Midwest Comprehensive Visualization Dashboards: Prioritizing Vaccinations in Cook County, Illinois

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1.0 Comprehensive Visualization Dashboards

The UIC School of Public Health (UIC-SPH) Public Health GIS (PHGIS) program will be presenting a series of Midwest Comprehensive Visualization Dashboards (MCVD) focusing currently on public health issues of COVID-19 in this region. The dashboards have as their primary objectives to create visualizations that lead to operational insights that enhance data-driven decisions about mitigation efforts to eradicate COVID-19. They were explicitly designed to overcome some of the limitations identified in the plethora of dashboards appearing in response to the pandemic. This is the third MCVD produced by our team, addressing COVID-19 vaccinations, provides information to assist Public Health (PH) professionals with the difficult task of prioritizing vaccinations and monitoring progress of vaccinations in Cook County (PVCC), Illinois. For brevity this dashboard will be referred to as MCVD:PVCC. The operational parameter that is included in this MCVD:PVCC is a measure of vulnerability in the form of a social vulnerability index. The direct link to the MCVD:PVCC is at:
https://univofillinois.maps.arcgis.com/apps/MapSeries/index.html?appid=13228803fcec4c478d44fb3e6cc71c47

2.0 Vaccine Prioritization Frameworks

The National Academies of Sciences, Engineering, and Medicine (NASEM) recommended a four-phase framework for equitable COVID-19 vaccine allocation. For the latter phases, NASEM made the specific recommendation that “vaccine access should be prioritized for geographic areas identified through CDC’s Social Vulnerability index or another more specific index.”[1]

The CDC’s Social Vulnerability index (CDC.SVI) is one of the many indices in use aiming to “help local officials identify communities that may need support before, during, or after disasters.”[2] This SVI, which is constructed from census data at various scales of aggregation, seeks to classify the relative social vulnerability of a location to a hazard based on a combination of factors. The CDC.SVI has a separate set of rankings for census tracts and counties according to 15 social attributes, including unemployment, minority status, and disability obtained from the American Community Survey. The CDC.SVI groups these attributes into four related themes: Socioeconomic Status; Household Composition & Disability; Minority Status & Language; and Housing Type & Transportation.

A notable strength of the CDC.SVI is the ease with which public health agencies can obtain the CDC.SVI ranking of their location from the well-organized CDC portal. From the perspective of planning and resource allocation, social vulnerability is presumed to be an indicator of a community's potential risk for COVID-19, along with the need for additional resources to mount mitigation efforts against the pandemic.

3.0 Classification of Geographic Units According to Vulnerability and Loss of Life

To overcome the limitations of current reporting systems, we have developed COVID-19 dashboards for counties across Midwestern states. These dashboards report COVID-19 mortality in long-term care facilities (LTCFs) and the wider community, classify communities according to their vulnerability, and (upcoming) provide periodically updated figures on vaccinations. The separation of LTCF and household COVID-19 mortality, which was recommended by the PHGIS team in July 2020,[3] became even more crucial in this phase of the pandemic because vaccination rollouts have been far more rapid and comprehensive in LTCFs, which should lead to a steeper drop in mortality rates compared to household settings. For Cook County, Illinois, the MCVD will be at a census tract (CT) level to maximize the operational benefits.

The widespread adoption of SVIs to prioritize COVID-19 vaccinations is becoming a reality. For example, the cities of Seattle and Chicago are taking into account SVIs to prioritize their plans for the latter phases. Specifically, the Chicago Department of Public Health created the COVID-19 Community Vulnerability Index (Chicago CCVI).[4] This index goes beyond the CDC.SVI input variable data set and incorporates components accounting for epidemiological and occupational risk factors as well as a cumulative COVID burden component.[4] Methodologically, it differs from the CDC.SVI since it does not create themes by using an additive model for its ranked input variables (i.e., CDC.SVI). The Chicago CCVI is using the term components instead of themes, and in some cases, the components are averaged; for example, the two epidemiological risk components were averaged to derive the overall risk factor score. [4]

