Epidemic and pandemic wave definitions are crucial for public health tools to help predict surges and optimize resource allocation. Literature offers various wave definitions, many of which emerge during the COVID-19 pandemic, yet there lacks consensus on their applicability and effectiveness. Accurately defining and characterizing pandemic waves is vital for enhancing pandemic preparedness and response strategies.

**Aim:** To apply and evaluate multiple wave definitions using COVID-19 case data from the United States and South Africa

**Methods:**
- **Data Sources:** Daily US COVID-19 case data from February 2020 to March 2022 from the Institute of Health Metrics and Evaluation and Johns Hopkins University COVID-19 data repository.
- **We identified and operationalized three existing wave definitions using the following approaches:**
  - **eR Approach:** waves defined as periods where the effective reproduction number (eR) > 1 for at least 14 days, using a Bayesian framework developed by Cori and colleagues
  - **Fold Approach:** waves defined as periods where the weekly case rate increased by at least one-fold followed by at least a one-fold decrease
  - **Threshold Approach:** waves defined as periods where the weekly case rate per 100,000 population surpassed 49.99, the US Centers for Disease Control threshold for moderate community transmission.
- **We generated summary statistics and visualized epidemic curves for comparison**

**Table 1. Summary characteristics of wave definition approaches applied to United States and South Africa**

<table>
<thead>
<tr>
<th>Approach</th>
<th>Number of Waves, n</th>
<th>Time between Waves, days (IQR)</th>
<th>Wave Duration, days (IQR)</th>
<th>In-Wave Daily Case Rate per 100,000 mean (95% CI)</th>
<th>Between-Wave Daily Case Rate per 100,000 mean (95% CI)</th>
</tr>
</thead>
<tbody>
<tr>
<td>eR Approach</td>
<td></td>
<td></td>
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<td></td>
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</tr>
<tr>
<td>United States</td>
<td>5</td>
<td>83 (42-111)</td>
<td>25 (7-44)</td>
<td>26.4 (23.8, 29.2)</td>
<td>12.5 (10.6, 14.6)</td>
</tr>
<tr>
<td>South Africa</td>
<td>5</td>
<td>129 (111-139)</td>
<td>94 (85-109)</td>
<td>11.3 (10.0, 12.7)</td>
<td>2.12 (1.79, 2.49)</td>
</tr>
<tr>
<td>Fold Approach</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>United States</td>
<td>10</td>
<td>25 (7-44)</td>
<td>47 (29-54)</td>
<td>19.7 (17.2, 22.5)</td>
<td>15.9 (13.9, 18.2)</td>
</tr>
<tr>
<td>South Africa</td>
<td>9</td>
<td>22 (6-27)</td>
<td>58 (22-106)</td>
<td>5.0 (4.4, 5.7)</td>
<td>2.4 (1.8, 3.1)</td>
</tr>
<tr>
<td>Threshold Approach</td>
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<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>United States</td>
<td>2</td>
<td>62</td>
<td>276 (251-301)</td>
<td>30.4 (28.6, 32.3)</td>
<td>3.7 (2.9-4.7)</td>
</tr>
<tr>
<td>South Africa</td>
<td>4</td>
<td>94 (73-122)</td>
<td>59 (46-63)</td>
<td>20.0 (19.2, 20.9)</td>
<td>2.89 (1.6, 2.2)</td>
</tr>
</tbody>
</table>

**Figure 1. COVID-19 case rate in United States and South Africa with applied wave definitions, Feb 2020-Mar 2022**

**Figure 1.**

**Discussion:**
- **Fold Approach:** produced greatest number of waves, suggesting high sensitivity to weekly case rate fluctuations
- **Threshold Approach:** produced highest in-wave average case rate and the lowest between-wave average case rate, suggesting that this approach may not appropriately capture inflection periods
- **eR approach:** may prove most generalizable across diseases given this approach is defined based on innate biology of the pathogen

**Limitations:**
- Each approach is retrospective, requiring existing data, thus limiting their predictive capability
- No definition of ‘success’ was incorporated in this analysis, limiting our ability to recommend a particular approach

**Conclusions:** The analysis characterized three approaches to defining and quantifying epidemic waves, utilizing example COVID-19 data
- The fold approach appears most sensitive to fluctuation, which if applied in pandemic response settings may lead to overly-rapid policy changes
- The threshold approach may not capture inflection periods, when disease may be spreading
- To build consensus and increase the public health utility of these approaches, further work may include
  - More robust characterization and application is required across countries, income settings, and pathogens
  - Adjusting data for country-level test positivity and test availability
  - Identifying predictors of wave features across approaches