What is the Association between Intensive Care Unit Capacity Strain and mortality in Scottish adult general ICUs? A Cohort Study.

Introduction:

Intensive Care Unit (ICU) capacity strain is the concept that daily fluctuations in demand for critical care may affect patient outcomes[1]. It was first defined as a concept in 2011 by Scott Halpern as "temporally varying influence on a given ICU's ability to provide high-quality care for everyone who is or could become a patient in that ICU on a given day"[1]. However, the idea that fluctuations in ICU demand and supply might affect patient care predates this definition. ICU Strain has previously been associated with a variety of patient-based factors in American studies, including mortality[2–7]. However, despite efforts to validate different metrics of ICU Strain[7,8], there exists no consensus on how best to measure it. Furthermore, no recent literature was found assessing the association between ICU Strain and patient outcomes in Scotland. This study aims to evaluate the association between ICU Strain and mortality in the Scottish ICU population.

Methods:

Cohort study of all admissions to Scottish adult general ICUs between 01/01/2005 and 31/12/2015, sourced from the Scottish Intensive Care Society Audit Group (SICSAG) database[9]. Patients were followed from ICU admission until ultimate hospital discharge, or death. Multivariable logistic regression was used to evaluate the associations between three metrics of ICU strain on day of admission (standardised census, proportion of new admissions, and daily occupancy), categorised into quintiles, and mortality. These exposure variables were defined as follows: Standardised Census, pre-specified as the primary exposure, was calculated using the daily census. Daily census was defined as the number of patients present on the unit at the beginning of the day (00:00hrs), plus any patients admitted that day. Standardised Census was then calculated as the ((daily census minus yearly mean census of that unit)/yearly standard deviation of the unit's census). In this way units of different size become comparable and data relating to bed occupancy are unnecessary. Occupancy was defined as the sum of the proportion of the day each patient spent on that unit, divided by the number of beds on that unit that day. For example, on a 4-bed unit, if three patients spent the entire day on the unit, a fourth patient was admitted at midday and there were no discharges, occupancy would be 3.5/4=0.875. Admission proportion was defined as the number of admissions per day divided by the daily census. These exposure variables were derived using admission and discharge time data, as well as

data concerning the number of occupiable beds present on each unit. The primary outcome was ultimate hospital mortality; the secondary outcome was ICU mortality.

Results:
Of the 111,385 patients in the analysis cohort, 179 (0.16%) lacked ultimate hospital mortality data. This proportion was similar across all strain quintiles. 24,943 (22.4%) patients died before ultimate hospital discharge. In the primary analysis, no statistically significant association was found between any of the strain variables and ultimate hospital mortality. In a sensitivity analysis, one quintile of standardised census was associated with ultimate hospital mortality (4^{th} quintile: Odds Ratio 1.06 (95% Confidence Intervals 1.00-1.13), p=0.042). The secondary analysis revealed no significant associations between strain and ICU mortality.

Discussion:
This study reports no association between ICU Strain and mortality in patients admitted to Scottish ICUs. This suggests that Scottish ICUs can cope well with extra Strain. These results may be useful to help guide quality improvement exercises within Scottish Critical Care. However, this study encountered several limitations. Wide confidence intervals resulted in challenging assessment of clinical significance; potential inaccuracies in exposure derivation (particularly when deriving Occupancy) may have biased results towards the null through misclassification; this study fails to capture the patient group of those refused admittance to ICU due to lack of bed availability, who may have instead received inferior care[10–12]; using three exposure variables categorised into quintiles, this study suffers from multiple testing and therefore greater chance of significance through Type I error. Further research with larger sample sizes and fewer limitations may be required to definitively answer our original research question. Overall, the enigma of ICU Strain, how best to measure it, and its effect on patients and staff, remains poorly understood.

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Acknowledgements:
I would like to thank my supervisor, Dr Nazir Lone for all the help and support he has given me throughout this project. I would also like to thank the Scottish Intensive Care Society Audit Group Steering Group for giving me permission to use the SICSAG dataset.
Finally, I would like to thank the Association of Anaesthetists of Great Britain and Ireland (AAGBI) and the National Institute of Academic Anaesthesia (NIAA) who have provided financial support for this project through the Intercalated John Snow Anaesthesia Award.