



Walking the talk on multi-level interventions: The power of parsimony

Colleen M. McBride^{a,*}, Hannah LF. Cooper^a, David R. Williams^b, Karen M. Emmons^b

^a Department of Behavioral, Social and Health Education Sciences, Rollins School of Public Health, Emory University, Atlanta, GA, USA

^b Social and Behavioral Sciences Department, Harvard T.H. Chan School of Public Health, Boston, MA, USA

ARTICLE INFO

Keywords

Interventions
Levels of influence
Disparities
Framework

ABSTRACT

There is strong consensus regarding the need for multi-level interventions (MLIs) to address today's complex health problems. Several longstanding social ecological frameworks are commonly referred to in guiding MLI development. The specificity and comprehensiveness of these frameworks unwittingly suggest that the totality of included influences are important in all health contexts. Not surprisingly, when viewed as requiring intervention at all levels of influence, MLIs are often considered to be infeasible due to sizeable cost and logistical barriers. Thus, efforts to develop and evaluate MLIs have been extremely limited, and comparatively few examples are found in the health literature. We argue that operational frameworks to identify *which levels matter* in which contexts – henceforth, referred to as parsimony – could accelerate the field towards broader use of MLIs. We suggest a hypothetical operational framework informed by complexity theory and pragmatic approaches that could enable us to conceptualize, design and evaluate MLIs to consider where reflexive and recursive process mechanisms that cross levels should be targeted by MLI. The approach also emphasizes sustainability of MLIs. Without developing parsimony-based operational frameworks to move us forward, we fear that little will change, and we will simply continue to talk, without proceeding to the walk.

1. Introduction

The greatest public health burdens globally (e.g., chronic and infectious diseases) derive from a mix of causal and contributing factors and are inherently complex, operating interdependently and reflexively over time. These factors span a continuum from influences at the macro-societal level, through to those at the individual level, through to processes at the cellular and molecular level. Beginning with the large community-based heart health trials of the 1980s, for decades multi-level interventions (MLIs) have been recognized and exemplified in widely referenced social ecological frameworks, as the gold standard for addressing this complexity.

Current conceptualizations of what it means for an intervention to be multi-level vary, with some arguing MLIs comprise two or more levels and others arguing for three or more (Paskett et al., 2016; Taplin et al., 2012). Alternatively, a MLI could be judged based on *which* levels of influence are considered (e.g. whether it includes a higher-level influence or not), rather than the number of levels targeted. Common in these conceptualizations is the assumption that MLIs comprise a well-defined package of strategies occurring concurrently or consecutively in a specified time period. For the present purposes, we define MLIs to be

interventions that address contributing factors operating at three or more levels of influence, and with intervention elements targeting lower and higher levels of influence. By contrast, uni-level interventions target a single level of influence. Accordingly, community-based interventions would be considered as MLIs only to the extent that they intentionally define and target at least three levels of influence.

Uni-level interventions have for some time dominated the field of public health (Scholmerich and Kawachi, 2016; Richard et al., 2011). Indeed, for many years public health interventions have largely been focused at the individual level, emphasizing individual risk behaviors (e.g., tobacco use, sedentary behavior) that have important proximal influences on health outcomes. Rightly, these interventions have been criticized for greatly underestimating larger contextual opportunities and barriers that shape these behaviors and for inadvertently blaming the victim. Other levels of influence (organizational, community, and macro-societal) have more recently become a focus. Given the long-standing and consistent evidence amassed over decades to demonstrate the fundamental influences of structural factors on health outcomes, some argue that macro-level interventions, such as economic or policy interventions, have such consequential health impact to be sufficient as uni-level interventions (Cavazos-Rehg et al., 2016; Bor

* Corresponding author.

E-mail address: cmmcbri@emory.edu (C.M. McBride).

