Applying National Estimates of Adults with Indications for Pre-exposure Prophylaxis to Populations of Men who Have Sex with Men and Persons who Inject Drugs in Colorado

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Abstract

(450 words max; current 431)

Background: Oral pre-exposure prophylaxis (PrEP) is a highly effective option for HIV prevention. To realize the full benefit of PrEP at the population level, uptake must reach those at greatest risk for HIV acquisition. National guidance published by the Centers for Disease Control and Prevention (CDC) suggests the number of individuals with indications for PrEP is 1.1-1.2 million based on survey data of key populations. We applied these estimates at state and county levels to determine the number of those who might benefit from PrEP in Colorado.

Objective: This analysis aimed to produce estimates of key populations at risk for HIV (men who have sex with men and people who inject drugs) in Colorado. These estimates will be used for public health strategic planning for HIV prevention goals at the state and county jurisdictional levels.

Methods: Colorado population estimates were obtained from the state demography office which utilizes U.S. decennial census data and input from county and local agencies to forecast the population. We limited our analysis to adults aged 18-59 years to be consistent with CDC methodology for PrEP estimates. We performed a literature review to determine the best population-level percentages to apply to determine the number of HIV-negative men who have sex with men (MSM) and people who inject drugs (PWID) in Colorado. These percentages were applied to the state and to each county by its rural-urban designation. Finally, CDC-derived percentages of MSM and PWID with indications for PrEP were applied to these estimates to determine the number of MSM and PWID that may benefit from PrEP use.

Results: In 2017, 3,252,648 adults aged 18-59 years were living in Colorado. Applying published estimates of percentages of men who had sex with other men in the past 12 months, we determined 41,353 – 49,624 adult males could be considered sexually active MSM. We estimated that 9,758 – 13,011 males and females ages 18-59 years were likely to have injected drugs in the past 12 months. Accounting for the numbers of people living with HIV in those categories and applying the CDC PrEP percentages of MSM and PWID with indications for PrEP, we estimated that 8,792-12,528 MSM and PWID had indications for PrEP in Colorado.

Conclusions: Employing a simple framework consisting of census data, literature review, population estimates, and national estimates for PrEP indicators, we derived estimates for potential PrEP use in our state. Statewide estimates of key populations by state and geographic regions have enabled health officials to set informed goals and track progress toward optimizing PrEP uptake. This formula may be applicable to other states with similar epidemics and resources.
Introduction
Like many states, Colorado observed a decline in HIV diagnosis rates between 2005 and 2015, leading regional stakeholders to consider the possibility of ending the HIV epidemic in the state.[1] The UNAIDS 90-90-90 movement further propelled that work by introducing international population-level goals for diagnosis and care for people living with HIV.[2] Colorado is close to reaching the goals of 90-90-90, yet numbers of individuals who are newly HIV-diagnosed annually has stabilized and in some regions increased in the past few years, marking a change from the prior decade of declining HIV rates.[3] It is clear that to complement the prevention benefits of optimal treatment for people living with HIV, pre-exposure prophylaxis (PrEP) for people at risk for acquiring HIV is also a necessary tool to end new transmissions and propel efforts to end the epidemic.[4]

Unlike the parameters of the 90-90-90 initiative, targets for PrEP use have not been well-established at the local level. In their paper in the Morbidity and Mortality Weekly Report, Smith et al. analyzed survey data from the National Health and Nutrition Examination Survey (NHANES), the National Survey on Drug Use and Health (NSDUH), and the National HIV Behavioral Surveillance System (NHBS) and concluded that nationally approximately 1.2 million individuals in the United States had CDC-recommended indications for PrEP.[5] They determined that 24.7% of men who had sex with men (MSM) in the past 12 months, 18.5% of people who injected drugs (PWID) in the past 12 months, and 0.4% of sexually active heterosexual adults had indications for PrEP. To create a similar analysis for Colorado, we employed a variety of population-level data sources to determine the numbers of HIV-negative MSM and PWID in the state who are likely to have indications for PrEP. These estimates were obtained by applying population level percentages of MSM and PWID to the state as a whole, and by calculating county—level estimates based on each county’s rural-urban designation and the percentage of estimated MSM and PWID in each county type. We then applied the CDC-derived percentages of MSM and PWID with PrEP indications. Our goal was to obtain estimates that could lead to precise, actionable goals for PrEP uptake at the state and local levels.