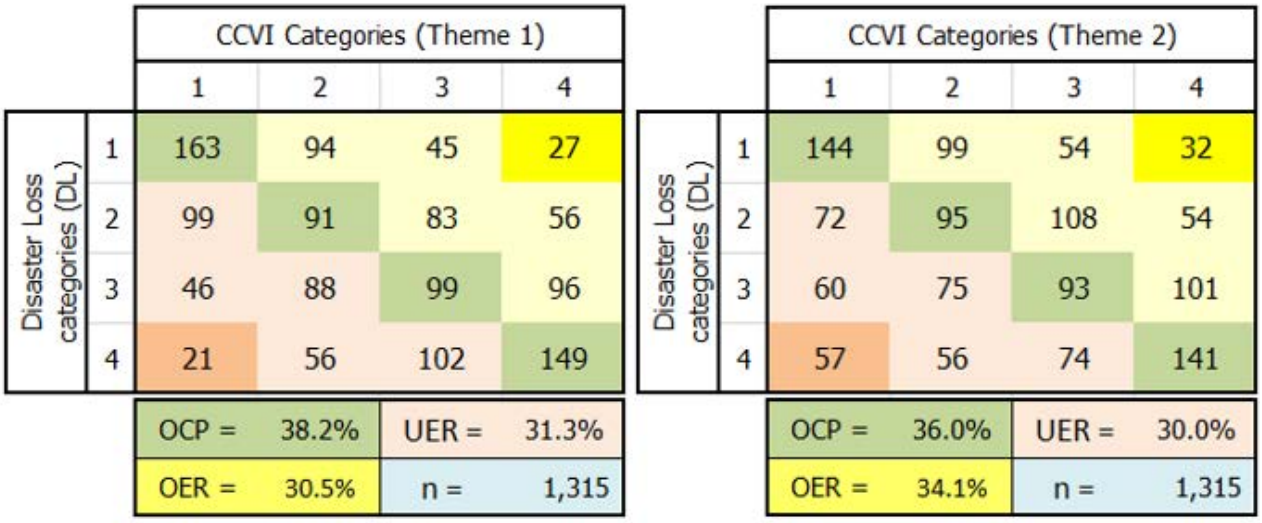
One limitation of these indices is the lack of validation.[4] In a recent publication we recommended that "The adoption of indices for vaccine prioritization should be carefully assessed, particularly for correspondence with outcomes (such as loss of life) in the context of the COVID-19 pandemic."[5] To this end, the PHGIS team proposed a validation approach based on the predictive performance matrix that quantifies certain performance characteristics.[5] This multidimensional approach classifies geographic units (e.g., census tracts) ranked independently along two (or three) dimensions: COVID-19 mortality rate (number of deaths per population in either the LTCF or household setting), and a multi-factorial vulnerability index (e.g.,CDC.SVI). Based on these rankings, we classify geographic units into tertiles or quartiles and visualize them in a matrix setting. This approach overcomes the one-dimensionality limitation of well-known indices such as the CDC.SVI[2] and the Surgo Ventures CCVI.[6] A detailed and comprehensive assessment of these indices is under preparation for a forthcoming publication. To following case study will demonstrate the potentials of the UIC-PHGIS approach.

3.1 UIC-PHGIS Approach Case Study

For this case study the Surgo CCVI[6] is used. This index provides seven themes and it has been created specifically to represent COVID-19 Community Vulnerability. The following two themes were selected:

- **Socioeconomic Status** theme, which includes the 2018 estimates for persons below poverty, per capita income, age 16+ unemployed, no high school diploma (age 25+), and percent of uninsured.
- **Household Composition and Disability** or (based on Surgo CCVI document) the Housing type, Transportation, Household Composition & Disability theme. This theme includes nine variables from the CDC, American Community Survey (ACS), 2014-2018 5-Year Estimate.

The following Figure summarizes the performance characteristics of the two Surgo CCVI themes (i.e., two of the seven themes comprising the CCVI). The UIC-PHGIS predictive performance matrix (PPM) approach[5] is applied at a census tract (CT) level, which provides a better resolution for mitigation planning and avoids geostatistical confounding problems. The CT death rate includes household-only population cases.[3] For this case study, data from the 2nd wave[7] of the pandemic have been used covering the time period from 9.27.20 through 2.25.21.



