Using Individual-Based Simulation Modeling to Integrate Big Data and Intervention Evidence to Inform Intervention Selection, Adaptation, and Evaluation: An example on Colorectal Cancer Screening

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Background

Despite evidence that colorectal cancer screening saves lives, adherence to care guidelines is suboptimal and disparities persist. One-at-a-time interventions have limited impact, and will not work in the same way in all settings. Guidance is needed on how best to implement integrated, multilevel intervention efficiently across diverse settings.

Methods

We used synthetic population data, statistical models estimating the relationship between multilevel determinants and both receipt and modality of screening, and a natural history simulation model of colorectal cancer to project the effects of different intervention approaches on colorectal cancer screening and outcomes to the population level in North Carolina overall and for subpopulations within the state (e.g., African American males, Medicaid enrollees). We used the model to estimate the combinations of individual intervention cost and effectiveness that result in cost-effectiveness estimates under $50,000 per Quality-Adjusted Life-Year (QALY) gained – the commonly accepted threshold for cost effectiveness in different contexts.

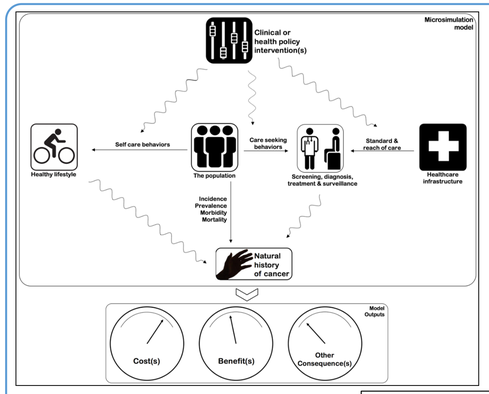
Findings

Two dimensional data tables and visual graphics depict the combinations of intervention cost and requisite per-person impact for alternate interventions to be cost-effective in a given context. For many interventions, cost-effectiveness may be more difficult to achieve in one context versus another (for example depending on how readily a given intervention could be integrated in current processes of care). This information can be used by stakeholders and decision makers to discuss what is most feasible within a given intervention context for approaches under consideration, informing which specific evidence-based interventions are chosen, how they are adapted to improve cost-effectiveness, and to establish benchmarks for ongoing evaluation.

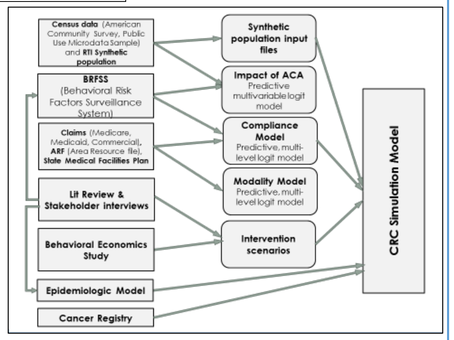
Implications for D&I Research

This presentation illustrates one approach for leveraging big data (here, all-payer claims data, census data, BRFSS, state medical facilities data, and trial data) and cutting-edge individual-based simulation methods to inform decision-makers' understanding of the reach, feasibility, and impact of interventions under consideration. Our model takes into account the unique, and changing, intervention context – including characteristics of the population, determinants of current care/behavior, and existing resources and processes.

Model schematic



Data sources for model components



Intervention scenarios

Objective: To estimate the impact and efficiency of distinct, evidence-based approaches on CRC screening rates in 50-75 year old adults at the population level over 10 years in North Carolina

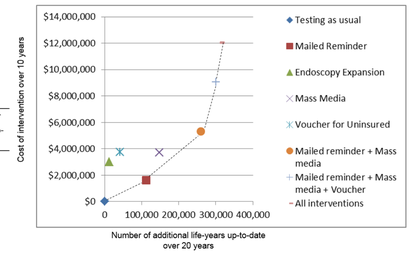
(1) a Medicaid mailed reminder and registry intervention
(2) an endoscopy facility expansion initiative to increase access to colonoscopy
(3) a mass media campaign encouraging African Americans to get screened
(4) an intervention offering vouchers to uninsured individuals
(5) immediately expanding Medicaid statewide*

