Summary:

As authors of the paper "Assessing the Impact of Pharmacy Prescription Refusals in North Carolina: A Mathematical Modeling Approach," we aimed to comprehensively evaluate the impact of pharmacy prescription refusals, especially on marginalized groups in our state. We developed two interconnected models using census data and national statistics.

In our first model, we focused on three key groups: Men Who Have Sex with Men (MSM) susceptible to HIV, transgender individuals seeking hormone therapies, and pregnant-capable women needing contraceptives or pregnancy termination drugs. We estimated the population of these groups in each geographic area (GeoID) and their medication needs. Our second model integrated these population estimates with geographic locations of pharmacies and transportation networks, identifying areas and specific pharmacies where prescription refusals would have the most significant impact.

Our findings revealed substantial differences in the potential impact of prescription refusals across different areas, with some GeoIDs being particularly vulnerable. We underscored the need for policy interventions to mitigate the adverse effects on these marginalized groups and called for further on-the-ground research to refine our model's predictions. The appendices of our paper include detailed data sheets, MATLAB code used for distance calculations, and a comprehensive reference list.

We began our paper with a background on pharmacy prescription refusals, highlighting their significance for marginalized communities and the lack of systematic documentation. Our goal was to craft a mathematical model to assess the impact on these groups, focusing on North Carolina. We outlined our methodology, assumptions, and the development of our model, which included a detailed analysis, highlighting the model's strengths, weaknesses, and future considerations.

In conclusion, we discussed the significant health, societal, legal, policy, economic, and psychological impacts of prescription refusals. We also included a letter to the Governor in our paper, highlighting our study's findings and proposing measures to address the issues we identified. Our appendices provide the MATLAB code used in our study and an Excel spreadsheet with the final results.

Selected Problem: Prescription Refusals

November 12th, 2023

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Abstract:
This study presents a comprehensive mathematical model to evaluate the impact of pharmacy prescription refusals in North Carolina, particularly on marginalized groups. Utilizing census data and national statistics, we developed two interconnected models. The first model focuses on three key groups: Men Who Have Sex with Men (MSM) susceptible to HIV, transgender individuals seeking hormone therapies, and pregnant-capable women needing contraceptives or pregnancy termination drugs. This model estimates the population of these groups in each geographic area (GeoID) and their medication needs. The second model integrates these population estimates with geographic locations of pharmacies and transportation networks, identifying areas and specific pharmacies where prescription refusals would have the most significant impact. Our findings reveal substantial differences in the potential impact of prescription refusals across different areas, with some GeoIDs being particularly vulnerable. The study underscores the need for policy interventions to mitigate the adverse effects on these marginalized groups and calls for further on-the-ground research to refine the model's predictions. The appendices include detailed data sheets, MATLAB code used for distance calculations, and a comprehensive reference list.
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I. Introduction

1.1. Background
At the heart of our interconnected society, the issue of pharmacy prescription refusals stands out as a pivotal challenge, merging the realms of social justice and healthcare. This problem predominantly affects marginalized communities, highlighting a critical intersection of medical ethics, legalities, and societal fairness. Across various states, legislative gray areas have created a contentious landscape, allowing pharmacists to refuse filling prescriptions based on personal moral or religious beliefs. The consequences of such decisions are significant, especially for medications crucial to many, including hormone therapies for transgender individuals, contraceptives, drugs for terminating pregnancies, and HIV prophylaxis. These medications are often vital for the health and well-being of those they are prescribed to.

Regrettably, there is a lack of information and systematic documentation of these refusals. This lack of data shields the true scope of the issue and its impact on those affected. In response, our advocacy group is committed to illuminating the consequences of prescription refusals throughout North Carolina, focusing on the plight of those marginalized by these practices.

1.2. Problem Restatement
Our aim is to craft a mathematical model to evaluate the impact of pharmacy prescription refusals on marginalized groups in North Carolina. Utilizing available census data and online resources, we intend to gather significant demographic information. This data, combined with details on pharmacy locations, will facilitate our ability to forecast the extent of the adverse effects caused by the refusal of critical medications.