Notes: OCP = overall classification performance, UER = under estimation rate, OER = over estimation rate, n = census tracts. Disaster loss is the household death rate. Details of the UIC-PHGIS PPM validations approach for COVID related indices at:
A Data Driven Approach for Prioritizing COVID-19 Vaccinations in the Midwestern United States

Figure 1. Surgo's CCVI themes and their relevance to high-risk COVID-19 death census tracts in Cook County, Illinois based on the UIC-SPH PHGIS approach.

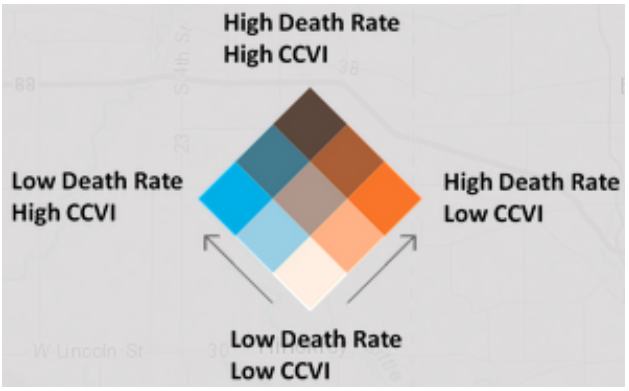
In this Figure, each cell contains Cook County CTs, and their concordance in terms of a two-dimensional classification. For example, suppose we use the diagonal of the PPM as a threshold. In that case 412 CTs under the diagonal are classified by the CCVI Theme 1 as having a potential low vulnerability (left PPM table in Figure 1). In reality though, these areas were heavily hit by the pandemic, as evident from the disaster loss classification (i.e., death rate). If the socioeconomic status theme 1 only were to be used for prioritizing vaccinations, 21 Chicago CTs would have been assigned the lowest priority. With a population of 62,918, these areas are at the top of the mortality loss classification and represent COVID-19 high-risk communities. The PPM cells provide the means to quantify the various levels of risk underestimation and to identify communities in need. In addition, the underestimation zone cells provide an overall metric of potential risk that can be converted into a meaningful population at-risk number. In this case study (left PPM table in Figure 1) the household population of the 412 CTs in the underestimation zone is 1,677,419 (based on ACS 2018 5-year estimate of "population not in group quarters").

The performance characteristics in Figure 1 corroborate our findings at a county level[5] and underline the need to use a two-dimensional approach for effective planning. The UIC-PHGIS predictive performance matrix approach provides effective means to set priorities by accounting for populations in high-risk areas and vulnerable communities. This approach, combined with the bivariate maps of the MCVD:PVCC, can become a reliable tool for validating vaccine prioritization plans and enhancing their effectiveness under scarcity conditions.

