32) | 0.06 |
| Vascular | 410 (5.5) | 1.74 (1.53 - 1.97) | 1.21 (1.05 - 1.4) | 0.01 |
| Head & neck | 674 (9.0) | 0.58 (0.53 - 0.64) | 0.77 (0.69 - 0.86) | <0.01 |
| Plastics & cutaneous | 244 (3.2) | 0.86 (0.75 - 1.00) | 1.15 (0.98 - 1.36) | 0.09 |
| Cardiac | 979 (13.0) | 6.70 (6.00 - 7.47) | 2.82 (2.45 - 3.26) | <0.01 |
| Thoracic  | 305 (4.1) | 1.80 (1.57 - 2.08) | 1.51 (1.28 - 1.78) | <0.01 |
| Other | 328 (4.4) | 0.56 (0.50 - 0.64) | 0.79 (0.68 - 0.9) | <0.01 |
|   |   |   |   |   |
| **Co-morbidity** |  |  |   |   |
| Coronary artery disease | 1525 (20.3) | 2.85 (2.66 - 3.01) | 1.03 (0.94 - 1.12) | 0.59 |
| Heart failure | 775 (10.3) | 3.76 (3.42 - 4.13) | 1.24 (1.10 - 1.40) | <0.01 |
| Diabetes mellitus | 1319 (17.6) | 1.85 (1.73 - 1.98) | 1.10 (1.02 - 1.20) | 0.02 |
| Cirrhosis | 113 (1.5) | 2.47 (1.97 - 3.10) | 1.47 (1.12 - 1.91) | 0.01 |
| Stroke | 451 (6.0) | 2.22 (1.98 - 2.49) | 1.13 (0.99 - 1.29) | 0.07 |
| COPD/Asthma | 1012 (13.5) | 1.73 (1.60 - 1.86) | 1.12 (1.03 - 1.23) | 0.01 |
| Other | 4134 (55.2) | 1.94 (1.85 - 2.04) | 1.19 (1.12 - 1.27) | <0.01 |
|   |  |   |   |   |
| **Country\*** |   |  |   |   |
| AA | 176 (19.9) | 1.12 (0.95 - 1.32) | 0.90 (0.66 - 1.23) | - |
| Z | 102 (19.3) | 1.08 (0.87 - 1.33) | 1.02 (0.72 - 1.43) | - |
| Y | 310 (31.4) | 2.07 (1.81 - 2.36) | 1.38 (1.01 - 1.90) | - |
| X | 129 (13.3) | 0.69 (0.58 - 0.83) | 0.98 (0.72 - 1.34) | - |
| W | 321 (21.5) | 1.24 (1.09 - 1.40) | 0.83 (0.62 - 1.10) | - |
| V | 1060 (9.6) | 0.48 (0.45 - 0.52) | 0.69 (0.56 - 0.86) | - |
| U | 223 (19.7) | 1.11 (0.96 - 1.28) | 1.08 (0.81 - 1.44) | - |
| T | 174 (17.8) | 0.98 (0.83 - 1.15) | 1.12 (0.83 - 1.50) | - |
| S | 529 (20.2) | 1.14 (1.03 - 1.26) | 1.18 (0.89 - 1.57) | - |
| R | 360 (20.6) | 1.17 (1.04 - 1.32) | 1.11 (0.88 - 1.42) | - |
| Q | 192 (16.9) | 0.92 (0.79 - 1.07) | 0.90 (0.67 - 1.22) | - |
| P | 70 (16.2) | 0.88 (0.68 - 1.12) | 1.09 (0.78 - 1.51) | - |
| O | 141 (19.2) | 1.07 (0.90 - 1.28) | 1.02 (0.73 - 1.42) | - |
| N | 79 (12.4) | 0.64 (0.51 - 0.81) | 1.10 (0.79 - 1.52) | - |
| M | 298 (19.2) | 1.07 (0.94 - 1.22) | 1.01 (0.75 - 1.37) | - |
| L | 265 (19.7) | 1.11 (0.97 - 1.27) | 1.11 (0.84 - 1.46) | - |
| K | 37 (16.0) | 0.86 (0.61 - 1.21) | 1.10 (0.78 - 1.55) | - |
| J | 168 (22.0) | 1.27 (1.08 - 1.51) | 1.10 (0.80- 1.50) | - |
| I | 304 (16.3) | 0.88 (0.78 - 1.00) | 0.94 (0.73 - 1.22) | - |
| H | 125 (19.1) | 1.07 (0.88 - 1.29) | 0.94 (0.68 - 1.32) | - |
| G | 39 (7.8) | 0.38 (0.28 - 0.52) | 0.85 (0.61 - 1.19) | - |
| F | 266 (20.4) | 1.16 (1.01 - 1.33) | 1.07 (0.79 - 1.45) | - |
| E | 163 (23.7) | 1.40 (1.18 - 1.66) | 1.13 (0.82 - 1.56) | - |
| D | 180 (15.4) | 0.82 (0.70 - 0.96) | 0.92 (0.68 - 1.24) | - |
| C | 589 (26.4) | 1.62 (1.47 - 1.79) | 1.03 (0.77 - 1.38) | - |
| B | 42 (23.0) | 1.35 (0.96 - 1.88) | 1.22 (0.86 - 1.72) | - |
| A | 1166 (16.6) | 0.9 (0.84 - 0.96) | 0.83 (0.72 - 0.96) | - |