In addition to a numerical analysis of the number of population impacted, we aim to identify the geographical areas most susceptible to these refusals, pinpointing specific locations and pharmacies that require further investigation. This initiative is about more than just measuring the issue—it's about uncovering where and in what ways we can step in to create a real, positive change for those who are impacted by these prescription refusals.

1.3. Our Work
Our strategy to tackle the issue of pharmacy prescription refusals in North Carolina is structured around a two-part modeling framework. In the initial phase, we categorize North Carolina into sections using GeoID - a unique numerical identifier assigned to each geographic area from census tract data. This step involves identifying the populations of three principal marginalized groups within each GeoID and estimating the number who might need specific medications, using a combination of national statistics and census data.
In the second phase, we integrate the population data from the first model with the geographic locations of pharmacies and transportation networks. This enables us to pinpoint the GeoIDs most susceptible to adverse effects of prescription refusals, and specific pharmacies with the most significant impact on minority communities, and therefore warrant closer examination.

Attached is a diagram that visually represent our approach and provide clarity of understanding:
II. Population Analysis Model

2.1. Objectives and summary of model
This model focuses on calculating the number of people that are susceptible to refusals in three key groups: Men Who Have Sex with Men (MSM) susceptible to HIV, transgender individuals seeking hormone therapies, and pregnant-capable women who might seek contraceptives or pregnancy termination drugs.

2.2 Definitions

Men Who Have Sex with Men (MSM) Susceptible to HIV: This group includes bisexual and gay men who are at risk of HIV. In our model, we focus on the subset of this group likely to seek HIV prophylaxis drugs.

Transgender Individuals: Individuals whose gender identity differs from their sex assigned at birth. For our model, we specifically consider those seeking hormone therapies.

Pregnancy-Capable Women: Women within the reproductive age range (15-49 years of age) who might seek contraceptives or pregnancy termination drugs.

2.3 Assumptions and Justifications
The introduction to our analysis and model relies on a series of critical assumptions. These assumptions are essential for constructing our model, especially in areas where specific local data is unavailable, ensuring that we can still provide meaningful insights and recommendations despite these data limitations:

1. Only statistics for MSM men aged 18 and above are included, excluding data for the Asian population due to unavailability.
   - Justification: This approach is based on the availability of reliable data. The exclusion of specific demographic data, like that of the Asian population, is due to the lack of detailed statistics in this subset, which could otherwise skew the accuracy of the model. The focus on adults (18+) is because they are more likely to be independent in their healthcare decisions and have distinctive healthcare needs compared to minors.

2. The percentage of MSM taking HIV prophylaxis in each GeoID mirrors the U.S. average.
   - Justification: Due to the absence of localized data on HIV prophylaxis usage, it's reasonable to apply the national average as a baseline. This assumption simplifies the model without significant loss of accuracy, as there's no evidence to suggest dramatic deviations in prophylaxis usage patterns across different regions.
3. Uniform distribution in each GeoID, based on age and birth rates.
   - Justification: In the absence of detailed, localized fertility data, a uniform distribution assumption allows for a generalized overview across different regions. It’s a pragmatic approach to estimate the number of women who might need pregnancy-related medications.

4. Distribution of transgender individuals seeking hormone therapy in North Carolina is similar to the U.S. average.
   - Justification: With limited state-specific data on transgender individuals and their healthcare needs, the national average provides the most reasonable proxy. It's a necessary simplification to model the potential demand for hormone therapies in the absence of more detailed local data.

5. Differentiating between prescription pill usage and emergency contraceptive usage, based on U.S. statistics per age and race.
   - Justification: This assumption is based on the availability of national statistics, which is the best available data in the absence of more granular, state-specific information. It allows the model to account for variations in contraceptive needs and preferences.