Methods
Colorado Population Estimates
Census data for the total population of Colorado was obtained from the Colorado State Demography website, which uses the most recent decennial US Census Bureau data and input from county and local agencies to estimate and forecast the population for intercensal years to forecast population at the state and county levels.[6] Numbers of adults aged 18-59 were extracted from the population totals as was the gender distribution and the geographic distribution of adults by county. We aggregated Colorado counties using the 2013 National Center for Health Statistics (NCHS) Urban-Rural Classification Scheme for Counties in the following groupings: large central metro, large fringe metro, medium or small metro and nonmetro urbanicity.[7] (See Figure 1.) Forecasted 2017 county population data was used to determine total county population, sex, and age stratifications.[6]
Estimates for MSM and PWID Not Known to be Living with HIV

We conducted a literature review to determine the most relevant and accurate percentages of adult populations that were likely to fall into the MSM and PWID categories. To reflect populations more at risk for HIV and to remain consistent with the selection criteria used by Smith and colleagues in their national PrEP estimates, for our final calculations we selected references that included estimates of proportions of adults with MSM and PWID behaviors in the past 12 months.[5] We then applied the national and regional estimates from the literature to the Colorado adult male and overall adult populations. Once the estimated numbers of MSM and PWID in Colorado were calculated, we utilized state HIV surveillance data to subtract the number of individuals known to be living with HIV from each group to determine the potential number of individuals at increased risk of HIV acquisition.[3] The exercise was repeated at the county level by applying varying percentages of individuals estimated to have had male-male sex or injected drugs in the past 12 months by county-type (urban-rural designation) and then subtracting the number of MSM or PWID living with HIV in each county-type from the total.

Estimates for MSM and PWID with Indications for PrEP

Using CDC-derived percentages of individuals in the MSM and PWID categories with indications for PrEP, we calculated the numbers of individuals in these categories by applying percentages to Colorado as a whole and by summing estimates for each county-type.[5] (See Textbox 1 for complete formula.)

Textbox 1. Formula to determine the number of individuals with indications for PrEP by MSM and PWID subgroup.

\[
\text{Estimated MSM with PrEP Indications} = \left(\text{Adult Male Population} \times \text{Estimated Percentage MSM last 12 months}\right) - \text{HIV-positive MSM} \times .0247
\]

\[
\text{Estimated PWID with PrEP Indications} = \left(\text{Adult Population} \times \text{Estimated Percentage PWID last 12 months}\right) - \text{HIV-positive PWID} \times .0185
\]
Results

The number of adults aged 18-59 years living in Colorado in 2017 was 3,252,648. Of those, 1,654,138 were men (51%). Overall, 53% of the population lived in counties classified as Large Central Metro/Urban Core or Large Fringe Metro/Suburban.[6] (See Table 1 for the distribution of adults by county urbanicity type.)