<https://doi.org/10.1016/j.socscimed.2021.114189>

Received 15 December 2020; Received in revised form 23 April 2021; Accepted 28 June 2021

Available online 4 July 2021

0277-9536/© 2021 Elsevier Ltd. All rights reserved.

et al., 2017).

We contend that although macro-level interventions alone may be more effective at improving population health than individual-level interventions alone, the wicked public health problems we face compel us to pursue the gold standard of MLIs. We and others (Paskett et al., 2016; Scholmerich and Kawachi, 2016; Glass and McAtee, 2006) base this contention on complexity theory, holding that public health problems are underpinned by a chain of nonlinear and recursive steps (e. g., process chains) that are embedded in social systems and networks (Aarons et al., 2011; Pawson et al., 2005). These systems are highly adaptive such that small changes and events can lead to an unpredictable series of consequences and compensatory responses, or ripple effects. These rippling effects may have unintended and potentially negative consequences. For example, reductions in traffic density resulting from COVID “stay at home” orders have been accompanied by significant increases in traffic speeds on interstate highways of Los Angeles and the Bay Area of California. Well-designed and conceptually-based MLIs are necessary to reduce the likelihood of iatrogenic ripple effects of uni-level interventions.

Our pitch for the importance of MLIs risks preaching to the choir. For example, in 2006 the UK Medical Research Council (O’Cathain et al., 2019) first published a framework for developing and evaluating RCTs of complex interventions. In 2018, PCORI (Esmail et al., 2020) developed methodology standards for analysis of complex interventions. Further, the use of implementation science methods has burgeoned (Brownson et al., 2018), complexity theory has gained acceptance in the public health context (Resnicow and Page, 2008; Kasman, 2021), intervention mapping frameworks have evolved (Fernandez et al., 2019) and design strategies to maximize MLI’s benefits for health equity are being discussed (Agurs-Collins et al., 2019). These all offer the opportunity to continue to evolve our thinking and develop “real world” interventions that target prioritized levels of influence.

Yet these advances in thinking will not redress the substantial feasibility and cost barriers that have inhibited MLI development. In this commentary we argue that considerations of parsimony are essential to increase the number of MLIs; all levels cannot matter all the time. The field needs *operational* frameworks to guide public health practitioners and researchers through a process of conceptual, methodological and evaluative considerations that could be applied in specific contexts for *deciding at which levels a MLI is likely to have the most impact*.

2. If parsimony is the goal, why not target macro-societal level alone?

Consistent with complexity theory, there are innumerable examples of interventions targeting tobacco cessation, poor diet, drug use, and many other health risks. In these contexts the health impact of interventions at one level of influence often had limited impact and/or contributed to health inequities as a result of changes at another level of influence. For example, early efforts in tobacco control were focused largely at the individual level, emphasizing personal responsibility for accessing treatment. This resulted in a sharp socioeconomic gradient in tobacco cessation. Recognizing the failing of this individually-focused approach, local, state, and federal policies were implemented that raised tobacco taxes and restricted public smoking. Overall smoking prevalence in the US dropped dramatically, but with relatively little impact on smoking among lower income groups. It was not until some state Medicaid programs began providing free comprehensive smoking cessation treatment, and resources and campaigns were put in place to increase smokers’ awareness that treatments were available, that there were significant reductions in smoking among low income populations (Land et al., 2010). Despite this progress, social gradients in tobacco remain, particularly in states that have not addressed the cost of and access to treatment. Sustained and equitable achievements in tobacco control have required the combination of interventions at the individual- and macro-societal levels, with specific consideration to groups

with fewer resources. If the cost of and access to evidence-based treatments had been considered earlier and consistently across states, significant suffering could have been avoided.

Growing understanding of the role of food deserts in obesity among low income populations led to significant efforts to increase the number of supermarkets in communities with limited supermarket access. Yet, increased neighborhood supermarket availability and increased access to healthy food in small groceries modestly increased *perceptions* of food access (Cummins et al., 2014). There also was limited evidence of an impact on fruit and vegetable intake, healthy food purchases, or reduced BMI (Cummins et al., 2014; Jilcott Pitts et al., 2018a, 2018b).

