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Rocuronium dosing for rapid sequence intubation: A retrospective analysis in ED and ICU settings

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ABSTRACT

Background: Rocuronium dosing varies in clinical practice, and optimal dosing has yet to be identified. Several studies have investigated differing dosing strategies and have suggested doses ≥1.2 mg/kg may lead to greater intubation success.
Objectives: This study aimed to compare the impact of rocuronium dosing on first attempt intubation success during rapid sequence intubation (RSI) with video laryngoscopy in the emergency department (ED) and intensive care units (ICU).
Methods: This was a single-center, retrospective chart review of adult patients undergoing RSI with rocuronium doses ≤1.2 or > 1.2 mg/kg. The primary outcome was successful first attempt intubation. Secondary outcomes included number of intubation attempts, time to successful intubation, 30-day mortality rate, and hospital and ICU length of stay. Subgroup analyses were performed for patients with hypoperfusion states including sepsis and heart failure, and for patients with obesity.
Results: Rocuronium doses >1.2 mg/kg were associated with significantly higher first attempt intubation success (100% vs. 89.5%; 95% confidence interval [CI] -0.2 to −0.03; $p < 0.01$) and fewer mean intubation attempts (1 vs. 1.1; 95% CI 0.01 to 0.20; $p < 0.01$). No statistically significant differences were observed in any other secondary outcomes or subgroup analyses.
Conclusion: Rocuronium doses >1.2 mg/kg significantly improved first attempt intubation success. However, no significant differences were observed in secondary clinical outcomes or in subgroup analyses across specific patient populations. Further research into the relationship between rocuronium dosing, first attempt intubation success, and clinical outcomes may inform more effective and evidence-based rocuronium dosing strategies.

1. Introduction

1.1. Background

Rocuronium is a nondepolarizing neuromuscular blocking agent frequently used in rapid sequence intubation (RSI) [1]. The manufacturer recommended dose for RSI is 0.6 to 1.2 mg/kg to provide good or excellent intubating conditions within two minutes for most patients.

The Society of Critical Care Medicine Guidelines for RSI in the Critically Ill Adult Patient do not specify a recommended rocuronium dose [2]. Several studies have investigated optimal rocuronium dosing for RSI via various techniques including both direct and video laryngoscopy (VL) [3-5]. While these studies suggest doses ≥1.2 mg/kg may lead to improved paralysis and higher rates of first attempt intubation, dosing thresholds vary widely, and none were designed to evaluate outcomes at the common 1.2 mg/kg dosing threshold.

1.2. Importance

During RSI, successful first attempt intubation is important. Multiple intubation attempts increase the likelihood of several adverse events including esophageal intubation, hypotension, regurgitation, hypoxemia, dysrhythmia and cardiac arrest [6,7]. Alsabri et al., concluded that VL is preferred to direct laryngoscopy in achieving successful first attempt intubation and reduced complications [8]. Administering higher doses of rocuronium may improve intubating conditions by producing a faster onset of action and more complete neuromuscular blockade, theoretically increasing the likelihood of first attempt success [9]. However, higher doses may also result in a significantly prolonged duration of paralysis, which can delay neurologic assessments and increase

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mechanical ventilation duration [9]. Prolonged paralysis may complicate assessment of patient sedation, potentially leading to unintended periods in which patients are awake, aware, and paralyzed. As a result, the optimal rocuronium dosing strategy for RSI remains unclear.

Patients with hypoperfusion states such as septic shock or heart failure may experience altered pharmacokinetics of rocuronium, potentially affecting both drug delivery and clearance [10,11]. In these conditions, reduced cardiac output may limit perfusion of the drug to the neuromuscular junction, which could necessitate higher doses of rocuronium to achieve effective paralysis and improve intubation success. Impaired circulation may also delay drug clearance, resulting in a prolonged duration of action that could be further intensified with higher doses. No prior studies have evaluated rocuronium dose strategies accounting for these physiologic alterations. Although patients with impaired circulation were included, they were not analyzed as a distinct subgroup, leaving the impact of altered hemodynamics on dosing and intubation outcomes uncertain.