**Supplementary table 2: Failure to rescue rates according to planned admission and unplanned patient admission to critical care in each quintile.**

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
|  | **Very low volume** | **Low volume** | **Medium volume** | **High volume** | **Very high volume** |
| **Failure to rescue following planned critical care admission** | 24/818 (2.9%) | 28/916 (3.1%) | 27/1033 (2.6%) | 15/946 (1.6%) | 11/647 (1.7%) |
| **Failure to rescue following critical care admission to treat a complication** | 28/274 (10.2%) | 28/248 (11.3%) | 30/264 (11.4%) | 22/284 (7.7%) | 11/163 (6.7%) |

**Supplementary table 3: Patient outcomes according to low, middle and high income country status.**

|  |  |  |
| --- | --- | --- |
|  | **Low and middle income countries****n=28 354** | **High income countries****n=16 460** |
| **Complications** | 5623/28354(19.8%) | 1185/16460(11.5%) |
| **Mortality** | 144/28354(0.5%) | 63/16460(0.4%) |
| **Failure to rescue** | 144/5623 (2.6%) | 63/1185(5.3%) |
| **Critical care admission to treat a complication** | 892/28251(3.2%) | 341/16460(2.1%) |

**Supplementary figure 1. Sensitivity analysis exploring the effect of excluding minor complications on the pattern of complication rates, mortality, failure to rescue (FtR), and critical care admission, across quintiles ranked according surgical procedural volume.**

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Emma Andrews, Lindsay Arrandale, Stephen Barrett, Heena Bidd\*, Elna Cifra, Mariese Cooper, Dragos Dragnea, Cifra Elna, Jennifer Maclean, Sonja Meier, Donald Milliken\*, Christopher Munns, Nadir Ratanshi, Suneil Ramessur \*, Abegail Salvana, Anthony Watson

**Sunderland Royal Hospital**

Hani Ali, Gill Campbell, Rebecca Critchley\*, Simon Endersby, Catherine Hicks, Alison Liddle, Marc Pass, Charlotte Ritchie, Charlotte Thomas, Lingxi Too\*, Sarah Welsh

**Royal Oldham Hospital**

Talvinder Gill\*, Joanne Johnson, Joanne Reed

**Royal Orthopaedic Hospital**

Edward Davis\*, Sam Papadopoullos

**Torbay Hospital**

Clare Attwood, Andrew Biffen\*, Kerenza Boulton, Sophie Gray, David Hay, Sarah Mills, Jane Montgomery\*, Rory Riddell, James Simpson

**Trafford Hospitals**

Neeraj Bhardwaj, Elaine Paul, Nosakhare Uwubamwen, Akbar Vohra\*

**Tunbridge Wells Hospital**

Emer Berntsen, Tracey Nolan\*, Angus Turner

**University College London**

Maini Alexander, James Arrich, Swarna Arumugam, Douglas Blackwood, Victoria Boggiano, Robyn Brown,Yik Lam Chan, Devnandan Chatterjee, Ashok Chhabra, Rachel Christian, Hannah Costelloe, Madeline Coxwell Matthewman, Emma Dalton, Julia Darko, Maria Davari, Tejal Dave, Matthew Deacon, Shantal Deepak, Holly Edmond, Jessica Ellis, Ahmed El-Sayed, Philip Eneje, Rose English, Renee Ewe, William Foers, John Franklin, Laura Gallego, Emily Garrett, Olivia Goldberg, Harry Goss, Rosanna Greaves, Rudy Harris, Charles Hennings, Eleanor Jones, Nelson Kamali, Naomi Kokkinos, Carys Lewis, Leda Lignos, Evaleen Victoria Malgapo, Rizwana Malik, Andrew Milne, John-Patrick Mulligan, Philippa Nicklin, Natasha Palipane, Thomas Parsons, Rebecca Piper, Rohan Prakash, Byron Ramesh, Sarah Rasip, Jacob Reading, Mariam Rela, Anna Reyes, Robert Stephens\*, Martin Rooms, Karishma Shah, Henry Simons, Shalil Solanki, Emma Spowart, Amy Stevens, Christopher Thomas, Helena Waggett, Arrash Yassaee