<table>
<thead>
<tr>
<th>Urbanicity Type</th>
<th>No. of Counties</th>
<th>Male Population</th>
<th>Female Population</th>
<th>Total Population</th>
<th>Percent of State</th>
</tr>
</thead>
<tbody>
<tr>
<td>State</td>
<td>64</td>
<td>1,654,138</td>
<td>1,598,510</td>
<td>3,252,648</td>
<td>100</td>
</tr>
<tr>
<td>Large Central Metro/Urban Core</td>
<td>1</td>
<td>228,148</td>
<td>220,601</td>
<td>448,749</td>
<td>14</td>
</tr>
<tr>
<td>Large Fringe Metro/Suburban</td>
<td>9</td>
<td>633,801</td>
<td>630,575</td>
<td>1,264,376</td>
<td>39</td>
</tr>
<tr>
<td>Medium/Small Metro</td>
<td>7</td>
<td>585,451</td>
<td>568,440</td>
<td>1,153,892</td>
<td>35</td>
</tr>
<tr>
<td>Nonmetro</td>
<td>47</td>
<td>206,737</td>
<td>178,894</td>
<td>385,631</td>
<td>12</td>
</tr>
</tbody>
</table>

Data from the Colorado State Demography Office. Population forecast for 2017 (https://demography.dola.colorado.gov/population/data/)

* Counties assigned to urbanicity in accordance with 2013 NCHS urban-rural classification scheme

Our literature review yielded four publications that characterized the percentage of the given populations of males that could be considered MSM, three of which included estimates for male-male sexual activity in the past 12 months.[8-11] The review yielded two publications that described population proportions of PWID, one of which specifically characterized percentage of the populations with history of injection drug use in the past 12 months.[9,12] (See Table 2 for details of the reviewed publications.) The estimates most applicable to our analysis were described by Oster et al., which suggested that 2.5% of the male population nationally and 3% of the males in the Western U.S. had a history of sex with men in the past 12 months. At the county level, estimates for recent male-male sexual activity ranged from 1.1% of adult males in nonmetro counties to 4.4% of adult males in large central metro counties.[9] We compared these findings with estimates produced by Grey et al. which suggested that 2.4% of the adult male population nationally had a history of sex with men in the past 12 months, and that 3.8% of men in Colorado had had sex with a man in the past 5 years. Male-male sexual activity in Colorado in the past 12 months was not described in the paper by Grey et al. County-level estimates ranged from 1% to 6.8% in nonmetro and large central metro counties, respectively.[8]

Oster et al. also estimated that 0.3% of the adult population nationally and 0.4% of the adult population in the West had a history of injection drug use in the past 12 months. Estimates of recent injection drug use at the county urbanicity levels ranged from 0.3% in the large central metro counties to 0.5% in the nonmetro counties.[9]
Statewide Estimates

By applying the national and regional MSM and PWID percentages by Oster et al. to the Colorado population as a whole, regardless of county-type, we determined that statewide between 41,353 – 49,624 males ages 18-59 were likely to be MSM in the past 12 months, depending on the whether we applied the national MSM estimates (lower estimate) or Western U.S. MSM estimates (higher estimate). Using the national and Western U.S. estimates for PWID, we determined that 9,758 – 13,011 individuals (males and females ages 18-59) were likely to have injected drugs in the past 12 months, also with the higher estimate derived from estimates for the Western U.S. rather than nationally. After accounting for individuals living with HIV in those two categories, we determined that 33,199 – 41,470 MSM and 9,098 – 12,351 PWID were eligible for the PrEP indications analysis.

County-level Estimates

When we applied estimates of percentages of individuals with MSM and PWID behavior in the last 12 months by county urbanicity type to the number of adults ages 18-59 living in each county-type in Colorado, we determined that 36,354 males were estimated to have had male-male sex in the past 12 months, and 10,143 individuals were likely to have injected drugs in the past 12 months. After

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Table 2. Literature Reviewed for Population Estimates

