Introduction to Structural Variables:

What they are, why we care, how to use them in studies

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Presented at the 2016 CDUHR Mini-Conference on Structural Variables - December 13, 2016

Agenda

Introduction to Mini-Conference on Structural Variables
David C Perlman, MD
9:35 – 9:55am

Structural Stigma and Sexual Orientation Health Disparities: Measurement, Methods, and Challenges
Mark Hatzenbuehler, PhD
9:55 – 10:30am

BREAK: 10:30 - 10:45am

Public Housing Relocations and Relocators' Vulnerability to HIV: A Structural Approach
Hannah Cooper, ScD
10:45 – 11:20am

Facilitated Panel Discussion and Q & A
11:20 – 12:00noon

Networking and Lunch
12:00 – 1:00pm

Introduction

- Increasing recognition of the importance of what have variously been called 'social determinants', 'supraindividual', 'social network', 'structural', 'area-based/place-based' factors in shaping epidemiology of health.
  - Reports from WHO, NIH, 2020 Healthy People, RAND, CDC, RWJ, IOM and others.
- These refer to the importance of variables with units of analysis above the level of the individual.
- Such variables are not only important contexts, but are often important fundamental causes of health outcomes and are relevant potentially modifiable factors and create risk/protective environments whose importance should be studied, inform public health monitoring, interventions, policy, and funding.

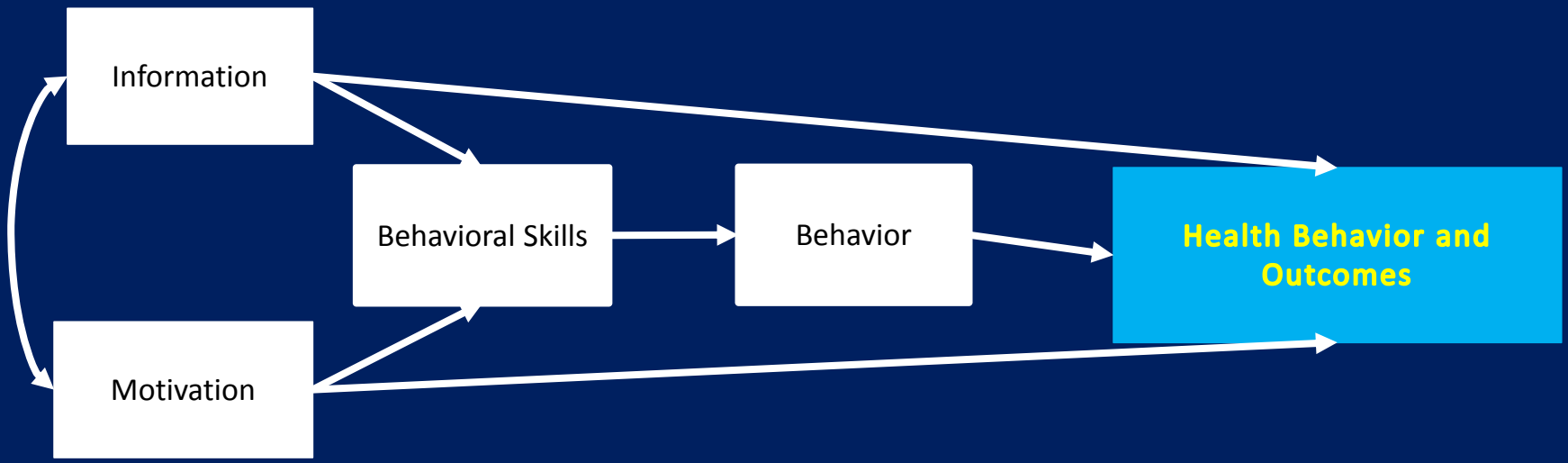
Under-implementation of the study of structural variables in health

- Prior under-development of relevant theory.
  - No longer the case, see Krieger text.
- Prior under-development of relevant methods.
  - No longer the case, multi-level modelling and data sources.
- These made translating ideas about the impact of structural factors into testable hypotheses difficult.
  - No longer the case
- Under-training of investigators in multi-level theory and methods.
- Structural forces are a cause of the under-study and under-training.
  - Examinations of structural factors are inextricably related to politics, power dynamics, and economics.
- We will begin to address these today–structural competency.

