A RESOURCE ALLOCATION MODEL FOR HIV PREVENTION IN THE STATE OF MICHIGAN, 2009

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Introduction and Policy Question At Hand

In September 2008, I testified under oath before Congressperson Waxman's House Committee on Oversight and Government Reform. The purpose of the testimony was to describe the resources and HIV prevention programs necessary to reduce HIV infection substantially in the nation. I testified that if the US Centers for Disease Control and Prevention's (CDC) HIV prevention budget were to be increased to $1.3 billion per year for four years (preceded by a planning year), it would be possible to reduce HIV incidence by 1/2 in the US, reduce the HIV transmission rate by 1/2, and increase awareness of HIV seropositivity to just over 90%. A mathematical model was used to generate these estimates. The model used the best available techniques for epidemiologic modeling, and relied on the scientific literature for input parameter value at every point possible. This model is the only one currently available that makes such calculations for the nation.

In the present project, this model was adapted for use in the State of Michigan. In particular, the policy question posed in Michigan was as follows:

> *At the current level of resources available for HIV prevention activities in the State, what array of services would result in the most HIV infections averted, result in the lowest HIV transmission rate possible, and maximize the level of awareness of HIV seropositivity?*

A second policy question was to quantify how many people living with or at risk of HIV infection go without HIV prevention services given constrained resource levels in Michigan.

Analytic Methods

The detailed mathematical model is given in its entirety in the attached spreadsheet. All input parameters and formula are provided in the Microsoft Excel file. Here we provide a general overview of how the model operates.

The model assumes a current year (called "Year 0") in which the resources levels and types invested -- and the statistics describing the state of the epidemic in Michigan -- are as currently realized. The model also takes extant information on HIV incidence and prevalence, and calculates the HIV transmission rate for the State. The transmission rate is further calculated for person unaware and aware of their HIV seropositivity. To our knowledge, these transmission rate statistics have not previously been estimated for Michigan, and are offered here for the first time.

Next, the model assumes (based on the results of another analysis part that is this project and is included in the spreadsheet as well) that in Year 1, a large-scale targeted counseling and testing campaign should be undertaken.[1] [Such a targeted HIV counseling and testing campaign serves to

[1] The results of the other analysis are contained in a companion report entitled "Costs and Consequences of Four HIV Testing, or Counseling and Testing Scenarios for the State of Michigan: 2009." The results of the "Costs and Consequences" analysis demonstrate that for Michigan, a targeted HIV counseling and testing strategy is likely to yield more new HIV diagnoses, link more HIV-infected persons to care, and result in more transmissions and infections averted than an opt out strategy.

immediately lower the unawareness rate of HIV seropositivity. This is critical because lowering the unawareness rate maximizes the number of people who may be able to access lifesaving HIV care and treatment. Further, lowering the unawareness rate also results in a lower HIV transmission rate for the State. It has been demonstrated nationally that persons who are aware of their seropositivity have an HIV transmission rate 3- to 4-fold lower than persons living with HIV who are unaware, and we estimate that the same is true in the State of Michigan.

The model assumes, based on consultations with the State, that the level of capacity building and public information should stay constant from Year 0 to Year 1, and that the investment in laboratory capacity should remain substantial but vary in proportion to the number of HIV tests offered. Given remaining resources available, the model then proceeds to calculate the optimal level of investment in targeted HIV counseling and testing, HIV prevention services for persons living with HIV, HIV partner services, and HIV prevention services for at-risk HIV seronegative persons. Further, the model estimates at the State-level the following outputs: HIV incidence, HIV prevalence, the HIV transmission rate, and level of HIV seropositivity awareness. To make these calculations, we assume intervention effect sizes based on the HIV prevention literature and costs of interventions per client based on the same literature (a point to which we return below).

The model then takes the results from Year 1, and uses them as input in to Year 2 calculations. Year 2 calculations mimic Year 1 methods, but there is no longer the assumption made that a massive targeted counseling and testing campaign is the best intervention option. Rather, we estimate the size of the population of persons living with HIV who are unaware, the number of persons living with HIV who are aware but continue to engage in transmission risk behavior, and the number of HIV seronegative persons at risk of infection. The model aims to invest (on a per person unaware of seropositivity basis) in a counseling and testing (or "serostatus awareness") effort, and covers with evidence-based prevention services all persons aware of their positive serostatus but who continue to engage in risk behavior. All persons newly learning of their serostatus via the recommended program are also covered with partner notification services. Finally, the model then invests in prevention for HIV negative persons at risk of infection until resources are exhausted (as will be seen below, current resources only allow for the investment of evidence-based prevention services for a tiny fraction of HIV seronegative persons at risk of infection in the State of Michigan). The effects sizes for these services as taken from the research literature are then used to estimate the impact of said services for the State overall. Again, based on consultation with the State of Michigan, we assume a constant level of investment in capacity building activities and public information services from year to year, and we assume a lab expense that is proportionate to the number of people tested in a given year (this is not a recommendation, but rather a modeling constraint).

