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Outcomes comparison in patients admitted to low complexity rural and urban intensive care units in the Veterans Health Administration

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ABSTRACT

Purpose: To evaluate mortality, length of stay, and inter-hospital transfer in the Veteran Health Administration (VHA) among low complexity Intensive Care Unit (ICU) patients.
Materials and method: Retrospective study of adult ICU admissions identified in VHA Medical SAS®; 2010–2015 at Veterans Affairs (VA) Medical Centers. Facilities classified by the Rural Urban Commuting Area code algorithm as large rural (referred to as rural) ($N = 6$) or urban ($N = 33$).
Results: In rural hospitals, patients ($N = 9665$) were less likely to have a respiratory (12.9% v. 18.9%; $p < .001$) diagnosis, more likely diagnosed with sepsis (17.6% v. 4.9%), and had a higher illness severity score (42.0 vs. 41.4; $p = .01$) compared to urban ($N = 65{,}846$) counterparts. Mortality within ICU did not vary across facility rurality. In unadjusted analyses, facility rurality (rural vs. urban) was associated with reduced inter-hospital transfers (OR = 0.74; 95% CI = [0.69, 0.80]; $p < .001$) and a shorter ICU length of stay (RR = 0.82; 95% CI = [0.74, 0.91]; $p < .001$). This did not hold when the hierarchical data was accounted for.
Conclusions: Despite challenges, low complexity ICUs in rural VA facilities fare similarly to urban counterparts. Being part of a national healthcare system may have benefits to explore in sustaining critical care access in rural areas outside the VA healthcare system.

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1. Introduction

Within the Veterans Affairs (VA) health care system, nearly three million veterans reside in rural communities, accounting for 33% of those enrolled for care [1]. For this population, rural residency has been associated with a higher prevalence of chronic medical diseases and conditions, poverty, poorer health, and difficulties accessing the health care system [2,3, 4-6]. Further, in the United States, rural patients generally may have limited health care access [7] and may also delay receiving appropriate treatment [8]. This delay in treatment is associated with adverse outcomes including mortality, especially in critically ill patients [7-11].

Rural patients seek treatment for acute critical illness in local rural hospitals [7,8]. Internationally and within the Unites States, rural facilities have fewer resources overall and within their intensive care units (ICUs) specifically, including a lower nurse-to-patient ratio, limited intensivist coverage, less use of standardized protocols, and patients typically exhibit worse outcomes, such as mortality [12-14]. Rural hospitals are also more likely to have lower ICU case-volumes than urban hospitals. Low ICU case-volume has been associated with unfavorable outcomes globally particularly for patients with moderate illness severity and those that require mechanical ventilation while in ICUs [15-22]. Outcome variation may be due to several factors; namely variation in care processes or experience level, but it is unknown whether patient outcomes in rural ICUs are worse than those of patients admitted to similar urban ICUs independent of ICU case-volume.

Our study objective was, therefore, to compare the outcomes of patients admitted to rural VA ICUs, including ICU mortality, 30-day mortality, ICU length of stay, hospital length of stay, and acute inter-hospital transfers, with the outcomes of patients admitted to urban ICUs using Veterans Health Administration data. As a secondary measure, we examined the effect of ICU location (rural vs. urban) on the above outcome within three ICU volume levels.

Abbreviations: VA, Veterans Affairs; ICU, Intensive care unit.

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2. Material and methods

As part of a larger mixed methods study [23-30], this work was approved by the Institutional Review Boards and Research and Development Committee at the Iowa City VA Health Care System, IRB 200910772. No patient consent was deemed necessary.

2.1. Setting

For this retrospective study, initially all admissions to VA ICUs from 2010 to 2015 were identified in the Veterans Health Administration Medical SAS inpatient data available through the VA Informatics and Computing Infrastructure (VINCI), which includes hospitalizations in VA facilities nationally and contains patient demographics; diagnosis and procedure codes during admission stay; admission sources; admission and discharge dates and times; and discharge status. Deaths were identified in the VA Vital Status file.