<table>
<thead>
<tr>
<th>Year</th>
<th>Population Age</th>
<th>Geographic Distribution</th>
<th>Behavioral Characteristic / Time Frame</th>
<th>U.S. Population Percentage (MSM: % adult males; PWID: % all adults)</th>
<th>Colorado or Western U.S. Population Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Oster et al.</strong></td>
<td>2015</td>
<td>13 years and older</td>
<td>National, Regional, and County Level</td>
<td>MSM / Lifetime MSM / Past 12 months PWID / Lifetime PWID / Past 12 months</td>
<td>4.7% 2.5% 2.3% 0.3%</td>
</tr>
<tr>
<td><strong>Grey et al.</strong></td>
<td>2016</td>
<td>18 years and older</td>
<td>National, State, County and core-based statistical area</td>
<td>MSM / Past 5 years MSM / Past 12 months</td>
<td>3.9% 2.4%</td>
</tr>
<tr>
<td><strong>Purcell et al.</strong></td>
<td>2012</td>
<td>13 years and older</td>
<td>National</td>
<td>MSM / Lifetime MSM / Past 5 years</td>
<td>6.9% 3.9%</td>
</tr>
<tr>
<td><strong>Lieb et al.</strong></td>
<td>2011</td>
<td>18 years and older</td>
<td>State Level</td>
<td>MSM / Past 12 months</td>
<td>2.9%</td>
</tr>
<tr>
<td><strong>Lanksy et al.</strong></td>
<td>2014</td>
<td>13 years and older</td>
<td>National Level</td>
<td>PWID / Lifetime</td>
<td>2.6%</td>
</tr>
</tbody>
</table>
accounting for MSM and PWID living with HIV in Colorado, we estimated that 28,200 MSM and 9,483 PWID were eligible for the PrEP indications analysis. (See Table 3).

Applying published estimates for the proportions of MSM and PWID with CDC indications for PrEP, we determined that the MSM population with indications for PrEP ranged from 8,200 – 10,243 males statewide, representing 24.7% of the estimated HIV-negative MSM population. We estimated that 1,683 – 2,285 individuals, representing 18.5% of the estimated HIV-negative PWID population had indications for PrEP statewide. By applying the formula for PrEP indications using the county-level MSM and PWID estimates, we determined that 6,965 MSM in Colorado were likely to have indications for PrEP and 1,827 PWID were likely to have indications for PrEP. The majority of MSM with PrEP indications were located in the one large central metro county (Denver) and the large fringe metro counties, while the number of PWID with PrEP indications was more evenly distributed throughout the state. (See Table 3 for the estimated numbers of MSM and PWID statewide and by county type.)

### Table 3. Estimated number of individuals with indications for PrEP in Colorado

<table>
<thead>
<tr>
<th>Key Population</th>
<th>Statewide (US-based)</th>
<th>Statewide (Western US-based)</th>
<th>Statewide (Sum of County-level Estimates)</th>
<th>Large Central Metro</th>
<th>Large Fringe Metro</th>
<th>Medium / Small Metro</th>
<th>Nonmetro</th>
</tr>
</thead>
<tbody>
<tr>
<td>Men who have Sex with Men (MSM)</td>
<td>8,200</td>
<td>10,243</td>
<td>6,965</td>
<td>1,536</td>
<td>3,311</td>
<td>1,676</td>
<td>442</td>
</tr>
<tr>
<td>Persons who Inject Drugs (PWID)</td>
<td>1,683</td>
<td>2,285</td>
<td>1,827</td>
<td>207</td>
<td>669</td>
<td>610</td>
<td>341</td>
</tr>
<tr>
<td>Total</td>
<td>9,683</td>
<td>12,528</td>
<td>8,792</td>
<td>1,743</td>
<td>3,980</td>
<td>2,286</td>
<td>783</td>
</tr>
</tbody>
</table>