The approach for Year 2 is then repeated in Years 3 and 4 (with the output of one year serving as the input to the next). Finally, a summary table is created showing the investment level by type of activity, and the impact of said activities on the epidemic.

Results

The results of the analysis are best seen in their entirety in the attached spreadsheet but a summary table is also provided below. Here, we highlight a few of the key results and their possible policy implications. If we assume that the current level of investment in HIV prevention services continues at approximately $8.6m per year, and if all resources except those for public information, capacity building and lab expenditures are put "on the table" for possible reallocation, it appears possible to lower HIV incidence in the State from 870 infections per year to 640 per year. Further, the transmission rate could be lowered from 4.8 per year to 3.2 per year (this is expressed as the number of HIV transmissions that occur per 100 people living with HIV in a given year). Awareness of HIV seropositivity could increase from the current 79% to approximately 90%.

As awareness of HIV seropositivity increases, the investment in targeted counseling and testing might be able to drop from $5.4m in Year 1 to $2.5m in Year 4. However, in the same time span, the investment in persons living with HIV who are aware of their serostatus but continue to engage in risk behavior rises from $0.5m to $2.7m; this is due to the fact that as awareness of serostatus grows and as HIV prevalence grows, the needs for "prevention for positives" programs will also rise and rise substantially. This is not due to an increase in the percentage of persons living with HIV engaging in transmission risk behaviors, but rather is due to the size of the population increasing. This major increase in prevention for positives services would mark a major change from the $333k invested in this type of service in “Year 0.”

The model suggests that partner service expenditures might be lower than they are in Year 0. The model assumes that for every newly diagnosed person living with HIV, $500 needs to be spent in partner services. This results in an annual investment in partner services in the State of about $250k to $275k (compared to the $610k invested in the same services in Year 0). It should be noted that this lessened amount of investment is because the model assumes that only persons newly diagnosed by the programs recommended here would require partner services. If there are other persons who test positive outside of the programs described here (e.g., who test positive in a private doctor’s office and are without public support for the test), then they too require public-sector partner services. To the extent that there are such additional new diagnoses, then the partner services demand would rightly increase. To the extent that the demand does increase, the requisite resources should seemingly come out of the investment to increase awareness of serostatus in Years 2 through 4 (since those resources are aimed at increasing awareness of serostatus and partner services certainly aim to do just that).

Unfortunately given fixed resources, only a small fraction of HIV seronegative persons could be served with evidence-based prevention programs (even brief programs). The percentage that could be served ranges from 3.5% to 5.5% in Years 2 to 4 (based on an estimation that about 11.9% of HIV negative persons in Michigan engage in risk behavior that could result in HIV infection). Fully serving the HIV prevention needs of over 800,000 persons at risk of infection in Michigan could require a more than doubling of the current budget.

Uncertainty in Results

It should be highlighted that every mathematical model has some uncertainty in its results, and this model is no exception. To the extent that there is uncertainty about any of the input parameters (e.g., HIV incidence in Michigan, cost per client for prevention services, and so on), so too will there be uncertainty in the results. However, the robustness of the results can be gauged by varying any of the input parameters in the spreadsheet and examining the impacts on the outputs.

One sensitivity analysis included in the spreadsheet that provides some assurance that the results are relatively stable examines the impact of constraining the HIV transmission rate to be constant from year to year for both the aware and unaware persons living with HIV (rather than allowing it to vary annually as is the case in the base case calculations). Doing so yields expenditure recommends very similar to the base case, and gives overall (not seroawareness specific) transmission rate results that are also very similar. The incidence results are not as favorable because the "flat" transmission rate by serostatus awareness approach underestimates the impact of counseling and testing programs by definition. Still, by Year 4, HIV incidence could be shown to drop to 758 from 870 per year. Overall, this sensitivity analysis is relatively reassuring in that adding a very conservative constraint to the model still generally yields roughly similar -- and favorable -- results.

Discussion

The model offered here makes specific suggestions for consideration about the level of investment and impact of a variety of HIV prevention services for the State of Michigan. It suggests that with some resource reallocation, improvements in HIV prevention outcomes maybe possible. However, the model also highlights that only a small fraction of all people in need of HIV prevention services in the State can currently access these services essentially guaranteeing a continued epidemic for some time to come even with the very best of efforts in Michigan.

The model also projects growing HIV prevalence suggesting that plans to clearly link prevention to care and treatment services are essential and will grow in cost in the years to come.

It should be noted that the model makes other recommendations that are inherent in the model. For instance, the model assumes that investments are made across communities in proportion to the level of HIV infection existing or possible in that community (and so investments should take into account, for instance, racial and ethnic health disparities). The money should not only follow, but anticipate the epidemic community-by-community.

Further, the effect sizes for interventions in the model indicate the specific type of service to be offered. For instance, based on the analysis in the second tab of the spreadsheet, targeted HIV counseling and testing is to be preferred over opt-out testing in terms of epidemic impact. Also, the model assumes effect sizes for prevention for positives programs that are similar to that seen for evidence-based interventions like Dr. Seth Kalichman's Healthy Living intervention (offered by CDC as an exemplary intervention type).