By justifying these assumptions, we can acknowledge the limitations of our model while ensuring that it remains a fair and reasonable tool for assessing the impact of pharmacy prescription refusals on marginalized communities in North Carolina.

2.4 Model Development

Our model is designed to estimate the population at risk of experiencing pharmaceutical refusals, with a particular focus on three groups: MSM susceptible to HIV, transgender individuals seeking hormone therapies, and pregnant-capable women. The development is twofold: we first estimate the total number of individuals in each group using available census data and national statistics for extrapolation. We then apply these figures to assess the portion of these populations likely to seek specific medications. For pregnant-capable women, detailed census data allows us to bypass the initial estimation step.

Variables, Parameters, Justifications:
- Census Data Utilization: We employ census data to ascertain the count of pregnant-capable women and extrapolate from national statistics for MSM and transgender populations.
- Medication Demand Calculation: We calculate the demand for medication by determining the proportion of each population group within each GeoID that is
likely to seek the relevant medication, guided by U.S. statistics for MSM and transgender individuals and by census data for pregnant women, differentiated by those who prefer prescription pills and those who opt for emergency contraceptives.

2.5.1 Extrapolation Method

We produce a model to estimate either the number of transgender people or LGBTQ men in a census tract of North Carolina (NC), given

- The proportion of people in each age category, and each race category (but not a joint category) in a fixed census tract of NC
- The proportion of people in each (age, race) category in NC that are transgender/LGBTQ.

The first category of information was gathered through publicly available census data. The second utilized primarily two papers both from the William's Institute.

Following the production of the model, we provide an analysis of the variance under some assumptions. In addition to this analysis, we evaluate the accuracy of the model by comparing the result with available statistics or previously published results.

Assumptions and estimating $E[X]$

We had no available statistics on the number of people in each specific category of race and age, however we may assume that when picking one person uniformly from a census tract at random, then their race category and age category are independent random variables. i.e. for all age category $A$ and race category $R$, $\mathbb{P}(A, R) = \mathbb{P}(A)\mathbb{P}(R)$

Such an assumption is reasonably justified due to the interactions between race and age distribution being only a matter of at max a few years difference. Such an interaction is not a significantly impactful factor given the host of other variables at play.

For the simplicity of the write-up, we proceed with describing either target population as simply, LGBTQ. Let $\mu_{A,R}$ denote the proportion of people in NC that are LGBTQ in the $(A, R)$ category. Then we make the key assumption for our model: we assume that $\mu_{A,R}$-proportion of the people in each census tract are LGBTQ. Then we estimate $\mu$, the mean of the proportion of people in the census tract that are LGBTQ to be

$$\mu = \sum_{(A,R)} p_{A|R} \mu_{A,R}$$
Where $p_A$ is the proportion of people in each age category of the census tract, $q_R$ is the proportion of people in each race category of the census tract, and $\mu_{A,R}$ is the proportion of people in each joint (age,race) category of NC.

This is theoretically justified by linearity of expectation; let $X$ be the proportion of people that are LGBTQ in the census tract, and for each joint $(A, R)$-category, let $X_{A,R}$ be the proportion of people in each $(A, R)$-category. Then by linearity of expectation, since

$$E[X] = \sum_{(A, R)} E[X_{A,R}],$$

We estimate $E[X_{A,R}] \approx p_A q_R \mu_{A,R}$ since by independence, $p_A q_R$-proportion of all people in the census tract belong to the joint (age,race) category $(A, R)$, and

Bounding $\sqrt{Var(X)}$

Let $n$ be the number of people in the census tract. Then

$$X = \frac{X_1 + \cdots + X_n}{n}$$

where for each $1 \leq j \leq n$, $X_j$ is the indicator variable for whether person $j$ is LGBTQ.

Major Assumption: $X_j, X_k$ are independent for all $j \neq k$.