1.3. Goals of this investigation

The purpose of this study was to compare the impact of rocuronium dosing on first attempt intubation success during RSI with VL in the emergency department (ED) and intensive care unit (ICU). Subgroup analyses were also conducted to assess outcomes in patients with hypoperfusion states including septic shock and heart failure, as well as patients with a body mass index (BMI) ≥ 30 kg/m^2.

2. Materials and methods

2.1. Study design and setting

This was a single center, retrospective, cohort study. Patients were identified using EPIC SlicerDicer™ dispensing records from the electronic medical records for rocuronium given in an ED or ICU location from June to September 2024. ICU locations included medical, surgical trauma, neurosurgical, cardiovascular and cardiothoracic ICUs. This study was certified by the Institutional Review Board, and the requirement for informed consent was waived as the study reviewed previously collected data. Rocuronium manufacturer recommended doses (≤1.2 mg/kg) and doses greater than that (>1.2 mg/kg) were assessed to determine the impact on first intubation success. Rounded doses were based on individual providers with most commonly institutional practice rounding to the nearest 10 mg.

2.2. Selection of participants

Patients at least 18 years of age who received rocuronium for RSI in the ED or ICU were included. Patients were excluded for the following: received rocuronium for any indication other than RSI, documentation of confirmed or suspected loss of intravenous access, intubated during cardiac arrest, received any other neuromuscular blocker prior to the intubation attempt, known history of myasthenia gravis, unavailable data for first attempt success, or intubation via any method other than VL (the standard of care at our institution). Pregnant patients and prisoners were also excluded.

2.3. Data collection

The following demographic data points were collected: age, sex, actual body weight, BMI, and history of heart failure. Pre-intubation clinical data points included the presence or absence of an acute diagnosis of sepsis, Charleson Comorbidity Index (CCI), Sequential Organ Failure Assessment (SOFA) score, and pre-intubation vital signs. Intubation-related data points included indication for RSI, rocuronium dose, number of intubation attempts and time to successful intubation. Patient outcome data points included ICU and hospital length of stay, and 30-day mortality.

2.4. Outcomes

The primary outcome was successful first attempt intubation, defined as a single attempt to place an endotracheal tube where the leading edge of the laryngoscope blade entered the oral cavity past the alveolar ridge, which did not require more than one dose of rocuronium or another neuromuscular blocking agent. This information was collected directly from the physician's intubation procedure note, where the number of intubation attempts is explicitly documented. Secondary outcomes included number of intubation attempts, time to successful intubation, hospital and ICU length of stay, and 30-day mortality rate. Subgroup analyses were also conducted to assess outcomes in patients with sepsis, heart failure, and BMI ≥ 30 kg/m^2.

2.5. Analysis

Study data were collected and managed using REDCap Version 15.0.10. Statistical analysis was completed using IBM SPSS Statistics (IBM Corporation, Armonk, NY, United States) for Mac, Version 30.0.0. Summary statistics for both continuous and categorical variables were used to analyze patient demographics. Continuous variables are expressed as mean and standard deviation or median and interquartile range and were analyzed using Student's *T*-Test or Mann-Whitney *U* Test. Categorical variables are expressed in frequency and percentage and were analyzed using Chi-square test, Fisher's Exact test, or *Z*-test for proportion. A p-value of <0.05 was used to signify statistical significance.

3. Results

3.1. Characteristics of study subjects

Of the 187 patients screened, 43 patients were excluded, and 144 patients were included. There were 10 patients who were intubated twice during the same admission, thus 154 total rocuronium administrations were available for analysis of our primary outcome (Fig. 1). To ensure secondary outcomes and subgroups could be measured and analyzed clearly, we restricted these analyses to patients with a single intubation event during admission.

There were 86 rocuronium administrations included in the ≤1.2 mg/kg group and 68 rocuronium administrations in the >1.2 mg/kg group. The average age was 63 and 57 years in the ≤1.2 mg/kg and > 1.2 mg/kg groups, respectively. Most patients were male. Average weight-based doses for each group were 1.0 and 1.5 mg/kg, respectively ($p < 0.01$). A fixed rocuronium dose of 100 mg was utilized in 59% of the included administrations (44.2% in the ≤1.2 mg/kg and 77.9% in the >1.2 mg/kg group). Only 5 administrations (3%) exceeded 100 mg, which likely reflects our institutions dosing practice, where pharmacists typically use ideal rather than actual body weight in patients >100 kg. There were statistically significant differences between the ≤1.2 mg/kg and > 1.2 mg/kg groups in actual body weight (88.3 vs. 71.3 kg; $p < 0.01$) and BMI (30.4 vs. 24.8 kg/m^2; $p < 0.01$). Additionally, a greater proportion of patients in the ≤1.2 mg/kg group were intubated in the ED, where patients are often less hemodynamically stable at the time of intubation and may potentially affect clinical outcomes. However, vasopressor use before intubation did not differ between groups, suggesting comparable baseline hemodynamic status. Additional patient baseline characteristics can be seen in Table 1 and Appendix 1.