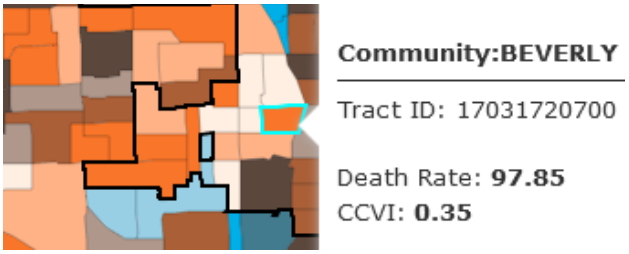
4.0 MCVD:PVCC Dashboard

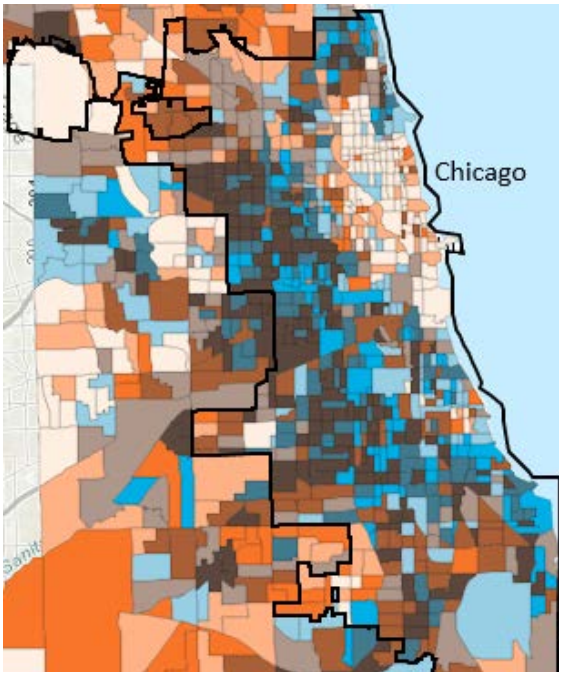
The MCVD:PVCC is an interactive ArcGIS Online dashboard that shows bivariate maps displaying COVID-19 mortality in relation to social vulnerability percentiles for Cook County, Illinois, at a census tract level. Based on our previous research,[3] household and long term care facility mortality rates are mapped separately. The mortality rates of the overall, household and LTCF populations are used to categorize the level of disaster losses in the CTs. The level of vulnerability for each CT is classified by using the summary (i.e., the summation of all themes) Surgo Ventures CCVI.[6] For each mortality rate, a map is created (e.g., Household Population Deaths vs CCVI; see Tab) to display at a Cook County areal scale the concordance between the two classifications for each census tract.

The bivariate maps, or more accurately choropleth maps (from Chóros/ χώρος meaning space and plēthos/ πλῆθος meaning multitude or many - in this case, variables), enable users to visualize the spatial relationship between the death rate and the CCVI rankings for each census tract. For the bivariate maps created by the tertiles of the variables, we assigned the visually distinguishable 3x3 color scheme in the adjacent figure. Thus, CTs with an extreme discordance between the two variables are easily identified (i.e., the orange and cyan blue horizontal edges of the color scheme).



By clicking on the CTs, additional information is revealed (see adjacent Figure). In this version of the MCVD, for CTs within the Chicago City limits, the Chicago community area name is included.





4.1 Potential uses of the MCVD:PVCC and the PPM

The current MCVD visualization provides an overall view of the concordance between the selected prioritization index (e.g., CCVI) and the loss reality this prioritization is aiming to ameliorate. The UIC-PHGIS predictive performance matrix approach provides a refined assessment of the prioritization strategy and quantitative metrics to make comparisons (e.g., UER) and optimizations. For example, the PPM approach can be used as an iterative strategy exploration/ optimization tool with two (or more) operational parameters and an objective function which can satisfy vaccination equity concerns. For prioritizing a limited supply of vaccines, the optimization potentials of this approach provide an attractive rational alternative.

5.0 Data Sources and Limitations

The primary data source for this study is the Medical Examiner (ME) Case Archive of COVID-19-related Deaths.[8] This archive is organized in a searchable on-line database format and contains information about "deaths that occurred in Cook County that were under the ME's jurisdiction." The recorded cases not from Cook County have been removed.

Data preparation and preliminary analysis was performed with the IBM® SPSS® Modeller 18.2.1. During the data preparation phase, text-mining techniques were applied to identify the nursing home locations, identify miss coded address records, etc. For the Cook County mortality database a data quality (DQ) iterative procedure was specifically developed by the PHGIS team. The main parameter was the address attribute of each record. Records lacking a structure number and street name were removed. The final phase of this procedure was the use of the geocoding process (i.e., conversion of an address to an actual latitude/ longitude coordinate point) with a performance threshold for termination of the DQ quality phase or to restart again. Without preparation, the original data records from the source had a conversion rate of less than 80%. For our studies, the performance threshold for conversion was set to a maximum of 2%.

Geocoding and aggregation at a census tract level was performed with the ArcGIS Pro locator, "ArcGIS World Geocoding Service", and three address location categories: Address Address, Street Address, and Postal's three subcategories. At the final iteration, less than 0.5% of the records were deleted as we could not confidently match to a proper address; this level of conversion was deemed acceptable for the goals of the study.

The socioeconomic data used to obtain the rates per 100,000 are available from the U.S. Census Bureau American Community Survey; 2018 release of 5-year estimates at: https://data.census.gov/cedsci/.