Buprenorphine has been a landmark success in treating opioid use disorder (OUD), and multiple federal policies have sought to enhance access through increasing physician-based buprenorphine prescribing (Johnson, 2016). When appropriately dosed, buprenorphine reduces overdoses and risks of HIV, hepatitis C, and other blood borne infections. Unlike methadone, it can be prescribed by physicians and dispensed by pharmacists in the US. Unfortunately, many pharmacists refuse to dispense buprenorphine or choose to ration it because of stigmatizing professional and community attitudes about people who use drugs and about medications to treat OUD. Reskin notes the interconnected nature of social systems and their influence on inequality, suggesting that efforts to increase buprenorphine use would need to consider not only prescribing, but also the impact of other stigmatizing social systems (Reskin, 2012). Reskin’s work illustrates that interventions on one system alone will likely always be insufficient because of compensatory processes from the other interlocking systems.

Interactions across levels can also be observed in interventions designed to improve economic conditions. The Great Smoky Mountain Study was a longitudinal natural experiment in North Carolina in which Native American households received additional income linked to the opening of a Casino. There were significant health impacts of this extra income on the health of adolescents, including declining rates of anti-social and aggressive behavior (Costello et al., 2003) and reduced risk of psychiatric disorders in adolescence that carried through to young adulthood (Costello et al., 2010). Income supplements were also associated with increased rates of high school completion, reduced incidence of minor criminal offenses in young adulthood, and the elimination of Native American versus white inequities for both of these outcomes (Akee et al., 2010). However, negative effects of the income supplements were also apparent, and included an increase in accidental deaths during the months that households received the income supplement, presumably linked to increases in vehicular travel and substance use (Bruckner et al., 2011). The supplements were also associated with increased adolescent obesity in families whose incomes were low at baseline, with no effect for those whose income was high (Akee et al., 2010). These findings suggest the importance of a comprehensive MLI approach that would combine the income intervention with individual- and family-level interventions to minimize risks associated with substance use and unhealthy nutritional patterns.

MLIs can play a crucial role in promoting distributive justice. There is abundant evidence to support the inverse care law, holding that public health programs and interventions – regardless of the targeted level of influence – benefit some groups more than others (Ceci and Papierno, 2005). This has been evidenced consistently in the context of health care delivery (Braveman et al., 2011). Tehranfar and colleagues note that there are few disparities in mortality between blacks and whites in cancers when there are few prevention or treatment options (Tehranfar et al., 2009). As treatments for specific cancers are developed, disparities increase significantly, reflecting the reality that interventions that provide better control of a disease may be more accessible to those with more socioeconomic resources (Tehranfar et al., 2016). This phenomenon has recently been noted related to lung cancer screening, where the availability of lung cancer screening facilities is lowest in regions of the country that are largely rural, with the highest prevalence of smoking and highest lung cancer burden (Wiener and Rivera, 2019; Kale et al.,

2019). Also notable is that lung cancer screening programs must provide access to cessation programs in order to be eligible for reimbursement through CMS (Kale et al., 2019). The pattern in which medical discoveries lead to health disparities has repeated itself over time, and is likely only going to be redressed with concerted efforts to develop MLIs that target the underlying barriers to access that inevitably occur. Yet health care advances and contexts will have idiosyncratic challenges where maximizing feasibility of MLIs must be considered.

Phibbs and colleagues (Phibbs et al., 2018) raise these considerations in the area of interventions to remediate effects of natural disasters – heat waves, hurricanes, earthquakes, and most recently COVID. These events occur amidst entrenched structural inequity. Consistent with the inverse care law, in all of these examples and often despite our best intentions, those most in need of services are least likely to receive them. Moreover, disasters disproportionately impact the poor and disadvantaged. MLIs that consider the complex ecosystem of policies, community and organizational responses and individual need are critically important in these settings. Yet, resources are finite making it incumbent that consideration be given to which levels of influence an MLI must address. Indeed, we argue there is no universal set of levels that must be considered by every MLI, but the importance of considering context in selecting levels to target cannot be overstated (Hawe et al., 2009).