Facility rurality was defined by the Rural Urban Commuting Area codes (RUCA) algorithm [2], which creates 30 mutually exclusive categories to represent population density and proximity to urban centers. These 30 categories were condensed to urban and large rural (subsequently referred to as rural) based on a commonly used algorithm [31]. Additionally VA uses a 4 tier classification of ICUs to account for the broad range of critical care services offered across its health care system – from highly complex (Level 1) to basic (Level 4) – adapted from a 3 tier system in the private sector [32,33]. Because rural VA ICUs have been exclusively categorized as Levels 3 and 4, we only included urban ICUs that were similarly classified. Under this classification, of 39 facilities with ICU complexity of 3 or 4, 6 were listed as being rural and 33 as urban. Levels 3 and 4 complexity VA ICUs are characterized by limited subspecialists; pharmacy; diagnostic and therapeutic radiology procedures; and laboratory services, including cardiac catheterization lab; no dedicated ICU attending staff; and typically, no intensivists. After excluding 9906 (11.6%) admissions to hospitals in which the ICU complexity could not be determined in any year of the study, we identified 9665 admissions to ICUs in rural VA hospitals and 65,846 in urban VA hospitals exclusively within the contiguous United States for 63,030 unique veterans from 2010 to 2015. There were no exclusions based on patient-level characteristics.

We defined ICU volume as the total number of ICU admissions to each VA facility spanning the 6-year study period and categorized this variable into tertiles: Low (1 to 1419 admissions), medium (1420 to 2098 admissions), or high (≥2099). There was a total of 39 facilities with 13 each classified into the low, medium, and high groups.

2.2. Outcomes

Primary outcomes of interest were (1) mortality, (2) length of stay, and (3) acute inter-hospital transfer. Each of these outcomes was considered with regards to the overall hospital admission, as well as within the ICU portion of the admission. Specifically, ICU mortality was defined as the occurrence of death in the ICU, where the date of death available in the VA Vital Status File transpired after admission to the ICU, but prior to ICU discharge. Similarly, mortality within 30 days of ICU admission was determined using the date of death and the initial ICU admission date. Length of stay considered both the overall length of continuous hospital admission, as well as the subset of the admission within the ICU itself (potentially a fraction of the complete admission) based on admission, discharge, and bedsection relocation dates. Finally, inter-hospital transfers from the initial treating facility to another acute care facility were defined in two ways as 1) being a transfer directly out of the ICU (i.e. without a transfer to a lower intensity bedsection within the same hospital) and 2) as a transfer from the treating facility regardless of the discharging bedsection, as determined by the discharge disposition for the stay indicating transfer to another acute care facility (either VA or non-VA)."

2.3. Patient characteristics

We identified patient demographics, including age, gender and race from the Veterans Health Administration Medical SAS patient data available through VINCI. Comorbid conditions were defined based on ICD-9-CM diagnosis codes on the inpatient record using algorithms developed by Quan et al. [34] Finally, lab and vitals data from the Corporate Data Warehouse and the VA Vital Signs File were used to calculate an illness severity via a prognostic score using a subset of predictor variables from the Acute Physiology and Chronic Health Evaluation (APACHE) III score [35-37]. This score, known as the modified APACHE (mAPACHE), included all components except arterial blood gases, urine output and the Glasgow coma scale as these variables were not available or not consistently recorded in our dataset.

2.4. Statistical analysis

Initially, unadjusted bivariate analyses were performed. Specifically, patient characteristics were compared in univariate analysis by facility rurality using the *t*-test and chi-square test, as appropriate. Similarly, unadjusted generalized linear mixed models with a logit link were calculated to determine the odds ratio of our categorical primary outcomes, while numerical outcomes were assessed using a normal distribution with identity link to calculate the relative risk of each primary outcome. Analyses were powered to detect a clinically meaningful difference in proportions for mortality and transfer outcomes of 1% and difference in mean length of stay outcomes equal 0.5 days.

Multivariate analyses utilized generalized linear mixed models as previously described, but with the inclusion of a random facility intercept to account for the hierarchical nature of the data. We note that the mAPACHE was quantifiable for 64.1% of the cohort, thus when multivariate analyses were adjusted for patient characteristics, multiple imputation was employed, assuming a multivariate normal distribution and missingness at random. We generated 5 imputed datasets via SAS (SAS version 9.4; SAS Institute, Cary, NC) using patient race, sex, patient's residential rurality, diagnosis category, illness severity score, an indicator of ICU discharge, and tertile of facility volume. Results were pooled from the imputed data sets to report odds ratios or risk ratios of rural relative to urban facilities with 95% confidence intervals [38]. A sensitivity analysis using complete data yielded comparable results (not shown). Finally, these same imputed multivariate models were used in a stratified analysis based on ICU volume.