Then

$$Var(X) = n^{-2} \sum_{1 \leq j, k \leq n} Cov(X_j, X_k) = n^{-2} \sum_{1 \leq j \leq n} Cov(X_j, X_j) = n^{-2} \sum_{1 \leq j \leq n} Var(X_j)$$

Note that if $j$ lies in category $(A, R)$, then $X_j$ is a Bernoulli random variable with parameter $\mu_{A,R}$, so $Var(X_j) = E[X_j^2] - E[X_j]^2 = \mu_{A,R} - \mu_{A,R}^2$

For each $(A, R)$, there are $np_A q_R$ people in this category. Thus,

$$Var(X) = n^{-2} \sum_{A,R} np_A q_R (\mu_{A,R} - \mu_{A,R}^2) = n^{-1} \sum_{A,R} p_A q_R (\mu_{A,R} - \mu_{A,R}^2)$$

Limitations of the bound
When this method is applied on a population of a census tract, we have $\mu \leq 10^{-3}$, and $\operatorname{Var}(X) \leq n^{-1} \sum_{A,R} p_{A|R} \mu_{A,R} = \frac{\mu}{n}$, where $n \approx 4000$ is a rough estimate for the number of people in a fixed county. With our data ($n \approx 4000$), estimates of the form $nX = [n\mu - n\sigma, n\mu + n\sigma]$ (where $c = (0.05)^{-1/2} < 4.5$ by Chebyshev inequality) is too precise (the interval has length $\leq 1$). Thus, for one census tract, this variance approximation is not reliable since there is only one integer in the interval.

This method is grounded on the assumption that the covariance 'errors' from one person being LGBTQ impacting another to be LGBTQ (or not) is negligible. Our results suggest this assumption is too strong, but the problem is intractable otherwise. The error in reality will make the sum of covariances of the events of two people being transgender a significant factor to the variance. This suggests the variance calculation is inaccurate, but the modeling method has great potential.

Applying this model allows us to derive the predicted number of transexual persons and gay men per North Carolina census tract region. We also produce similar information for the number of pregnant capable people via grouping together available census statistics by age by sex.

This produced the following results:

<table>
<thead>
<tr>
<th>Total NC Estimation Via the Model Compared with Previous Literature</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Our Model</strong></td>
</tr>
<tr>
<td>----------------</td>
</tr>
<tr>
<td>LGBTQ Men</td>
</tr>
<tr>
<td>Transexual Persons</td>
</tr>
</tbody>
</table>

Given the reasonable difference from the previous literature about the total number of LGBTQ Men and Transexual Persons, we may assume that our data per census tract is similarly reasonably accurate. Furthermore the variance calculations from above, although not largely accurate, do serve to suggest the models accuracy.

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$^1$ https://williamsinstitute.law.ucla.edu/visualization/lgbt-stats/?topic=LGBT&area=37&characteristic=male&demographic

2.5.2 Narrowing Down:

**MSM and Transgender Individuals Under Hormone Treatment:**

Men Who Have Sex with Men (MSM): We utilize census data detailing the percentage of LGBTQ men who are MSM (83%)\(^3\) to determine the number of MSM in each GeoID. Then we apply the national percentage of MSM taking HIV prophylaxis (42%)\(^4\) to this population to estimate the number likely to seek medication.

**Transgender Individuals:** We estimate the number of transgender individuals in each GeoID using national data and local demographics. Apply the percentage (84%)\(^5\) who desire hormone therapy and the subset (55%)\(^6\) actually receiving it to estimate those likely to seek medication.

**Pregnant-Capable Women:**

Demographic Segmentation by Age:

- Our analysis commenced with a thorough examination of North Carolina's census data, extracting age-specific demographics for women aged 15-49, aligning with medically established reproductive ages.
- We then divided this demographic into narrower age bands (such as 15-19, 20-24, and so forth) to capture the nuanced contraceptive needs and preferences that evolve with different life stages.

Contraceptive Utilization Estimation:

- Utilizing CDC national usage rates for both prescription birth control pills and emergency contraceptives, we were able to address the contraceptive demands of each age group with greater accuracy.
- By mapping these usage rates to the female population across each age segment and GeoID, we calculated the projected number of women who might seek each contraceptive category.