**Discussion**

Of the 3,252,648 individuals ages 18 – 59 residing in Colorado in 2017, we determined that between 8,648 - 12,528 MSM plus PWID were likely to have indications for PrEP as described in the 2015 CDC guidelines for PrEP use. Of those, approximately 81-82% are MSM and 65% live in large central or large fringe metro areas. By target population, 70% of MSM live in large central or large fringe metro areas and 50% of PWID live in large central or large fringe metro areas, reflecting the more rural distribution of injection drug use. The county distribution of PrEP for MSM is similar to the distribution of HIV among MSM in Colorado, in which 70-75% of the MSM living with HIV reside in the five-county Denver Metro area.[3]
As has been observed with national PrEP estimates, the number of individuals estimated to have an indication for PrEP in Colorado was close to the number of individuals living with HIV in the state.[5] Some authors have suggested that an alternate method for estimating PrEP need could employ HIV diagnoses as a reference point.[13] In 2016, approximately 8,500 MSM, 1,400 MSM-PWID, and 500 PWID were known to be living with HIV in Colorado, which are similar numbers overall to the estimates for PrEP we present here.[3] However, the number of non-MSM PWID living with HIV in Colorado is significantly lower than the number of individuals we estimated were PWID with indications for PrEP. Another approach to using HIV diagnosis data to estimate numbers of individuals with indications for PrEP at the local level was recently presented by the CDC. This approach relies on the ratio of percentage of PWID diagnosed with HIV to percentage of MSM diagnosed with HIV in a given area. This ratio is further refined by applying race and ethnicity data.[14] Once published, this technique may provide guidance for local jurisdictions that could yield more accurate and nuanced PrEP estimates.

Limitations
Our analysis is subject to several limitations. Most notably, we did not include estimates of heterosexual individuals with indications for PrEP. We initiated this process using similar methodology as that employed for MSM and PWID estimates but deemed the estimates likely to be inaccurate as the epidemiology of HIV in Colorado is heavily skewed toward MSM with a much lower percentage of individuals living with HIV in the state being heterosexual than is the case nationally. Similarly, we were not able to estimate prevalence of transgender persons in Colorado or subsequent numbers of transgender individuals with indications for PrEP. The inclusion of these two populations would make the analysis richer and more complete and will be the focus of future efforts at the state and local health department levels.

The analysis is also limited by our reliance on national and regional estimates of sexual behavior and drug use, which may be less accurate for Colorado. In particular, Colorado has been heavily affected by the opioid epidemic and may have a significantly higher number of PWID than presented here.[15] Also, both the behavioral estimates obtained from the papers by Grey et al. and Oster et al., and the PrEP indication estimates by Smith et al. rely on data from NHANES which is limited to individuals who are not institutionalized or homeless.[5,8,9] This exclusion is likely to lead to an underestimation of the prevalence of recent injection drug use, thereby leading to an underestimate of the number of PWID with indications for PrEP. A revised estimate of prevalence of PWID that accounts for homeless and incarcerated populations would be of great benefit. These estimates are also limited by the variability in published estimates of percentages of men who have sex with men. However, when we substituted MSM estimates into our equation from the paper referenced above by Grey et al., we found that our results did not differ significantly. Finally, as noted by Smith and colleagues, as sample sizes get smaller, estimation is more unstable. Therefore, the estimates we have presented have been used specifically for program planning purposes and are limited in generalizability.

Implications and Final Summary
Although simple in its methodology, this exercise is a practical means to estimate the need for PrEP at the state and local levels. To our knowledge, this is the first instance of a state-level application of national estimates. Additional methodologies using surveys and more precise population-level statistics as have been employed in other jurisdictions as alternate approaches to estimating PrEP demand or PrEP
targets.[16-18] However, for states with relatively smaller epidemics and for whom resources for population-level HIV prevention analyses are more limited, we offer this approach as a feasible option that provides immediate, actionable estimates that can be quickly revised as new estimates for key populations become available.

As Colorado and its individual metro areas develop strategic plans to end the HIV epidemic, measurable targets for PrEP uptake may help direct efforts to the most relevant populations and regions.[1] At this time, our state health department is conducting an analysis of insurance claims data to determine the approximate number of PrEP prescriptions filled in 2017. This will serve as a starting point for measuring progress toward optimal PrEP uptake. Ongoing education and financial support for PrEP programs will be crucial to ensuring that this highly effective intervention reaches those who need it most.
Figure 1. Map of Colorado counties by urbanicity designation
References