**University Hospital of North Durham**

Anthony Kennedy, Sara Scott, Sameer Somanath\*

**University Hospital of North Tees**

Andrew Berg, Miguel Hernandez, Rajesh Nanda\*, Ghanshyambhai Tank, Natalie Wilson, Debbie Wilson

**University Hospital of Wales**

Yassr Al-Soudaine, Matthew Baldwin, Matthew Baldwin, Julie Cornish, Zoe Davies, Leigh Davies\*, Marc Edwards, Natasha Frewer, Sian Gallard, James Glasbey, James Glasbey, Rhiannon Harries, Luke Hopkins, Taeyang Kim, Vilavan Koompirochana, Simon Lawson, Megan Lewis, Zaid Makzal, Sarah Scourfield

**University Hospital Southampton**

Yousra Ahmad, Sarah Bates, Clare Blackwell, Helen Bryant, Hannah Collins, Suzanne Coulter, Ross Cruickshank, Sonya Daniel, Thomas Daubeny, Mark Edwards\*, Kim Golder, Lesley Hawkins, Bryant Helen, Honor Hinxman, Denny Levett, Karen Salmon, Leanne Seaward, Ben Skinner, Bryony Tyrell, Beverley Wadams, Joseph Walsgrove

**Wansbeck General Hospital**

Mike Bradburn\*, Jane Dickson

**Watford General**

Kathryn Constantin, Markwell Karen, Peter O'Brien\*, Lynn O'Donohoe, Hannah Payne, Saul Sundayi, Elaine Walker

**West Suffolk Hospital**

Jenny Brooke, Jon Cardy, Sally Humphreys, Laura Kessack, Christiane Kubitzek\*, Suhas Kumar

**Weston General Hospital**

Donna Cotterill, Emil Hodzovic, Gurunath Hosdurga\*, Edward Miles\*, Glenn Saunders

**Whipps Cross University Hospital**

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**Whittington Hospital**

Aditi Naik, Ayo Oshowo\*, Rajarajan Ramamoorthy\*, Nimesh Shah, Axel Sylvan\*

**Worcestershire Royal Hospital**

Katharine Blyth, Andrew Burtenshaw\*, David Freeman, Emily Johnson, Philip Lo, Terry Martin, Emma Plunkett, Julie Wollaston\*

**Yeovil District Hospital**

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**York Hospital**

Andrew McDonald, Davies Simon\*, Vivek Sinha, Thomas Smith

**United States of America**

**Beth Israel Deaconess Medical Centre**

Valerie Banner-Goodspeed\*, Myles Boone\*, Kathleen Campbell, Fengxin Lu, Joseph Scannell

**Columbia University Medical Center**

Julia Sobol\*

**Duke University in Durham**

Naraida Balajonda, Karen Clemmons, Carlos Conde, Magdi Elgasim, Bonita Funk, Roger Hall, Thomas Hopkins\*, Omowunmi Olaleye, Omer Omer, Michelle Pender, Angelo Porto, Alice Stevens, Peter Waweru, Erlinda Yeh

**Icahn School of Medicine at Mount Sinai**

Daniella Bodansky, Adam Evans\*, Steven Kleopoulos, Robert Maril, Edward Mathney\*, Angela Sanchez, Elizabeth Tinuoye

**Massachusetts General Hospital**

Brian Bateman\*, Kristen Eng, Ning Jiang, Karim Ladha\*, Joseph Needleman

**Mount Zion**

Lee-lynn Chen\*

**Parnassus/Moffit-Long Hospital**

Lee-lynn Chen\*, Rondall Lane, David Robinowitz

**South Shore Hospital**

Neil Ghushe, Mariam Irshad, John O'Connor, Samir Patel\*

**San Francisco Veterans Affairs Medical Center**

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**The University of Maryland School of Medicine**

Michael Mazzeffi\*, Peter Rock, Karin Wallace, Xiaomao Zhu

**University of Pennsylvania**

Pandora Chua, Lee Fleisher\*, Matthew Mattera

**University of Washington Medical Center**

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**UPMC Presbyterian and Montefiore Hospitals**

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**Washington University in St Louis**

Michael Avidan\*, Hannah Maybrier, Maxwell Muench, Troy Wildes