3. Results

Patient characteristics of the 75,511 ICU admissions to low complexity facilities are shown in Table 1. There were 9665 and 65,846 patients admitted to rural and urban facilities, respectively. We note patients in rural facilities were less likely to have a respiratory (12.9% v. 18.9%; $p < .001$) diagnosis, more likely diagnosed with sepsis (17.6% v. 4.9%), and had a higher mAPACHE score (42.0 vs. 41.4; $p = .01$) compared to urban counterparts. This difference in mAPACHE was, however, not *clinically* meaningful. Additionally, patients admitted to rural hospitals were older (67.4 years vs. 66.9 years; $p < .001$), more likely to be white (88.4% vs. 82.1%; $p < .001$) and less likely to originate from an urban residence (31.0% vs 84.0%; $p < .001$).

In unadjusted analyses, ICU (OR = 0.99; 95% CI = [0.88, 1.10]) and 30-day (OR = 0.97; 95% CI = [0.89, 1.05]) mortality did not vary between urban and rural low complexity facilities (Table 2). Of patients admitted to VA urban ICUs, 7.3% (4843 of 65,846) were transferred to another hospital, compared to 9.6% (932 of 9665; $p < .001$) of patients admitted to VA rural facilities. In unadjusted analyses, facility rurality among low complexity hospitals was associated with increased ICU acute inter-hospital transfers (rural vs. urban) with an odds ratio (OR) of 1.36 (95% CI = [1.25, 1.45]; $p < .001$). In terms of length of stay, on average, patients in urban facilities remained in the ICU for 2.9 days

Table 1
Characteristics of intensive care unit patients by facility rurality.

Patient characteristics		Total	Urban facilities (n = 33)	Rural facilities (n = 6)	p-Value[a]
Admissions, N		75,511	65,846	9665	NA
Age, Mean (SD), y		67.0 (12.4)	66.9 (12.5)	67.4 (11.8)	<0.001
Race, N (%)	Black	7096 (9.4)	6567 (10.0)	529 (5.5)	<0.001
	Other	4150 (5.5)	3787 (5.8)	363 (3.8)	
	Unknown	1668 (2.2)	1439 (2.2)	229 (2.4)	
	White	62,556 (82.9)	54,014 (82.1)	5842 (88.4)	
Sex, N (%)	Male	72,448 (95.9)	63,109 (95.8)	9339 (96.6)	<0.001
	Female	3063 (4.1)	2737 (4.2)	326 (3.4)	
Patient Rurality, N (%)	Isolated	4465 (5.9)	2752 (4.2)	1713 (17.7)	<0.001
	Small rural	4369 (5.8)	3071 (4.7)	1298 (13.4)	
	Large rural	8383 (11.1)	4729 (7.2)	3654 (37.8)	
	Urban	58,220 (77.2)	55,229 (84.0)	2991 (31.0)	
Diagnosis Category, N (%)	CVS	20,384 (27.0)	17,787 (27.0)	2597 (26.9)	<0.001
	Endocrine	2722 (3.6)	2401 (3.7)	321 (3.3)	
	Gastrointestinal	11,148 (14.8)	9501 (14.4)	1647 (17.0)	
	Genitourinary	5042 (6.7)	4226 (6.4)	816 (8.4)	
	Hematology	2201 (2.9)	1933 (2.9)	268 (2.8)	
	Neurological	6973 (9.2)	6228 (9.5)	745 (7.7)	
	Respiratory	14,137 (18.7)	12,436 (18.9)	1244 (12.9)	
	Sepsis	3530 (4.7)	3204 (4.9)	1701 (17.6)	
	Other	9370 (12.4)	8126 (12.3)	326 (3.4)	
mAPACHE[b], Mean (SD)		41.5 (16.6)	41.4 (16.7)	42.0 (16.0)	0.01
Imputed mAPACHE, Mean (SD)		41.2 (16.2)	41.2 (16.2)	41.6 (15.8)	0.02
ICU Discharge, N (%)		27,050 (35.8)	23,746 (36.1)	3304 (34.2)	<0.001
DRG[c] Type	Medical	58,444 (77.4)	51,170 (77.7)	7274 (75.3)	<0.001
	Surgical	17,061 (22.6)	14,670 (22.3)	2391 (24.7)	