The statistics applied below are from the CDC:

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5. [https://www.cnn.com/2020/11/17/health/transgender-hormone-prescriptions-barriers-trnd/index.html#:~:text=About%2084%25%20of%20respondents%20to,they%20were%20using%20nonprescribed%20hormones](https://www.cnn.com/2020/11/17/health/transgender-hormone-prescriptions-barriers-trnd/index.html#:~:text=About%2084%25%20of%20respondents%20to,they%20were%20using%20nonprescribed%20hormones)

6. [https://www.cnn.com/2020/11/17/health/transgender-hormone-prescriptions-barriers-trnd/index.html#:~:text=About%2084%25%20of%20respondents%20to,they%20were%20using%20nonprescribed%20hormones](https://www.cnn.com/2020/11/17/health/transgender-hormone-prescriptions-barriers-trnd/index.html#:~:text=About%2084%25%20of%20respondents%20to,they%20were%20using%20nonprescribed%20hormones)
<table>
<thead>
<tr>
<th>Age</th>
<th>Contraceptive Pill Usage&lt;sup&gt;7&lt;/sup&gt;</th>
<th>Emergency Contraception Usage&lt;sup&gt;8&lt;/sup&gt;</th>
</tr>
</thead>
<tbody>
<tr>
<td>15–19</td>
<td>16.6%</td>
<td>13.7%</td>
</tr>
<tr>
<td>20–29</td>
<td>19.5%</td>
<td>23.2%</td>
</tr>
<tr>
<td>30–39</td>
<td>11.0%</td>
<td>15.5%</td>
</tr>
<tr>
<td>40–49</td>
<td>5.1%</td>
<td>5.0%</td>
</tr>
</tbody>
</table>

Upon applying our population analysis model, we discovered that the total number of pregnant-capable women who use emergency contraceptives in North Carolina amounts to 344,430, while those who utilize general contraceptive methods total 299,320. This data, broken down by individual GeoID, provides a granular view of contraceptive needs across the state. For a detailed breakdown of these figures, refer to the comprehensive data sheet included in the appendix of this report. This localized information is pivotal, as it allows us to pinpoint areas where pharmacy prescription refusals could have the most significant impact, particularly on women's health and autonomy.

III. Geographic and Pharmacy Impact Analysis Model

3.1 Objectives and summary of Model

The primary goal of this model is to pinpoint the specific geographic areas (GeoIDs) in North Carolina that are most susceptible to the adverse effects of pharmacy prescription refusals. A key aspect of our analysis involves identifying pharmacies whose operational policies significantly influence access to medication for vulnerable communities. Ultimately, our objective is to comprehensively estimate the total number of individuals affected within the three identified minority groups, integrating insights derived from our Population Model.

3.2 Additional definitions, assumptions, and variables:

**Unreliable Long Distance Transportation:** Persons who are not guaranteed to have access methods of transportation that allows for ease of accessing far away pharmacies. Formally we define this as persons, who commute to work via walking, public transport, or carpooling. Although these categories are not by any way guaranteed to suggest that such persons would

<sup>7</sup> [https://www.cdc.gov/nchs/data/databriefs/db327_tables-508.pdf#page=3](https://www.cdc.gov/nchs/data/databriefs/db327_tables-508.pdf#page=3)

<sup>8</sup> [https://www.cdc.gov/nchs/data/databriefs/db112_tables.pdf#2](https://www.cdc.gov/nchs/data/databriefs/db112_tables.pdf#2)
have difficulties accessing a car or other methods of easy transportation, it provides a reasonable estimate.

1. **All minority groups have similar transportation usage patterns as the general population in their county.**
   - Justification: This assumption is made due to the lack of detailed transportation usage data specific to each minority group. It's a reasonable approximation given that transportation infrastructure and availability are more likely to be influenced by geographic location rather than individual demographic characteristics.