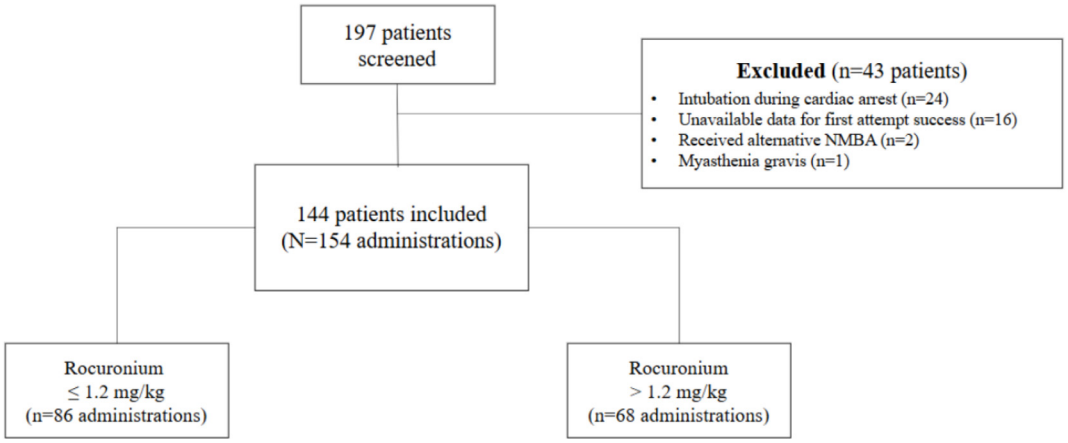

Fig. 1. Inclusion and exclusion criteria for this study. NMBA = neuromuscular blocking agent.

3.2. Primary and secondary outcomes

Rocuronium doses >1.2 mg/kg were associated with significantly higher first attempt intubation success rates (100% vs. 89.5%; absolute risk difference −0.1, 95% confidence interval (CI) −0.2 to −0.03; $p < 0.01$) as well as fewer mean intubation attempts (1.0 vs 1.1; mean difference 0.1, 95% CI 0.01 to 0.2; $p = 0.03$). Time to successful intubation, 30-day mortality rate, and hospital and ICU length of stay were similar between the two groups (Table 2 and Appendix 2).

Among patients with hypoperfusion states or obesity, no significant differences in any outcomes were observed, though a trend toward reduced hospital length of stay was observed with rocuronium doses ≤1.2 mg/kg (Tables 3 and 4).

4. Discussion

In this study, higher doses of rocuronium were associated with a significantly higher first attempt intubation success rate and fewer intubation attempts compared to the standard dose group. These findings align with emerging evidence in literature [3-5]. Levin et al. similarly demonstrated that rocuronium doses of ≥1.4 mg/kg for ED intubations were associated with the highest rates of first attempt intubation success, although this difference was not significant when stratified to patients who underwent VL [4]. April et al., including both direct and VL in the ED, found that rocuronium doses of 1.2 mg/kg or greater were associated with improved first attempt intubation success [5]. Hayes-Bradley et al. found prehospital and inter-hospital transfer intubations using doses >1.5 mg/kg led to lower rates of inadequate paralysis [3]. These findings, along with the results of our study, suggest that a dose-dependent relationship may exist, where increasing the dose beyond the traditional 1.2 mg/kg threshold may lead to improved intubation conditions and procedural success. Since first attempt success is linked to lower complication rates, the use of higher doses of rocuronium may offer important clinical advantages.

Despite the improvements in intubation success, this study did not demonstrate a correlation with key clinical outcomes such as mortality

Table 1
Baseline characteristics.

