Relating Local COVID Hospitalizations to Vaccination and Variant Stages

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Abstract: Since vaccinations for COVID first rolled out in December 2020, assessing the impact of vaccinated individuals on health outcomes (such as COVID hospitalizations) has been imperative. A prior-year COVID-tracking time-series analysis did not have sufficient vaccination cases to integrate. Since COVID vaccinations were subsequently offered in stages (according to various risk factors of recipients), the primary focus of this project is to assess the changes in hospitalizations across both the vaccination and variant stages. Wisconsin statewide and county-level data is obtained from the WI Department of Health Services2-3, from their public data pages to support community decision-making. To determine different vaccination stages as described by policy dates and lag times. The proportional distribution of COVID-19 cases and hospitalizations across age groups is visualized by bar charts. We compared and assessed how these distributions changed between vaccination stages.

Goals and Process
The most substantial amount of time was spent organizing, coding, and visualizing the trends in the case- and hospitalization-count data. Initial analyses of the data found strong evidence of different distributions within age groups, across vaccination stages (see definitions below).

Since vaccinations were first approved for adults, and progressively made available to older age groups (along with healthcare and essential workers) earlier in the pandemic, we looked for evidence of a relative relationship between age group and hospitalizations across vaccination stage: (1) describing and testing directional relationships, statewide and locally, between age group and chronological stage of vaccine-availability; and (2) connecting data-driven transitions in hospitalization rates to the various vaccination stage changes statewide.

Vaccination Rollout Stages

<table>
<thead>
<tr>
<th>Stage</th>
<th>Start Date (Total Days)</th>
<th>Vaccination Analysis</th>
</tr>
</thead>
<tbody>
<tr>
<td>V0</td>
<td>6/25/2020</td>
<td>Data available before vaccination rollout</td>
</tr>
<tr>
<td>V1A</td>
<td>January 1, 2021 [45]</td>
<td>Frontline healthcare workers, nursing home residents and staff, and residents and staff at assisted-living facilities.</td>
</tr>
<tr>
<td>V1B</td>
<td>February 15, 2021 [70]</td>
<td>January 25: Police, fire personnel, correctional staff, those aged 65 and older, education and childcare workers, people in congregate living, public-facing essential workers, and people in Medicaid long-term care. March 21: People ages 16 to 64 with high-risk medical conditions.</td>
</tr>
<tr>
<td>V2</td>
<td>April 26, 2021 [86]</td>
<td>Everyone aged 16 and older.</td>
</tr>
<tr>
<td>V3</td>
<td>June 3, 2021 [118]</td>
<td>Pfizer vaccines are authorized for the 12 to 15 age group.</td>
</tr>
<tr>
<td>B1</td>
<td>September 27, 2021 [38]</td>
<td>September 27: Pfizer booster shots for high-risk groups including older adults, patients with underlying conditions and those with more exposure based on where they work or live.</td>
</tr>
<tr>
<td>B3</td>
<td>January 5, 2022 [85]</td>
<td>Booster doses available for 16-17-year-olds and immunocompromised 5-11-year-olds.</td>
</tr>
</tbody>
</table>

Nonparametric Methods for Tabulated Data
(1) Simple chi-squared tests were used for data tabulated across age group and vaccination stage, testing for evidence of association. (2) We use a nonparametric test due to the ordinal data1. Stuart-Kendall tau-C measure4,5 was chosen for its ability to handle rectangular tables with ties. This measure includes number of concordant pairs, minus the number of discordant pairs, where:
- concordant: individual 1 is recorded in a chronologically later stage and in an older age group than 1
- discordant: individual 3 is recorded in a chronologically later stage and in an younger age group than 1

Notes: timelines for all age groups across stages, there are large counts of both discordant and concordant pairs. The inferential goal is to determine if there is preponderance of counts in either direction.

Eau Claire Analysis

Question:
While hospitalization counts were split by age group at the state level, they were not subdivided by age group for the county level data. Additionally, the granularity of hospitalization data within the age group might have been lost. We thus examined the case-count distributions within age groups different significantly across stages. The chi-squared test shows extraordinarily strong evidence (p≈0.005), supporting the differences between the distributions within the various age groups, across all vaccination stages. While it is enlightening to see significant differences, this is unsurprising due to the high case count and uninformative with regards to direction / pattern of differences.

Concordance:
- Following up with inference about Kendall’s tau-C test, there is some evidence of discordance (that is, as stage increases chronologically, cases tend to occur more often in the 0-18 age groups) through stage V2. An approximate 95% confidence interval for tau is (−0.001, 0.005), which supports this inference between stages.

Rates of Hospitalizations (Lagged) vs. Cases
As has been evidenced historically, hospitalization rates have: (1) Occurred at a lagged timeline2; (2) Changed across the pandemic timeline. What are possible reasons?
- COVID tests were not as readily available during the first several months of the pandemic – partial adjustment was to look at counts post-August 1, 2020.
- Variants have different short-term effects on hospitalization – need to identify pattern/concordance.
- Variations in hospitalizations and their availability have an impact on hospitalizations, if said variables are indeed effective – need to identify pattern/concordance.

Wisconsin Analysis

Summary of Positive Case Counts

<table>
<thead>
<tr>
<th>Stage</th>
<th>Estimated Hospitalization Rate</th>
</tr>
</thead>
<tbody>
<tr>
<td>B1</td>
<td>0.031</td>
</tr>
<tr>
<td>B2</td>
<td>0.005</td>
</tr>
<tr>
<td>B3</td>
<td>0.003</td>
</tr>
</tbody>
</table>

Primary Research Question:
Did the proportions of cases resulting in hospitalization within age groups change significantly over stages?
- As age increases, the ratio of hospitalizations reliably increases. All the age groups had a peak in this ratio during V2. This may be an artifact of the decrease in cases before any resulting decrease in hospitalizations as vaccines rolled out, as there was no lag used in this calculation. Additionally, V2 had the shortest time range of any stage.
- Post stage V2, there tended to be a strong decrease in the ratio across vaccination stages shown for all age groups except from 0-19.

Methods References
8. Reference for Stuart endorsement: R package (DataTools) v 0.9.44

Acknowledgements and Contact Information
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Data Access and Principles
- Data is downloaded from the WI Department of Health Services (DHIS), which provide access to data to the public2. The WI DHIS is a statewide, public-health agency, and it serves as a central coordinator of services, repository of data, and reference for a wide variety of health conditions, and for research.
- The COVID data is well-defined2, documented2, and summarized2. Analytic goals and data granularity were aligned with the principle of Respect of Persons and goal of maintaining anonymity of data.

Wisconsin Data References
1. WI DHS data page: https://www.dhs.wisconsin.gov/covid-19/data.htm
3. WI DHS “About” statement: https://www.dhs.wisconsin.gov/about/index.html
5. WI DHS documentation: https://www.dhs.wisconsin.gov/covid-19/data.htm
6. WI State Laboratory of Hygiene, Wisconsin SARS-CoV-2 Genome Database: https://dataportal.dsh.wisconsin.gov/