[a] If numeric, via T-Test without equal variances and if categorical, via the chi-square test.
[b] This illness severity prognostic score was derived from the Acute Physiology and Chronic Health Evaluation (APACHE) III score without arterial blood gases, urine output, and the Glasgow coma scale.
[c] Diagnosis Related Group.

compared to 2.7 days in rural facilities ($p < .001$) with overall hospital stays of 6.9 days and 6.7 days ($p = .09$), on average, respectively. Outcomes were further summarized overall and within the top three diagnosis categories (Supplemental Fig. 1) over the full study period as percentages or averages. We note ICU and 30-day mortality are greatest among those with a respiratory diagnosis category, while acute inter-hospital transfer, both from the ICU directly or the facility in general, are more likely when the patient has a cardiovascular diagnosis.

Acute inter-hospital transfers (OR = 1.40; 95% CI = [0.83, 2.36]; $p = .21$) and hospital length of stay (RR = 0.48; 95% CI = [0.08, 3.02]; $p = .43$) were not statistically significant, when multivariate models accounting for the hierarchical nature of the dataset were incorporated (Table 3). Similarly, there was no evidence of statistical differences of rural compared to urban low complexity facilities in terms of transfers from the ICU (OR = 1.42; 95% CI = [0.83, 2.42]; $p = .20$) and ICU length of stay (RR = 0.73; 95% CI = [0.40, 1.32]; $p = .30$). Statistical significance was also not attained in hierarchical models adjusting for patient characteristics with comparable results as previously reported.

These low complexity facilities were classified by their overall ICU volume during the study period into high, medium, and low tertiles. Outcomes were considered within each of these categorizations (Table 4) independently via a stratified multivariate analysis. No statistically significant differences across facility rurality were found. For example, among high volume hospitals, ICU mortality (OR = 2.02; 95% CI = [0.46, 8.90]; $p = .35$), transfers from the ICU (OR = 1.50; 95% CI = [0.63, 3.60]; $p = .36$), and ICU length of stay (RR = 1.05; 95% CI = [0.41, 2.64]; $p = .93$) were not statistically significant among rural compared to urban facilities with a low complexity ICU classification. Additionally, 30-day mortality within low volume facilities (OR = 0.77; 95% CI = [0.39, 1.51]; $p = .45$) and acute inter-hospital transfers in medium volume facilities (OR = 0.85; 95% CI = [0.52, 1.41]; $p = .54$) were not significant.

4. Discussion

We found that patients treated in rural, low complex VA ICUs were more likely to be diagnosed with sepsis, less likely diagnosed with respiratory issues, and on average, had a higher, but not clinically meaningful, difference in mAPACHE compared to low complexity, urban VA ICUs. In unadjusted analyses, inter-hospital transfers from the ICU specifically and from the hospital in general were greater among rural facilities, while ICU length of stay was slightly shorter in rural ICUs compared to urban locations. However, when the hierarchical setting was accounted for no statistical differences in patient outcomes were detected.

Compared to other studies [39-41] our study sample of low complexity rural and urban VA ICUs exhibit lower mortality, higher transfer rates, and shorter length of stay. It is likely that patients admitted to an ICU with fewer resources may be less severely ill compared to more complex and higher resource facilities better-suited to the medical

Table 2
Unadjusted patient outcomes based on facility complexity and rurality.