Additional details regarding source data limitations could be found at the exemplary "Medical Examiner Case Archive - COVID-19 Related Deaths" data portal maintained by the Cook County Medical Examiner's Office.[8]

6.0 Concluding Remarks

The main purpose of this paper is to describe a visualization and vaccine prioritization tool for public health professionals. Due to the importance of this issue, a case study we included which provides additional tools for optimization (see Section 3.1). This information is vital for the multidimensional needs of an effective vaccination strategy which will account for population vulnerability as well as the realized losses within each community.

No attempt was made to draw insights from the application of this MCVD. The authors hope that public health professionals will undertake this task and share with us their findings.

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7.0 References

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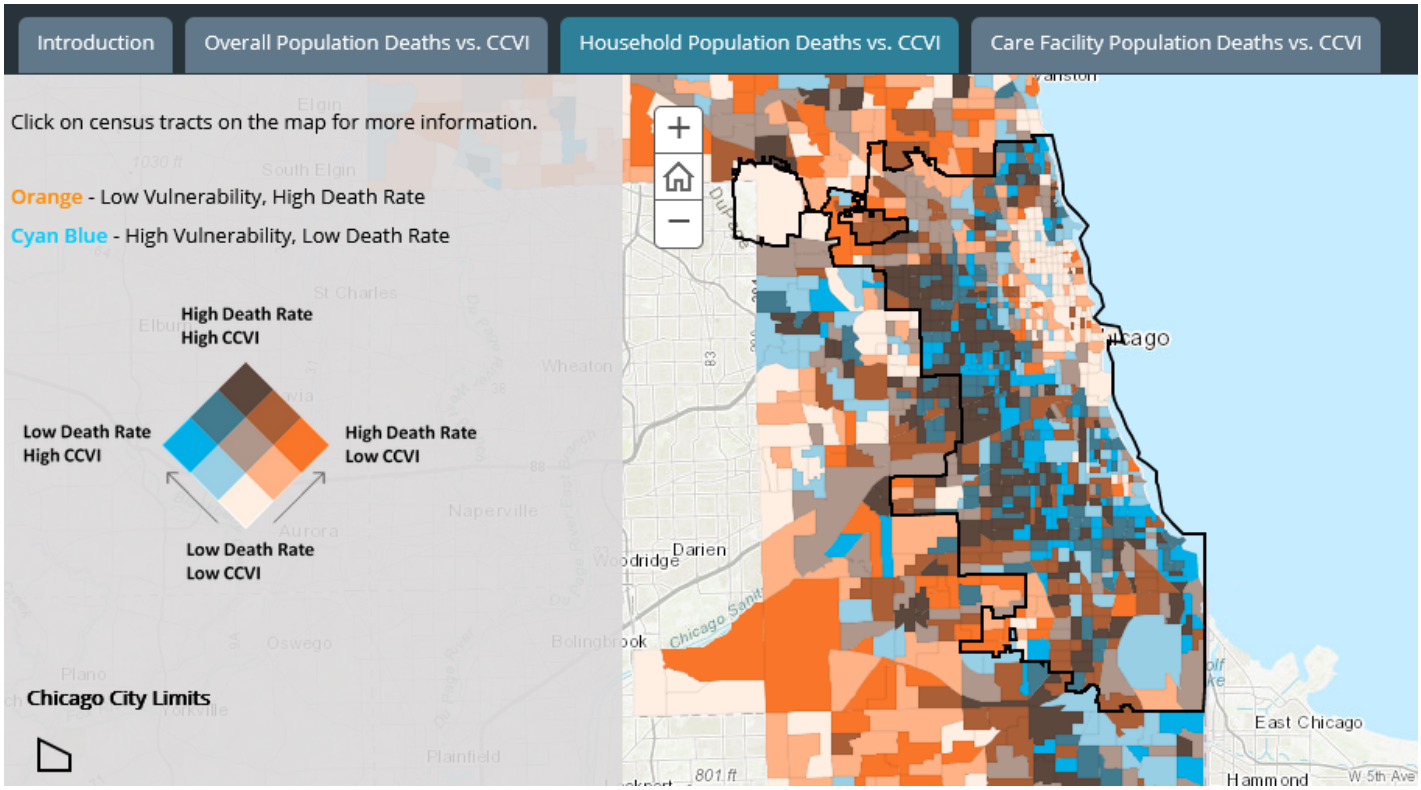
VIEW OF MCVD:PVCC INTERFACE



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