Operational frameworks that build on implementation science, complexity theory, intervention mapping frameworks are needed to guide public health practitioners and researchers in *deciding at which levels* a MLI is likely to have the most impact.

Social ecological models of multi-level influences on health are abundant (Glass and McAtee, 2006; Flay and Petraitis, 1991; Bronfenbrenner, 1999). Common across frameworks is the comprehensiveness of the contributors they include. These heuristics unwittingly suggest that the totality of influences are important in all health problem contexts. Moreover, many of these frameworks depict graduating levels of influence as concentric circles with neither porous boundaries, specified mechanisms of cross-level influence, nor directionality. The relative infrequency of MLIs suggests that such comprehensive frameworks have not been especially useful in guiding MLI development when faced with the appreciable barriers suggested earlier.

Broadening the field towards MLIs will benefit from a parsimony-focused operational framework to guide intervention and program developers to explicate which cross-level mechanisms should be targeted (conceptual clarity), guide selection of pragmatic study design (methodologic pragmatism), and articulate how sustainability will be defined and maximized (sustainability evaluation). A parsimony-focused framework would be guided by questions addressing the many barriers to MLIs, including changing context, costs, and varying values and perspectives of stakeholders at different levels. To follow our own advice, we engaged in an exercise to develop a hypothetical framework. The framework draws from well-developed concepts suggested in several lines of thought where the push is to integrate “real world” thinking into intervention development. Our focus in this exercise is on considerations that could foster parsimony in selecting which levels are most likely to enable or undermine intervention effectiveness. These include: 1) conceptual models that address complexity (Hawe et al., 2009); 2) pragmatic methods for practice translation (Glasgow, 2013); and 3) implementation science (Brownson et al., 2018), as highlighted in Table 1.

While conceptual clarity is strongly encouraged for interventions generally, it is essential for planning MLIs. Taken at face value, ecological frameworks appear to suggest that *every level matters in all contexts*. Yet, the realities of public health research and practice limit the resources that can be expended. We and others (Hawe et al., 2009) have suggested complexity theory as one example of a conceptual model to guide visioning for how MLIs might lead to bi-directional and synergistic influences on targeted health outcomes that could be capitalized on for maximal benefit. We borrow from complexity domains enumerated in the “realist” framework presented by Pawson et al. (Pawson

Table 1

Example intervention mapping process for planning multi-level interventions (MLIs).