Some definitions

- *Supraindividual*: refers to all constructs measured above the level of the individual (includes social network, structural, and place-based/area-level factors).
- *Social network*: refers to interaction between individuals and specific (known or unknown) other individuals.
- *Structural*: refers to all factors above the level of the individual and social network, and includes economic, policy, and social; includes factors that vary as a function of geographic unit.
- *Place-based or area-level variables*: refers to a subset of structural variables constructed with data derived from administrative databases for specific geographic units (e.g., census tract, zip code, country).
- *Individual*: refer to characteristics measured at the level of the individual including genetic, socio-demographic, behavior, experiential, and perceptions held by an individual.

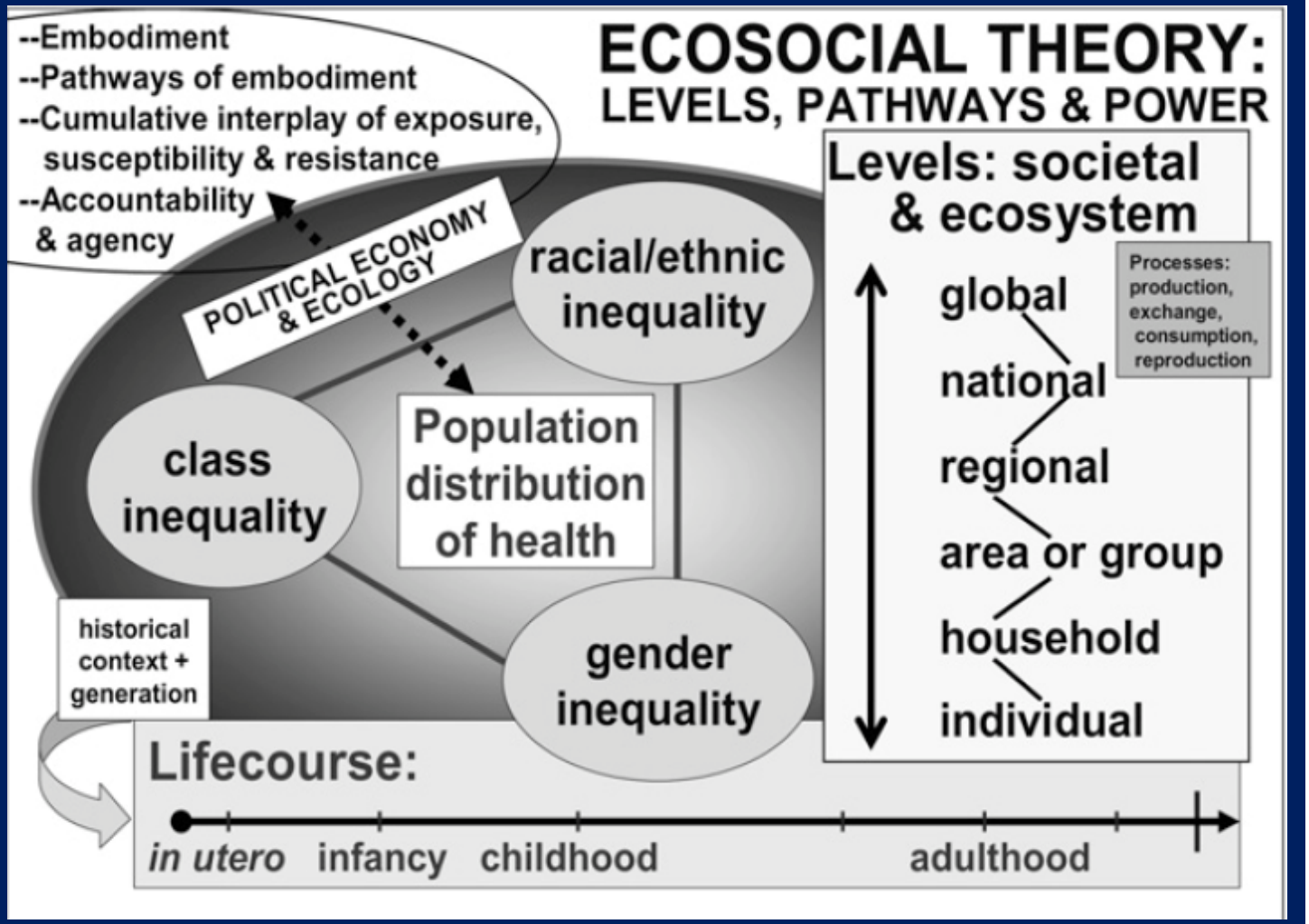
IMB Model of Behavior Change



Fisher & Fisher 1994

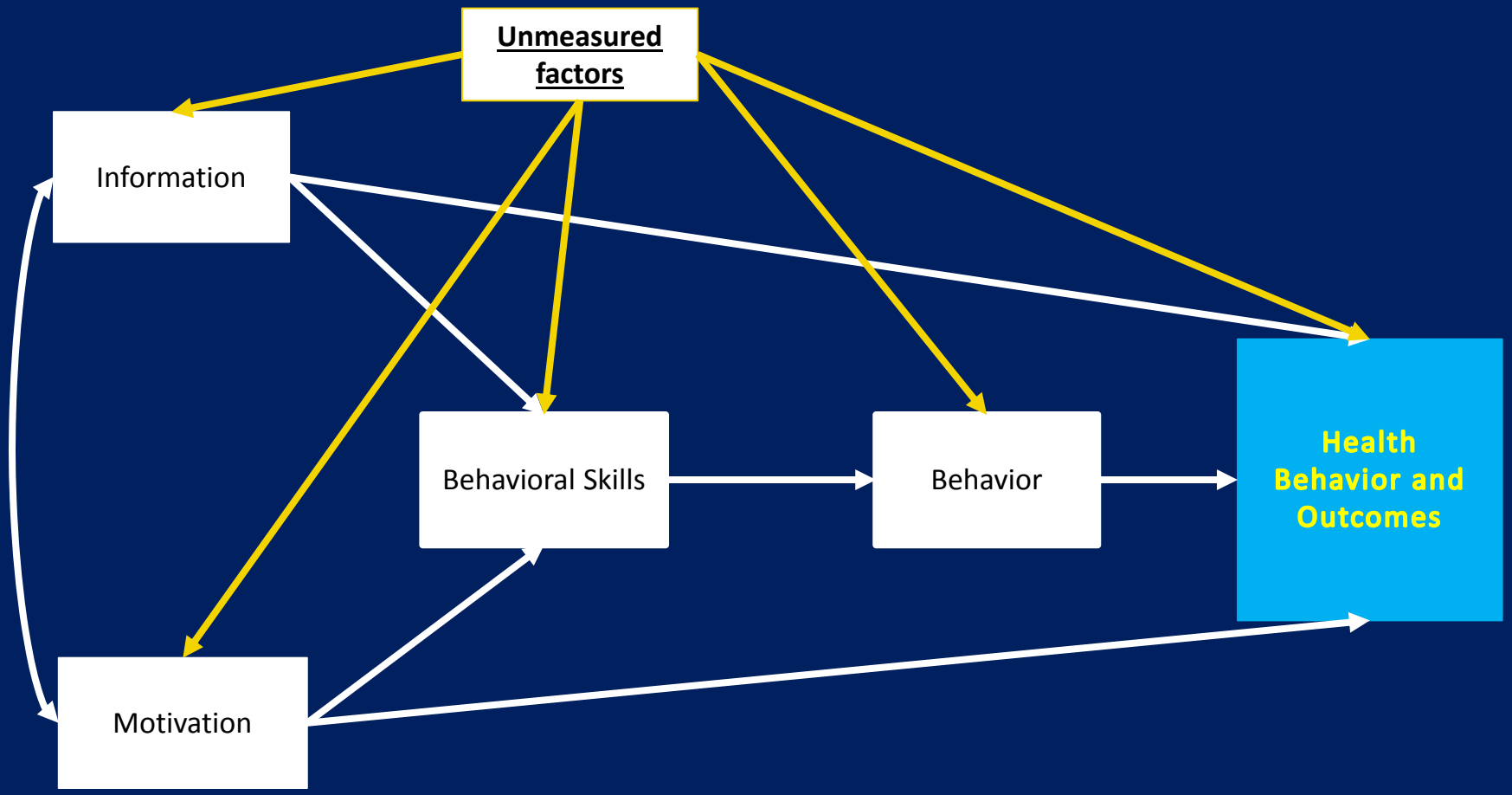
Ecosocial theory: Core constructs

1. Embodiment
2. Pathways of embodiment
3. Cumulative interplay of exposure; susceptibility, and resistance across the life course
4. Accountability and agency