Variable*	Rocuronium ≤ 1.2 mg/kg ($n = 86$)	Rocuronium > 1.2 mg/kg ($n = 68$)	p-value
Patient baseline characteristics			
Age, years	62.5 (16.1)	57.2 (17.2)	0.03
Actual body weight, kg	88.3 (25.8)	71.3 (14.3)	<0.01
Male sex, n (%)	53 (61.6)	37 (54.4)	0.38
BMI, kg/m^2	30.4 (9.3)	24.8 (4.9)	<0.01
Comorbidities			
History of heart failure, n (%)	29 (33.7)	16 (23.5)	0.17
Sepsis present on admission, n (%)	20 (23.3)	11 (16.2)	0.28
CCI	5 [2–7]	4 [2–6]	0.03
SOFA Score	7 [5–10]	9 [5–11]	0.13
Intubation procedure			
Intubation location, n (%)			
Emergency department	28 (32.6)	18 (26.5)	0.41
Intensive care unit	58 (67.4)	50 (73.5)	0.41
Indication for RSI, n (%)			
Hypoxic respiratory failure	57 (66.3)	39 (57.4)	0.26
Altered mental status/unable to protect airway	62 (72.1)	48 (70.6)	0.84
Surgery/procedure	3 (3.5)	3 (4.4)	1.00
Rocuronium dose, mg	88.3 (23.4)	102.4 (19.1)	<0.01
Weight-based dose, mg/kg	1.0 (0.1)	1.5 (0.3)	<0.01
Vasopressors at time of intubation	29 (33.7)	24 (35.3)	0.83
Pre-intubation GCS	6 [4–9.8] $^+(n = 20)$	9 [5.5–13.5] $^+(n = 17)$	0.05

Abbreviations: *BMI*, body mass index; *CCI*, Charlson Comorbidity Index; *GCS*, Glascow Coma Scale; *RSI*, rapid sequence intubation; *SOFA*, Sequential Organ Failure Assessment.
* Values followed by parenthesis are noted to be mean (standard deviation) unless otherwise noted; values followed by brackets are noted to be median [interquartile range].
$^+$ Population values differ secondary to unavailable data.

Table 2
Outcomes.

Outcome*	Rocuronium ≤ 1.2 mg/kg (n = 86)	Rocuronium > 1.2 mg/kg (n = 68)	Difference (95% CI)∞	p-value
Primary outcome				
Successful first attempt intubation, n (%)	77 (89.5)	68 (100)	−0.1 (−0.2 to −0.03)+	<0.01
Secondary outcomes+	**(*n* = 77)**	**(*n* = 57)**		
Number of intubation attempts	1.1 (0.3)	1 (0)	0.1 (0.01 to 0.2)	0.03
30-day mortality rate, n (%)	26 (33.8)	19 (33.3)	0.00 (−0.2 to 0.2)	0.65
Hospital LOS, d	15.3 [7.6–30.6]	18.7 [8.3–36.6]	−2.1 (−7.6 to 3.1)	0.41
ICU LOS, d	9.6 [5.0–14.3]	7.3 [3.6–15.0]	0.9 (−1.6 to 3.5)	0.24

Abbreviations: *CI*, confidence interval; *ICU*, intensive care unit; *LOS*, length of stay.
* Values followed by parenthesis are listed as mean (standard deviation) unless otherwise noted; values followed by brackets are noted to be median [interquartile range].
∞ Absolute risk difference was calculated using a *Z*-test for proportions for nominal data. Mean difference was calculated using the Student's T-test. Median difference was estimated using the Hodges-Lehmann estimate.
+ Analyses restricted to patients with only a single intubation event during their admission.

Table 3
Perfusion subgroup analysis.