Assumptions	MLI development considerations	Examples Questions to Guide MLI Planning
Conceptual clarity: Realist Framework of Complexity Considerations (Pawson et al., 2005)		
Interventions must be underpinned by theory	Theories differ by level targeted and will need to be linked conceptually	How might theoretical constructs at each level serve as mechanisms to link levels of influences in the problem context?
Interventions operate through chains of steps and processes that involve actions of people as influencers, individuals and groups	Identify process chains that span levels of influence to drive the targeted health problem Identify areas of agreement amongst stakeholders at levels of influence	What inter-level process chains that are key drivers for the target health problem are amenable to intervention? What areas of stakeholder agreement across levels of influence must be targeted?
Process chains are embedded in social systems and are reciprocally linked	Characterize potential feedback loops within individual/group process chains and potential for emergence of unintended effects	How might theory-based mechanisms interacting at graduating levels of influence result in feedback loops that support or undermine selected intervention approaches?
Interventions occur in open systems and effects can be influenced through learning	Potential for individuals, groups, organizations to ‘game’ an intervention over time	
Disparities occur at each level of influence that limit equitable intervention benefits (Reskin, 2012; Williams and Purdie-Vaughns, 2016)	Characterize linked structural inequities that underpin process chains and may impede equitable intervention effectiveness	At which levels of influence are linkages in inequities important to consider to make an intervention maximally effective?
Methodologic pragmatism: Pragmatic Methods Frameworks (Shelton et al., 2020)		
Testing intervention effectiveness in ‘real world’ context increases the generalizability of findings	Real world context comprises messiness that can both augment and undermine efforts to validly test intervention effectiveness Potential for context at one level to augment or undermine intervention strategies at another level (Kemp et al., 2019)	Across the targeted levels of influence, what background factors must be considered in evaluation of the MLI to enhance the generalizability of effectiveness findings?
MLI evaluation can be challenged by: infeasibility of randomization, difficulty of finding comparators, and limited power.	Importance of parsimony in specifying process chains targeted by MLIs How to apply accepted pragmatic study designs, measures and metrics to test MLI’s effects on process chains	What qualitative and quantitative data (ideally brief, broadly applicable and sensitive to change) could be used to assess whether MLI had expected (or unexpected) influence on process chains? How might existing data and new data collection be harmonized to give insight into how process chains would have evolved without the MLI intervention?
Sustainability Evaluation: Implementation Science (Hailemariam et al., 2019)		
MLI sustainability is a key element for judging effectiveness	Defining what level of sustainability and at what levels of influence is the goal.	What resources would be required at what levels of influence to sustain MLI effectiveness?

(continued on next page)

Table 1 (continued)

Assumptions	MLI development considerations	Examples Questions to Guide MLI Planning
		Are there economies of scale that can be leveraged at one level of influence to offset required resources at other levels of influence?

et al., 2005). When considering which levels of influence might be most important, this framework calls upon MLI designers to clarify assumptions about the chains of mechanisms (i.e., process chains) that must be influenced for an MLI to be effective and anticipate complex system processes such as emergence (i.e., unexpected beneficial and harmful responses to an intervention) and weathering (i.e., tendency to become desensitized to interventions). As shown in Table 1, key assumptions of complexity theory compel MLI development considerations and inform questions for developers to pose in specific contexts.

Through the lens of the inverse care law, MLIs must be conceptualized to acknowledge that inequities at different levels of influence are likely to restrict benefits accrued to structurally marginalized populations and may become part of the marginalizing process (Reskin, 2012; Williams and Purdie-Vaughns, 2016). Links across levels that perpetuate these inequities must be considered as they can induce metaphenomena that impede intervention effectiveness. For example, the link between everyday experiences of discrimination, such as residing in segregated, unsafe neighborhoods and living under criminal justice policies that are imposed differentially – all elements of discrimination – will likely reduce the impact of an MLI if not carefully considered (Reskin, 2012). Thus, a step in the conceptual process is to ask “at which levels of influence are linkages in inequities important to consider to make an intervention maximally effective for those who typically get the least benefit”?

Deciding on optimal methods for testing the impact of a MLI on targeted health outcomes is also vital to planning. Pragmatic approaches have gained acceptance for assessing impact when context does not enable experimental control, such as randomization (Glasgow, 2013). An advantage of pragmatic approaches is the assumption that MLIs are inherently more “real-world” and as such, results will be more broadly generalizable (Table 1). Relatedly, context includes inherent messiness that can augment or undermine efforts to validly test a MLI’s effectiveness, while also enhancing the generalizability of effectiveness findings. In addition, given the practical challenges and complexity of intervening at multiple levels in ways that leverage the process chains that are embedded within and across social systems, pragmatic approaches that fit with the implementation context are most likely to be sustained (D’Angelo et al., 2020; Coronado et al., 2017; Harden et al., 2018).