Krieger, et al., 2012

IMB Model of Behavior Change



Fisher & Fisher 1994

Considerations of correlated constructs

- Constructs with correlates at different levels.
  - Measures of individual income (absolute income with respect to a threshold) versus income of those in one social network (e.g., social capital consideration) versus area-level income (mean, median)– are related, non-independent but distinct constructs.
  - Measures of individual race/ethnicity versus race/ethnicity of those in one's network versus area-level measures of racial composition.
  - Asking someone about their neighborhood is an individual construct; measures of number of abandoned buildings in a neighborhood is a structural variable.
- Constructs without correlates at the individual-level.
  - Income inequality or laws and policy.

Considerations of terminology

- Relevant literature comes from diverse fields hence many different sets of terms have been proposed and have been used.
- Some terms impose particular frames that should be recognized, thoughtfully chosen, or avoided.
  - *Social determinants of health:* emphasizes social over structural factors, also frames them as determined and unchangeable and may therefore suggest particular limited responses; e.g., if gender bias at a structural-level is identified as a barrier, seeing this bias as fixed and unchangeable may lead to efforts to 'build an individual's strength or self-efficacy' to navigate this bias as opposed to seeing a need to reduce or eliminate gender bias by changing a law, policy, or how people think (e.g., by informational campaigns).

Examples of structural variables and their sources

- Economic, housing, foreclosure,, access to healthcare and prevention services, social capital, segregation, racial, gender and sex discrimination and stigma, population density, CDC social vulnerability and county-level vulnerability indices, many others.
- PhenX Toolkit (phenxtoolkit.org) has individual-level measures (e.g., neighborhood collective efficacy) and structural variables (e.g., neighborhood concentrated disadvantage from census/ American Community Survey).
- US DHHS has a compendium of publically available datasets (minorityhealth.hhs.gov/npa (go to *Resources*))
- See excellent tables in papers by Cooper, Hatzenbuehler, Friedman, Van Handel, and others.

Considerations of geographic unit

- Many options from census block, census tract, zip code, county, MSA, state, country; groups of these.
- Different data are readily available for a range of geographic units.
- Different geographic units may be more applicable to specific questions based on theoretic underpinning of research question.
- Use of optimal or suboptimal geographic unit may influence identified associations.

Types of Studies

Independent Variable(s)	Dependent Variable	Type of Study
Supraindividual-level*	Supraindividual-level	Ecological
Individual-level	Individual-level	Individual-level
Supraindividual- and individual-level	Individual-level	Multilevel or contextual

*(e.g., zip code, clinic, subpopulation)

Diez-Roux, 1998, AJPH

Terms and concepts

- Cross-level inference: drawing inferences across levels; appropriate only when issues of non-independence and clustering have been addressed.
- Ecologic fallacy: applying inferences from associations between group*-level exposures and group-level outcomes to individuals.
- Atomistic (individualistic) fallacy: applying inferences from associations between individual-level exposures and individual-level outcomes to groups.
- Sociologistic fallacy: the failure to consider individual-level characteristics in drawing inferences regarding causes of variability across groups.
- Psychologistic fallacy: the failure to consider group-level characteristics in drawing inferences in the causes of variability across individuals.