Outcome*	Heart Failure				Sepsis			
	Rocuronium ≤ 1.2 mg/kg (*n* = 29)	Rocuronium > 1.2 mg/kg (*n* = 14)	Difference (95% CI)∞	p-value	Rocuronium ≤ 1.2 mg/kg (*n* = 16)	Rocuronium > 1.2 mg/kg (n = 9)	Difference (95% CI)∞	*p*-value
Weight-based dose, mg/kg	1.0 (0.1)	1.4 (0.2)	−0.4 (−0.5 to −0.3)	<0.01	1.0 (0.1)	1.5 (0.3)	−0.5 (−0.7 to −0.3)	<0.01
Successful first attempt intubation, n (%)	28 (96.6)	14 (100)	−0.03 (−0.1 to 0.1)	0.48	16 (100)	9 (100)	–	–
Number of intubation attempts	1.0 (0.2)	1.0 (0)	−0.03 (−0.1 to 0.1)	0.49	1 (0)	1 (0)	–	–
30-day mortality rate, n (%)	12 (41.4)	5 (35.7)	0.1 (−0.3 to 0.3)	0.72	8 (50)	6 (66.7)	−0.2 (−0.6 to 0.2)	0.41
Hospital LOS, d	12.9 [8.1–23.9]	20.7 [11.9–35.1]	−6.1 (−15.1 to 2.6)	0.16	10.6 [7.9–18.2]	8.3 [4.9–44.4]	1.2 (−17.6 to 7.8)	0.93
ICU LOS, d	10.0 [5.1–12.9]	9.9 [3.9–20.8]	−0.8 (−7.4 to 5.0)	0.74	9.7 [2.3–11.9]	5.4 [2.5–13.3]	2.3 (−5.1 to 7.2)	0.64

Abbreviations: *CI*, confidence interval; *ICU*, intensive care unit; *LOS*, length of stay.
* Values followed by parenthesis are listed as mean (standard deviation) unless otherwise noted; values followed by brackets are noted to be median [interquartile range].
∞ Absolute risk difference was calculated using a *Z*-test for proportions for nominal data. Mean difference was calculated using the Student's T-test. Median difference was estimated using the Hodges-Lehmann estimate.

Table 4
Obesity subgroup analysis.

Outcome*	Rocuronium ≤ 1.2 mg/kg (*n* = 32)	Rocuronium > 1.2 mg/kg (n = 6)	Difference (95% CI)∞	p-value
Weight-based dose, mg/kg	1.0 (0.2)	1.4 (0.2)	−0.4 (−0.6 to −0.3)	<0.01
Successful first attempt intubation, n (%)	29 (90.6)	6 (100)	−0.1 (−0.2 to 0.3)	0.44
Number of intubation attempts	1.1 (0.4)	1 (0)	0.1 (−0.2 to 0.5)	0.48
30-day mortality rate, n (%)	12 (37.5)	1 (16.7)	0.2 (−0.2 to 0.5)	0.23
Hospital LOS, d	13.8 [7.6–25.2]	14.8 [9.6–40.1]	−2.1 (−13.8 to 10.1)	0.68
ICU LOS, d	9.9 [5.5–17.7]	7.6 [5.1–12.0]	2.1 (−4.2 to 10.1)	0.46
Average weight-based dose for IBW, mg/kg	1.7 (0.5)	2.3 (0.3)	−0.6 (−1.0 to −0.2)	0.01

Abbreviations: *CI*, confidence interval; *ICU*, intensive care unit; *LOS*, length of stay.
* Values followed by parenthesis are listed as mean (standard deviation) unless otherwise noted; values followed by brackets are noted to be median [interquartile range].
∞ Absolute risk difference was calculated using a *Z*-test for proportions for nominal data. Mean difference was calculated using the Student's T-test. Median difference was estimated using the Hodges-Lehmann estimate.

or length of stay. However, it is difficult to attribute any differences in these long-term clinical outcomes solely to a single dose of rocuronium or successful intubation on the first attempt.

The findings of this study also suggest that the use of higher doses of rocuronium does not provide a clinical advantage in patients with a BMI of ≥30 kg/m^2. In our separate analysis of obese patients, no significant difference in first attempt intubation was found, suggesting that higher rocuronium doses may not be needed for optimal intubation success in obese patients and that using ideal body weight could reduce total doses without compromising efficacy. Furthermore, 97% of all patients received rocuronium doses ≤100 mg, indicating that a maximum recommended dose of 100 mg may be appropriate. Additionally, hypoperfusion states did not appear to meaningfully alter rocuronium pharmacokinetics, as no significant differences in any outcomes were observed when these patients were evaluated in separate subgroup analyses.