Intervention	Effect Size	Base ($)	Cost Components
Medicaid Mailed Reminder	5%age point increase in p(screen)	$10,000	Develop registry & reminder content (one-time)
		$200 / year	Programming time to identify enrollees
		$0.71 / reminder	Materials (postage, paper, ink)
		$3,850 / year	Mail reminders
Endoscopy Expansion	Individually-specific predicted p(screen) based upon claims-based statistical models	$500,000 / facility	Financial incentive to locate facility in 6underserved areas
Mass Media	Will reach 80% of African Americans, 2%age point increase in p(screen)	$368,000	Content development (one-time)
	Will reach 40% of non-African Americans, 1%age point increase in p(screen)	$332,000 / year	Advertising purchase of month long campaign
Voucher for uninsured	500 uninsured individuals turning 50 will receive colonoscopies	$750 / person	Voucher for colonoscopy

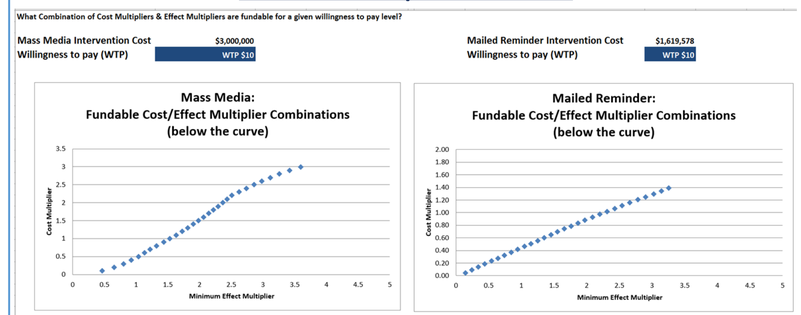
Intervention cost, impact, and cost-effectiveness (compared to testing as usual)

Undiscounted:

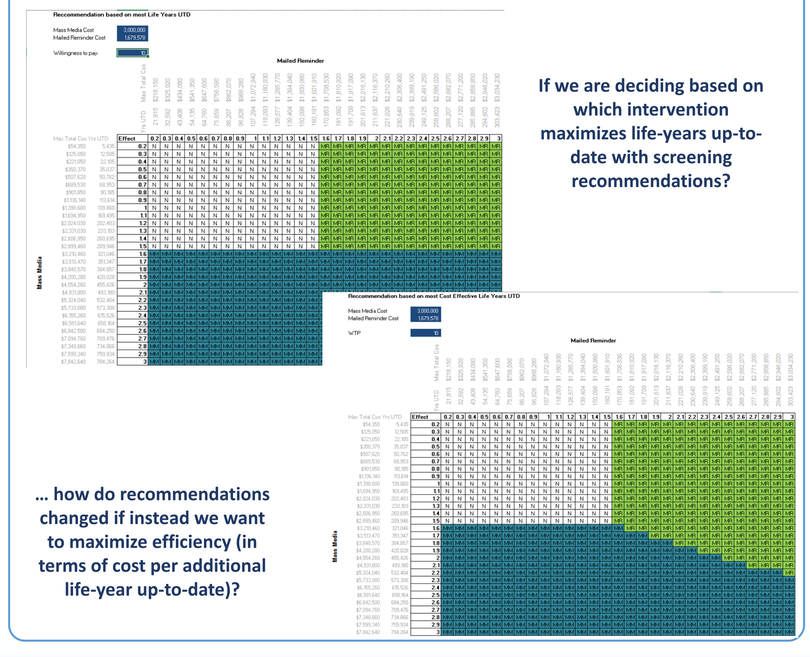
	Cost of intervention	Additional life years up-to-date	Intervention cost per additional life year up-to-date
Mailed Reminder	$1,619,578	111,516	$14.52
Endoscopy Expansion	$3,000,000	11,832	$253.98
Mass Media	$3,694,800	148,305	$24.91
Voucher for Uninsured	$3,750,000	41,709	$89.91



For a given willingness to pay, how far off can we be on our cost and impact estimates?



For various combinations of effectiveness, how much would we pay (for a given willingness to pay) and which intervention is dominant?



If we are deciding based on which intervention maximizes life-years up-to-date with screening recommendations?

… how do recommendations changed if instead we want to maximize efficiency (in terms of cost per additional life-year up-to-date)?