* = any supraindividual construct, including groups of individuals

Pathways through which structural variables may act

1. Act via influencing individual behavior – *theory of social comparison* (Kawachi); hierarchy stress affects the impacts of these structural factors to either cause psychologic or biologic responses (e.g., depression, HTN) or to influence individual-level behaviors (e.g., increase risk taking due to stress, depression).
2. Act at social network level – *erosion of social capital* (Kawachi); these structural factors impact social interactions (degrees of social support or mistrust) among those in social networks.
   - Each of these two may influence individual behavioral choices or in fact constrain or eliminate choice.
3. Act independent of individual level behavior – *disinvestment in human capital* (Kawachi); these factors (e.g., income inequality) may (e.g., by influencing context, social spending) shape disease patterns beyond anything that an individual can overcome by changed behaviors.

Kawachi and Kennedy, 1999; Link, et al., 1998

Examples of these possible pathways

1. Structural factor acting through influencing individual behavior with no significant constraint on choice: healthy food placed first or last in a cafeteria line in a school, all going through line have same freedom of choice but putting healthy food first leads to more people choosing more healthy food.
2. Structural factors acting through constrained choice: An individual in a low-income country with symptoms of TB (even with knowledge and motivation for treatment) in an area with no or very restricted treatment access; in a high-income country desire to implement exercise in an area of neighborhood disadvantage (e.g., no sidewalks) or violence.
3. Acting independent of individual behavior: Vaccination of some threshold of a population (herd immunity) leads to lower risk to an individual independent of that individual's vaccination status or behavior by lowering overall are prevalence.

Statistical considerations

- A key assumption of standard multivariate analysis is the independence of all considered exposures.
- When examinations include data from two or more levels, the assumption of independence is commonly violated (e.g., individual-level income is not the same construct as the mean, median or distribution of income in that individual's area but they are not independent).
- This non-independence results in data that are correlated or clustered.

Statistical considerations: Need for multi-level models

- If data are correlated, and it is not accounted for:
  - Standard errors may be underestimated for time invariant covariates;
  - Standard errors may be overestimated for time varying covariates.
- Earlier approaches to this included 'population average models', these models account for correlation between levels or clusters by modelling the correlations (rather than by allowing for random effects as multi-levels do) (e.g., fixed or random effects models, often using generalized estimating equations (GEE)).
- Multi-level models account for potential residual correlation by modelling intercepts and regression co-efficients as random.

Statistical considerations: Optimizing inferences

- Only multi-level analyses can distinguish structural or contextual health effects from individual-level effects.
- Controlling for individual-level factors that lie in the causal pathway between place and outcomes may decrease effect estimates for some place-based exposures; directed acyclic graphs can guide which variables to control for.
- Environments may be racialized/ segregated: Effect estimates (ORs, RRs, HRs) to quantify exposure-outcome relationships may yield an incomplete or erroneous picture of the impact of place by ignoring variation in exposure prevalence by race.
- Calculating race/ethnicity specific population-attributable risk percentages (PAR%) can yield a more complete picture.

Kondo, et al., 2009; Cooper, et al., 2016

Statistical considerations: Agent based models

- Agent-based models (ABM) are also used to analyze phenomena in which two or more levels are involved.
- ABM is a computational method to experiment with models composed of autonomous agents that interact within an environment; they focus on the dynamics of the social networks that shape and are shaped by interactions within that environment.
- While ABMs are parameterized using empiric data, the outcomes are simulated not real-world data, dependent on all parameters and assumptions; further it is not clear to me that they consider all potential pathways through which structural variables may act (e.g., perhaps not those acting not through the individual).

Policy variables: Applications

Outcome(s)	Policy structural variable and geographic level	Measure and magnitude of association	Author	Type of study
TB incidence, prevalence, mortality	Receipt of IMF funds with structural adjustment at the country level	Outcomes increased 13-16%; 1-4% / year funding	Stuckler, et al., PLoS Med, 2008	Ecologic
Fast food consumption and BMI	Heritage Foundation *Index of Economic Freedom*; index at the country level	Beta = 0.27, 95% CI 0.16-0.37	De Vogli, et al., Bulletin of WHO, 2014	Ecologic
Rx opioid MME prescribing rate; Rx opioid and heroin OD rates	State-level laws requiring mandatory Rx review or regulating pain clinics	All statistical tests resulted in significant associations	Dowell, et al., Health Affairs, 2016	Ecologic
Acute HCV infection rates at county-level	Buprenorphine prescribing potential by waiver at county-level	Standardized regression coefficient is 0.046, p-value 0.0095	Van Handel, et al., JAIDS, 2016	Ecologic