This study has several strengths, first is the inclusion of patients in both the ED and ICU settings, which captures a diverse patient population and reflects real-world clinical practice, enhancing the generalizability of findings. Additionally, this is one of the first studies evaluating medication dosing in RSI to exclusively examine VL as the primary method of intubation. This approach better reflects current clinical practice, where VL is becoming the standard of care. Lastly, this study is also among the first to explore the potential impact of altered rocuronium pharmacokinetics in hypoperfusion states on intubation outcomes.

4.1. Limitations

This study has several limitations to consider. First, this study was conducted as a single-center, retrospective chart review with a limited sample size, which constrained the ability to control for potential confounding baseline demographic variables. Statistically significant differences in actual body weight and BMI were observed between groups, which may have impacted intubation success as patients with higher body weight often present with challenging airways and suboptimal intubating conditions. Furthermore, some data was unavailable. Most notably, time to intubation for ICU patients could not be collected consistently, and the outcome was restricted to ED patients only.

Another important limitation of this study was that the duration of paralysis following rocuronium administration was not assessed. As a result, it is unclear whether higher doses of rocuronium were associated with significantly prolonged neuromuscular blockade and what clinical consequences may have resulted.

5. Conclusions

This study suggests higher doses of rocuronium, > 1.2 mg/kg, improve first attempt intubation success when using VL in the overall cohort. However, no benefit was observed in obese patients or in those with hypoperfusion, where higher doses did not improve intubation outcomes. Further research is needed to confirm these results in larger, more diverse populations. A deeper investigation into the relationship between rocuronium dosing, first attempt intubation success, and clinical outcomes may inform more effective and evidence-based rocuronium dosing strategies.

CRediT authorship contribution statement

Megan Szesnat: Writing – review & editing, Writing – original draft, Project administration, Methodology, Investigation, Formal analysis, Data curation. **Alyssa Watts:** Writing – review & editing, Project administration, Methodology, Investigation, Formal analysis, Conceptualization. **Morgan Audrey Tobin:** Writing – review & editing, Project administration, Methodology, Formal analysis. **Taylor H. Cason:** Writing – review & editing, Project administration, Methodology, Formal analysis. **Michael Gibbs:** Writing – review & editing, Supervision, Conceptualization.

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Declaration of competing interest

The authors have no conflicts of interest or anything to disclose.

Appendix A. Pre-intubation vitals.

Variable*+	Rocuronium ≤ 1.2 mg/kg	Rocuronium > 1.2 mg/kg	*p*-value
Heart rate, beats per min	105 (21.2) (*n* = 26)	108.1 (22.5) (*n* = 16)	0.33
Systolic blood pressure, mmHg	142 (45.5) (n = 26)	148.25 (43.1) (n = 16)	0.43
Diastolic blood pressure, mmHg	84.3 (25.6) (n = 26)	88.9 (24) (n = 16)	0.28
Mean arterial pressure, mmHg	104.7 (31.2) (n = 26)	108.7 (26.8) (n = 16)	0.34
Oxygen saturation, %	97.8 (5.1) (*n* = 25)	98.4 (2.5) (*n* = 15)	0.34
Respiratory rate, breaths per min	23.3 (7.4) (n = 26)	20.3 (5.7) (n = 15)	0.09

* Values followed by parenthesis are noted to be mean (standard deviation).
+ Population numbers differ secondary to unavailable data.

Appendix B. Time to successful intubation, seconds.*+

	Rocuronium ≤ 1.2 mg/kg	Rocuronium > 1.2 mg/kg	Difference (95% CI)	p-value
Total Population	**(n = 26)** 196.2 (176.0)	**(n = 16)** 251.3 (421.6)	−55.9 (−243.4 to 133.2)	0.56
Heart Failure Subgroup	**(*n* = 9)** 253.3 (218.0)	**(n = 2)** 180 (84.9)	73.3 (−293.5 to 440.1)	0.66
Sepsis Subgroup	**(*n* = 7)** 240 (232.4)	**(n = 2)** 30 (42.4)	210 (−199.0 to 61.9)	0.26
BMI ≥ 30 mg/m^2 Subgroup	**(n = 8)** 262.5 (228.9)	**(n = 1)** 240 (0)	–	–

* Values followed by parenthesis are noted to be mean (standard deviation).
+ Population numbers differ secondary to unavailable data.

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