For at-risk HIV seronegative persons, the intervention selection issue is a bit more complex. Year 1 is primarily a massive targeted counseling and testing campaign; the at-risk seronegative persons possibly identified during this first Year's program would seem to need an individual-level intervention but resources are constrained so a relatively inexpensive yet evidence-based intervention is necessary. An evidence-based, individual-level, relatively inexpensive, prevention intervention like the brief video-based program "Voices/Voces" developed by Dr. Lydia O'Donnell would seem to possess the necessary criteria. Such intervention costs roughly $50 per client to deliver and so that cost-per-client is used in the model.

In Year 2 through 4, the recommendation for specific interventions for HIV seronegative persons is not quite as clear. The current resource level available is very constrained and only a tiny fraction of at-risk seronegatives needing services will receive them in Michigan. For this reason, the model continues to assume the cost-per-client of a brief intervention like Voices/Voces because it is evidence-based and relatively inexpensive per client. However, the available resources for HIV seronegative persons can be used in reasonable, alternative ways as well. One could use the available monies to take a more community-level intervention approach with an aim that evidence-based, community-level services (such as the peer-opinion leader interventions developed by Drs. Jeffrey Kelly, Susan Kegeles and Kathy Sikkema) could reach more people; however, the number of infections-averted-per-client-reached might not be as high. If resources remain limited at this level, then one would ideally identify the 3.5% to 5.5% of HIV seronegative persons <u>most</u> at risk of infection in a given year, and identify for the specific population or populations represented in that 3.5% to 5.5% the interventions that can prevent the most infections for a given, limited resource level. This intervention selection can be done by consulting the tables in papers by Dr. John Hornberger et al (Medical Decision Making, 2007) and Dr. Steven Pinkerton et al (AIDS, 2001) which list the cost-effectiveness ratios for a variety of interventions for a number of communities, and selecting the most cost-effective interventions from the lists. (Please note, I would be pleased to develop a list of such interventions from these articles but would need additional guidance from the State on which 3.5% to 5.5% of HIV seronegative persons are most at risk of infection; it may be the case that current behavioral surveillance efforts are not able to answer this very specific "priority seronegative population" question.)

I should also note that this model is entirely focused on maximizing epidemic impact given resource constraints. The model makes no statements about political or social feasibility of implementing such recommendations. Rather, it attempts to consider public health impact only so as to serve as input to a dialogue with diverse partners impacted by the HIV epidemic.

Summary of Resource Allocation Model Results (Base Case)

	Year 0	Year 1	Year 2	Year 3	Year 4
Model Outputs (Yrs 1-4)					
Incidence (est.)	870	822	729	672	640
Prevalence (est.)	18,200	18736	19,172	19,546	19,882
Transmission Rate (est.)	0.0478	0.0439	0.0380	0.0344	0.0322
Seropos. Unawareness (est.)	0.21	0.18	0.15	0.13	0.10
Total Costs	$ 8,635,000	$ 8,640,855	$ 8,660,784	$ 8,640,856	$ 8,554,930
Unaware (VCT services)	$ 4,934,361	$ 5,350,000	$ 3,383,365	$ 2,947,099	$ 2,479,559
HIV+, Aware (prev svcs)	$ 332,568	$ 535,469	$ 2,456,461	$ 2,595,981	$ 2,730,583
HIV- high risk (prev svcs)	$ 1,123,071	$ 797,057	$ 1,467,791	$ 1,821,109	$ 2,125,639
Partner services	$ 610,000	$ 267,735	$ 275,623	$ 257,475	$ 262,494
Capacity building (fiat)	$ 450,000	$ 450,000	$ 450,000	$ 450,000	$ 450,000
Lab (fiat)	$ 660,000	$ 715,594	$ 452,545	$ 394,192	$ 331,656
Public Info/Newsltr (fiat)	$ 525,000	$ 525,000	$ 175,000	$ 175,000	$ 175,000

Summary of HIV Counseling and Testing Policy Analyses (*for details, please see spreadsheet and second narrative document*)

	Opt-Out Testing with Behavioral Disinhibition	**Opt-Out Testing**	**Routine Counseling (no post-test counseling for low risk HIV- persons)**	**HIV Counseling and Testing Targeted by Geographic & Venue Prevalence**
No. Tested	1,201,382	1,201,382	1,201,382	547,973
No. Undiagnosed HIV+ Reached	544	544	544	1,726
No. High Risk Negatives Tested	142,792	142,792	142,792	128,468
Total Testing Cost	$ 17,246,008	$ 17,246,008	$ 28,354,611	$ 17,246,008
Transmissions Averted	42	42	42	134
Infections Averted	(7)	-	21	17
Transmissions + Infections Averted	35	42	63	151
Gross Cost Per Trans+Inf Averted	$ 488,560	$ 407,280	$ 448,172	$ 114,069
Public Support for Med Care Needed (One Year)	$ 12,284,498	$ 12,284,498	$ 12,284,498	$ 38,957,956