Area-level structural variables: Applications

Outcome(s)	Structural variables and geographic level	Measure and magnitude/ significance of association	Author	Type of study
Area-level depression rates	Area-level foreclosure rates	Significant associations consistently	Multiple	Ecologic
Onset of depressive symptoms (individual level)	Zip code level foreclosure rates	*Significant* **Δ** associations; ORs range from 1.45 – 1.75	Cagney, et al., AJPH, 2014	Multi-level study
Sharing injection equipment (individual level)	Gentrification composite variable (index of % Δ change over time in economic and demographic measures)	Not significant	Linton, et al., AJE, 2016	Multi-level study
Late HIV diagnoses in zip code	Social capital at the zip code level	Significant measure that vary by gender	Ransome, et al., JAIDS, 2016	Ecologic

Area-level economic variables: Examples

Outcome(s)	Structural variables and geographic level	Measure and magnitude/ significance of association	Author	Type of study
Probability of an HIV outbreak among PWID (country-level)	Change in GDP; income equality (S80/S20)	1% GDP increase assoc. w/ 30% decrease in odds of HIV outbreak	Nikolopoulos, et al., PLoS One, 2015	Ecologic
Acute HCV incidence at county-level	Per capita income county-level	Standardized regression co-efficient= -0.125, p-value < 0.0001	Van Handle, et al., JAIDS, 2016	Ecologic
Infant mortality at the census tract	Index of concentration at the extremes (ICE) at census tract (income equality + racial segregation)	Outcome significantly associated with ICE composite measures	Krieger, et al., AJPH, 2016	Ecologic
Hypertension at the individual level	Index of concentration at the extremes (ICE) at census tract (income equality + racial segregation)	OR= 0.48, high-income white vs. low-income black	Feldman, et al., J Epi Comm Health, 2015	Multi-level study

Structural variables and structural interventions

- Structural interventions act to change a structure, but the factor addressed may be ones at any level, individual, social or structural.
- Some structural interventions may only act on individual-level behaviors; e.g., an intervention to increase knowledge and self-efficacy to choose an appropriate health insurance to improve health outcomes.
- Structural intervention may directly change structure to change outcomes; e.g., a change in policy to promote a single payor plan to improve health outcomes.
- Structural interventions (e.g., new efficacious innovations) are implemented in settings that have been historically structured and may, upon implementation (unintentionally), exacerbate existing disparities and inequities.

Disseminating findings on structural health influences

- **Unique issues arise in disseminating information on structural factors both to health professionals, lay audiences, and policy makers.**
- **Surveys suggest substantial majorities of US adults rate access to affordable healthcare as having a very strong effect on health; fewer reported understanding community safety or where a person lives as having strong health effects.**
- **Of primary care providers a RWJ survey (2011) found 85% agreed that unmet social needs are leading to worse health outcomes for Americans and that these impede ability to provide care.**
- **Qualitative studies of policy makers shows they are commonly aware of structural influences on health disparities but that due to 'the complexity of the issues,' awareness commonly doesn't translate into clear policy actions.**
- **These data suggest a need for a greater reliance on policy analysis theory, greater use of clear statistical data combined with moral and philosophical reasoning, and awareness of time-limited but recurring windows.**

Carey, 2015; Embrette, 2014; Robert, 2011; Baum, 2013

Conclusion

- **Structural factors are critical drivers of health outcomes, supported by theory and empirical data.**
- **The means to measure relevant structural constructs exists.**
- **The statistical methods to examine combinations of individual, social and structural factors and relevant interactions exists.**
- **To not consider the impact of structural variables can lead to erroneous estimates of statistical inference (e.g., associations and causes) and suboptimal public health responses.**
- **Consideration of structural factors will enhance the understanding of fundamental causes of health outcomes, facilitate development of appropriate structural intervention, and address health disparities and inequities.**
- **There are highly relevant domains in which structural factors have been underexplored and many being soundly explored: we will hear two talks of applications of structural-level analyses to structural stigma and sexual orientation health disparities and structural vulnerability to HIV, and then have a facilitated, interactive discussion.**