Outcome	Total ($N = 75{,}511$)	Urban Facilities ($N = 65{,}846$)	Rural Facilities ($N = 9665$)	Estimate (95% CI)	p-Value
ICU mortality, N (%)	2859 (3.8)	2497 (3.8)	362 (3.8)	0.99 (0.88, 1.10)	0.82
30-day mortality, N (%)	5536 (7.3)	4845 (7.4)	691 (7.2)	0.97 (0.89, 1.05)	0.46
ICU acute transfer, N (%)	4391 (5.8)	3672 (5.6)	719 (7.4)	1.36 (1.25, 1.48)	<0.001
Acute transfer, N (%)	5775 (7.7)	4843 (7.3)	932 (9.6)	1.34 (1.25, 1.45)	<0.001
ICU length of stay, mean (SD), d	2.9 (4.8)	2.9 (4.9)	2.7 (4.0)	0.82 (0.74, 0.91)[a]	<0.001
Hospital length of stay, mean (SD), d	6.8 (9.7)	6.9 (9.7)	6.7 (9.9)	0.83 (0.68, 1.02)[a]	0.09

[a] Relative risk (95% CI).

Table 3
Adjusted patient outcomes across facility rurality.

Outcome	Rural vs. Urban Estimate[a]	p-Value	Rural vs. Urban Estimate[b]	p-Value
ICU mortality, OR (95% CI)	0.98 (0.60, 1.58)	0.92	0.92 (0.44, 1.90)	0.82
30-day mortality, OR (95% CI)	0.95 (0.68, 1.31)	0.74	1.00 (0.70, 1.45)	0.98
ICU acute transfer, OR (95% CI)	1.42 (0.83, 2.42)	0.20	1.20 (0.74, 1.94)	0.47
Acute transfer, OR (95% CI)	1.40 (0.83, 2.36)	0.21	1.12 (0.71, 1.78)	0.61
ICU length of stay, RR (95% CI)	0.73 (0.40, 1.32)	0.30	0.95 (0.51, 1.77)	0.87
Hospital length of stay, RR (95% CI)	0.48 (0.08, 3.02)	0.43	0.98 (0.21, 4.63)	0.98

[a] Unadjusted hierarchical model accounting for facility as a random component.
[b] Model adjusted for patient age, race, sex, residential rurality, diagnosis category, imputed mAPACHE score, an indicator of ICU discharge, and tertile of facility Volume along with a random component for facility.

needs of high severity patients. Moreover, low acuity ICUs often transfer their sickest patients to other tertiary facilities, which may explain the shorter length of stay within our cohort.

Additionally, for this cohort 2334 (3.1%) and 2057 (2.7%) of the full sample were transferred to a non-VA or VA facility, respectively. Among these patients, those admitted to an urban facility were more likely to be transferred to a non-VA hospital ($N = 2100$; 57.2%) while those admitted to a rural facility were more likely to be transferred to another VA medical center ($N = 485$; 67.5%). Under a triage system, a 'step up' in care may well be dependent upon a patient's starting facility and the resources that facility can offer, in addition to the services of the closest alternative options. For example, in the event of a cardiovascular diagnosis, transfers were more likely and are probably related to the lack of catheterization labs or interventional cardiologists in these lower complexity facilities. Yet in both urban and rural settings, the patient would require transfer. The difference being that for an urban facility multiple nearby, high acuity hospitals outside the VA are viable transfer options, whereas the nearest public facilities in a rural setting may also lack these resources increasing the practicality of staying within the VA healthcare system. Likewise, those served by a facility in a more rural setting are likely to be either less severely ill, or more ill but unwilling to move to an urban location. In the latter case, patient outcomes may be affected by additional outside influences, including available social support, family structure, or patient decision-making regarding their own care.

Table 4
Comparison of patient outcomes within facility volume by facility rurality.[a]

		Rural vs. Urban Estimate	p-Value
ICU Mortality, OR (95% CI)	High volume	2.02 (0.46, 8.90)	0.35
	Medium volume	1.15 (0.46, 2.86)	0.76
	Low volume	0.50 (0.13, 1.93)	0.31
30-day Mortality, OR (95% CI)	High volume	1.25 (0.60, 2.63)	0.55
	Medium volume	1.10 (0.67, 1.83)	0.70
	Low volume	0.77 (0.39, 1.51)	0.45
ICU Acute Transfer, OR (95% CI)	High volume	1.50 (0.63, 3.60)	0.36
	Medium volume	0.95 (0.52, 1.73)	0.87
	Low volume	1.76 (0.57, 5.43)	0.32
Acute Transfer, OR (95% CI)	High volume	1.23 (0.60, 2.52)	0.57
	Medium volume	0.85 (0.52, 1.41)	0.54
	Low volume	1.56 (0.49, 5.01)	0.45
ICU Length of Stay, RR (95% CI)	High volume	1.05 (0.41, 2.64)	0.93
	Medium volume	1.21 (0.52, 2.78)	0.66
	Low volume	0.52 (0.14, 1.88)	0.32
Hospital Length of Stay, RR (95% CI)	High volume	1.02 (0.03, 35.84)	1.00
	Medium volume	2.27 (0.46, 11.15)	0.31
	Low volume	0.14 (0.01, 3.77)	0.24