2. **For individuals walking or using public transport, the probability they decide not to pursue medication because of refusal is correlated to the distance to the next closest pharmacy.**
   - Justification: This assumption is based on practical considerations of distance and accessibility. It considers average travel capabilities and limitations faced by individuals depending on their mode of transportation.

3. **The model uses a direct distance calculation for considering commute time distances between pharmacies and GeoIDs.**
   - Justification: Given the intricacies of road networks and the fact this analysis is applied to those without consistent access to cars, simplifying considering the distance using geodesic calculations is sufficient to determine which areas have large distances between available pharmacies.

Below is a Diagram of GeoIDs and pharmacy locations: red dots being GeoID, marks being pharmacies
3.3 Model Development

**Transportation Methods and Impact Analysis:** The model addresses the impact of transportation methods on pharmacy access, considering how individuals in each minority group travel, whether by walking, public transportation, or other means. We've utilized census tract data to estimate the proportion of each minority group reliant on these transportation methods to access pharmacies.

**Impact Analysis:** The analysis investigates how the distance to the nearest pharmacy—and the next accessible one—shapes the likelihood that marginalized individuals will abstain from seeking medication following a refusal. This includes assessing the effects of such refusals on populations identified as homosexual, transgender, and those in need of contraceptives.

**Impact Analysis Table:** Included within the model is a table illustrating how the probability of not obtaining medication correlates with distance for the respective groups. This vital component aids in quantifying the influence of pharmacy access at varying distances.

The model computes the minimum distance individuals must travel to reach the second closest pharmacy should the nearest one refuse service, adding this to the distance to the first pharmacy. It then uses these distances to determine the impact on the respective populations, categorized by the number of GeoIDs within each distance range:

<table>
<thead>
<tr>
<th>Distance (Miles)</th>
<th>Homosexual</th>
<th>Transexual</th>
<th>Emergency Contraceptive</th>
<th>Contraceptive</th>
<th>Number of GeoIDs</th>
</tr>
</thead>
<tbody>
<tr>
<td>10</td>
<td>99%</td>
<td>99%</td>
<td>99%</td>
<td>99%</td>
<td>47</td>
</tr>
<tr>
<td>8</td>
<td>97%</td>
<td>97%</td>
<td>95%</td>
<td>97%</td>
<td>106</td>
</tr>
<tr>
<td>6</td>
<td>95%</td>
<td>95%</td>
<td>90%</td>
<td>95%</td>
<td>238</td>
</tr>
<tr>
<td>4</td>
<td>70%</td>
<td>70%</td>
<td>50%</td>
<td>70%</td>
<td>590</td>
</tr>
<tr>
<td>2</td>
<td>20%</td>
<td>20%</td>
<td>10%</td>
<td>20%</td>
<td>1570</td>
</tr>
</tbody>
</table>

The model then identifies the GeoIDs most adversely affected by prescription refusals and estimates the number of impacted individuals within those regions. For example, our
analysis predicts that as many as 5,584 individuals across various GeoIDs might be denied access to necessary medications due to such refusals.

**GeoID and Pharmacy Proximity Analysis:** Using MATLAB, we determined the GeoIDs at greatest risk and identified the pharmacies whose refusal to dispense medications would most significantly affect minority groups. The specifics of the MATLAB code used for these calculations are provided in the appendix.

**Key GeoIDs and Their Closest Pharmacies:** The model provides specific details of the GeoIDs closely situated to pharmacies, underlining areas that require immediate attention:

<table>
<thead>
<tr>
<th>Location</th>
<th>GeoID</th>
<th>Latitude</th>
<th>Longitude</th>
<th>Pharmacy</th>
<th>Links</th>
</tr>
</thead>
<tbody>
<tr>
<td>Harrells, NC</td>
<td>37163971002</td>
<td>35.0939</td>
<td>-76.2593</td>
<td>CVS Pharmacy</td>
<td>Link</td>
</tr>
<tr>
<td>Salvo, NC</td>
<td>37055990100</td>
<td>35.5547</td>
<td>-75.4468</td>
<td>Beach Pharmacy of Avon</td>
<td>Link</td>
</tr>
<tr>
<td>Fairfield, NC</td>
<td>37095920101</td>
<td>35.5791</td>
<td>-76.0945</td>
<td>Columbia Pharmacy</td>
<td>Link</td>
</tr>
<tr>
<td>Near Gull Rock Game Land, NC</td>
<td>37095990200</td>
<td>35.2967</td>
<td>-76.0240</td>
<td>Walgreens Pharmacy</td>
<td>Link</td>
</tr>
<tr>
<td>Near Starlight Hills Campground, NC</td>
<td>37161960101</td>
<td>35.5062</td>
<td>-81.7542</td>
<td>Walmart Pharmacy</td>
<td>Link</td>
</tr>
</tbody>
</table>

By examining these locations, we aim to direct research and advocacy efforts towards pharmacies with a substantial potential impact on minority groups, promoting investigations that can lead to policy changes and improved access to healthcare services.

**Assessment of Population Impact:**

The model quantifies the potential repercussions of pharmacy prescription refusals by calculating the number of individuals likely affected within each GeoID. This quantitative assessment provides insight into the extent of the impact. For example, the model's predictions indicate that approximately 5,584 individuals could be denied access to essential medications as a result of these refusals, emphasizing the urgency of addressing this issue.

**IV. Model Analysis**

Our mathematical model, aimed at assessing the impact of pharmacy prescription refusals in North Carolina, serves as a pivotal tool in understanding the scope of challenges faced...
by marginalized communities—specifically, MSM susceptible to HIV, transgender individuals requiring hormone therapies, and pregnant-capable women seeking contraceptives or pregnancy termination drugs.

### 4.1 Strengths of the Model:

- The model’s strength lies in its data-driven approach, leveraging both national statistics and detailed census data to provide a thorough analysis of the population at risk.
- It facilitates the identification of specific geographic areas and pharmacies, thereby enabling targeted interventions where they are most needed.
- Our use of a multi-faceted model incorporating demographics, pharmacy locations, and transportation networks offers a comprehensive view of the potential barriers to medication access.

### 4.2 Weaknesses of the Model:

- A notable limitation is the assumption of uniform behavior across GeoIDs, which may not account for local variations in culture, education, or healthcare infrastructure.
- The model assumes independence between race and age when estimating LGBTQ populations, which may not capture complex socio-demographic interdependencies.
- Our analysis does not account for the dynamic nature of populations and their healthcare needs over time, which can fluctuate due to various factors such as migration, economic changes, and evolving healthcare policies.

### 4.3 Future Considerations

- To enhance the model's precision, future iterations could incorporate political affiliation data, considering the influence of political climate on healthcare access and attitudes towards marginalized groups.
- Refinements could also include temporal data to track changes over time and consider the impact of new healthcare policies or shifts in political landscapes.
- Additionally, more granular local data could be integrated as it becomes available, to refine the model’s predictions and make it more reflective of individual communities’ needs.
V. Results and Conclusion

The refusal to fill prescriptions has significant implications for public health and individual well-being. With our model estimation of the number of people impacted total in North Carolina shown below:

<table>
<thead>
<tr>
<th>Category</th>
<th>Number</th>
</tr>
</thead>
<tbody>
<tr>
<td>MSM</td>
<td>415</td>
</tr>
<tr>
<td>Women: Contraceptives</td>
<td>2440</td>
</tr>
<tr>
<td>Women: Emergency Contraceptives</td>
<td>2355</td>
</tr>
<tr>
<td>Transgender</td>
<td>75</td>
</tr>
</tbody>
</table>

Here is an impact assessment on our results:

1. Health Implications: MSM who are denied HIV prophylaxis face a heightened risk of HIV transmission. Transgender individuals without access to hormone therapies may experience severe psychological distress. Women unable to obtain contraceptives or pregnancy termination drugs could be forced into unsafe alternatives, increasing health risks.