[a] Model adjusted for patient age, race, sex, residential rurality, diagnosis category, imputed mAPACHE, an indicator of ICU discharge, and tertile of facility volume along with a random component for facility.

Despite differences in transfer rates and length of stay as unadjusted outcomes, it is important to mention that these outcome differences were *not* statistically significant once we appropriately considered the hierarchical nature of the data. This was true regardless of the inclusion of patient-level variables. This finding suggests unmeasured facility variation accounts for outcome differences rather than rural or urban classification. The results of the multivariable model illustrate the need for statistical analyses that correctly considers the data structure to ensure proper conclusions can be drawn and acted upon. For example, a rural policy analysis that did not account for the hierarchical nature of the data would falsely conclude rural VA ICUs are transferring patients at higher rates than their urban counterparts and could lead to misplaced intervention.

Previous studies have shown ICU volume and resources to be associated with outcomes [13,15,20,42]. Specifically high volume ICUs have better outcomes in several areas including acute coronary syndromes [43], chronic obstructive pulmonary disease [16], sepsis [20], respiratory failure requiring mechanical ventilation [15], and hematological diseases [42]. In contrast several reports have shown no association between volume and outcomes suggesting volume may be a confounding factor [44–46]. Associations between ICU volume and favorable outcomes may be due to facility characteristics, such as access to more resources, including more experienced staff members, a lower bed-to-nurse ratio [12], dedicated ICU attending physicians, protocolized evidence based practice [47] (e.g. stroke team), or availability of advanced diagnostic and therapeutic options (e.g. neurosurgery etc.). Additionally, the VA has instituted ICU “bundles” which standardize care and monitor outcome measures and compliance across the nation for central line and urinary catheter insertion, as well as the maintenance and care of ventilated patients. Therefore, as with our cohort, ICU volume may not impact outcomes at facilities where these resources are less available.

In VA, 35% of hospitals include ICU services with a low complexity (levels 3 or 4) categorization. In our study considering these ICUs, we found no evidence of patient outcome differences between rural and urban facilities. This agrees with a previous report showing that outcomes of mechanically ventilated patients in the VA did not vary between high and low volume ICUs [48].

Our study has several limitations. We have no data regarding ICU staffing levels, such as nurse to patient ratio, nor the availability of other subspecialties, the pharmacy level, access to laboratory and radiology services, or whether medicine and surgery is an in-house service. Additionally, we purposefully did not include high complexity ICUs (levels 1 or 2; those with a dedicated intensivist), and these finding may not be generalizable to this setting. Relatedly, as this study was performed within the VA and thus reflects the acuity of this health system, it may not be generalizable to private health care. It is possible that rural facilities are located near urban centers in suburb-type locations, rather than truly rural localities. We also used only administrative data. These limitations, however, do not undermine the strength of our study: a large sample size and the availability of an illness severity prognostic score to consider patient acuity.

5. Conclusions

Among low complexity ICUs, we found no evidence to suggest that critically ill patients have worse outcomes within rural ICUs compared to urban ICUs or comparing ICU volume. Despite the challenges these rural facilities face, low complexity ICUs in rural VA facilities are faring similarly to their urban counterparts on multiple patient outcomes. Being part of a larger, national healthcare system may have additional benefits that should be explored in sustaining access to critical care in rural areas outside the VA healthcare system.

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Author contributions

A.M.J.O. had full access to all the data in the study and takes responsibility for the integrity of the data and the accuracy of the data analysis. All authors substantially contributed to the study design, writing and critical review of the manuscript.

Disclaimer

The views expressed in this article are those of the authors and do not necessarily reflect the position or policy of the Department of Veterans Affairs or the United States government.

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Declarations of interest

None.

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