2. Societal Impact: Prescription refusals deepen the marginalization of already vulnerable groups, reflect and intensify societal discrimination, and pose ethical dilemmas by violating the medical principle of providing unbiased care.

3. Legal and Policy Issues: The legal ambiguity surrounding prescription refusals necessitates clearer guidelines to balance religious freedom with healthcare rights, and calls for policy reforms to ensure equitable healthcare access.

4. Economic and Public Health Consequences: Refusals can escalate healthcare costs due to untreated health issues and have broader public health consequences, like increased disease transmission and unintended pregnancies.

5. Psychological and Quality of Life Effects: Being denied medication can lead to significant mental health issues and a deterioration of trust in the healthcare system, impacting the quality of life and community trust.

VI. Letter to Governor

Dear Governor,

Subject: Action Required: Addressing Pharmacy Prescription Refusals

Our team's recent study, "Impact of Pharmacy Prescription Refusals in NC," has highlighted urgent healthcare access issues for marginalized communities. We've identified MSM, transgender individuals, and women in need of contraceptives or termination drugs as vulnerable populations facing significant barriers due to prescription refusals.

The study's findings are alarming, showing a disproportionate impact in specific regions, including Harrells, Salvo, Fairfield, and vicinities near Gull Rock Game Land and Starlight Hills Campground. These communities are at an elevated risk of health complications and societal discrimination due to the lack of accessible medication.

To address these critical issues, we propose the following measures for your administration's consideration:

- Draft and enforce clear legal standards that prevent prescription refusal on subjective grounds, ensuring equitable medication access. Establish a tracking system for pharmacy refusals to promote transparency and accountability.
- Initiate healthcare programs tailored to the needs of affected communities to guarantee that all individuals receive the care they need.
- Support the collection of comprehensive data on the prevalence and impact of prescription refusals to inform and refine policy decisions.

Your decisive action on this matter is pivotal. It is an opportunity to lead a change that not only upholds the right to health but also strengthens trust in our healthcare system.

We appreciate your attention to this pressing issue and are at your disposal to discuss our findings or assist in any way possible.

Best regards,

Paul Rosu,
Conrad Qu,
Kai Wang
VII. References


VIII. Appendix

Excel Spreadsheet With Final Results:

Matlab Code:

```matlab
```
% This function calculates the distances between GeoIDs and Pharmacies as described in the paper
function [D,L] = PharmDistances(G,P,V)

% Initialize matrices
D = zeros(length(G),2);
D1 = zeros(length(G),2);
D2 = zeros(length(G),2);
D3 = zeros(length(G),2);
locations = zeros(1,3);

% Determine minimum distance from pharmacy P to each location in G
for i = 1:length(G)
    [M, I] = min(distance(G(i,2:3), P));
    D1(i,:) = [M, I];
end

% Remove minimum distance from original distance array
for i = 1:length(G)
    Premoved(D1(i,2),:) = [0 0];
    [M, I] = min(distance(G(i,2:3), Premoved));
    D2(i,:) = [M, I];
end

% Determine minimum distance from closest pharmacies to all other pharmacies
for i = 1:length(G)
    [M, I] = min(distance(P(D1(i,2,:),), P));
    D3(i,:) = [M, I];
end

% Store the sum of the minimum distances in D
for i = 1:length(G)
    m = min(D2(i,1),D3(i,1));
    D(i,1) = m + D1(i,1);
    D(i,2) = D1(i,2);
end
```
% Convert the distances from degrees to kilometers
D(:,1) = deg2km(D(:,1));

% Find the distances greater than 10 km and store their indices and distances
j=0;
for i = 1: length(G)
    if (D(i,1)>10)
        j = j+1;
        locations(j,1:2) = D(i,:);
        locations(j,3) = i;
    end
end

% Store the locations in L and increment the indices by 1
L = locations;
L(:,2:3) = L(:,2:3) + ones(length(L),2);

end