Implementation science thinking also will be essential in the MLI planning process. Implementation efforts are often large-scale, can involve interventions at multiple levels, and are conducted across multiple sites simultaneously (Huynh et al., 2018). Further, the use of implementation strategies has become increasingly sophisticated, and often target multiple levels of influence within organization or around an organization. Field theory would suggest that implementation activities across levels may be more likely to lead to incorporation of implementation strategies within organizations in ways that may maximize their sustainability (Kozlowski and Klein, 2012). Glasgow et al., define sustainability as “the extent to which an evidence-based intervention delivers its benefits over an extended period of time after external support from the donor agency is terminated” (Glasgow et al., 2013). For MLIs, the considerations include the need to define the goal for sustainability, at what levels of influence it must be evidenced, how different implementation strategies might influence sustainability, and what resources would be required. Considering implementation science

in the context of social science frameworks such as the inverse care law is important to considering how health inequities might limit sustainability (Senier et al., 2019).

3. Conclusions

In this Commentary, we argue that if we are to increase the application of MLIs to promote both population health and health equity, it is imperative that we develop and apply parsimony-focused operational frameworks to increase the feasibility of this pursuit. We suggest one hypothetical framework guided by emerging lines of thought to select context-specific levels of influence that should be targeted. Parsimony is supported when we can conceptualize, design and evaluate MLIs that can exploit linkages across levels of influence, recognizing where the impact of reflexive and recursive process chains of mechanisms that cross levels are most influential in differing contexts. Without doing so, we fear that little will change, and we will simply continue to talk, without proceeding to the walk.

References

- Aarons, G.A., Hurlburt, M., Horwitz, S.M., 2011. Advancing a conceptual model of evidence-based practice implementation in public service sectors. *Adm. Pol. Ment. Health* 38 (1), 4–23.
- Agurs-Collins, T., Persky, S., Paskett, E.D., Barkin, S.L., Meissner, H.I., Nansel, T.R., et al., 2019. Designing and assessing multilevel interventions to improve minority health and reduce health disparities. *Am. J. Publ. Health* 109 (S1), S86–S93.
- Akee, R.K., Copeland, W.E., Keeler, G., Angold, A., Costello, E.J., 2010. Parents’ incomes and children’s outcomes: a Quasi-experiment. *Am. Econ. J. Appl. Econ.* 2 (1), 86–115.
- Bor, J., Cohen, G.H., Galea, S., 2017. Population health in an era of rising income inequality: USA, 1980–2015. *Lancet* 389 (10077), 1475–1490.
- Braveman, P.A., Kumanyika, S., Fielding, J., Laveist, T., Borrell, L.N., Manderscheid, R., et al., 2011. Health disparities and health equity: the issue is justice. *Am. J. Publ. Health* 101 (Suppl. 1), S149–S155.
- Bronfenbrenner, U., 1999. Environments in developmental perspective: theoretical and operational models. *Measuring Environment across the Life Span: Emerging Methods and Concepts*. American Psychological Association, Washington, DC, US, pp. 3–28.
- Brownson, R.C., Proctor, E., Colditz, G.A., 2018. *Dissemination and Implementation Research in Health: Translating Science to Practice*, second ed. Oxford University Press, New York.
- Bruckner, T.A., Brown, R.A., Margerison-Zilko, C., 2011. Positive income shocks and accidental deaths among Cherokee Indians: a natural experiment. *Int. J. Epidemiol.* 40 (4), 1083–1090.
- Cavazos-Rehg, P.A., Krauss, M.J., Sowles, S.J., Spitznagel, E.L., Grucza, R., Chaloupka, F. J., et al., 2016. Multiple levels of influence that impact youth tobacco use. *Tob. Regul. Sci.* 2 (2), 106–122.
- Ceci, S.J., Papierno, P.B., 2005. The rhetoric and reality of gap closing: when the “haves-nots” gain but the “haves” gain even more. *Am. Psychol.* 60 (2), 149–160.
- Coronado, G.D., Schneider, J.L., Petrik, A., Rivelli, J., Taplin, S., Green, B.B., 2017. Implementation successes and challenges in participating in a pragmatic study to improve colon cancer screening: perspectives of health center leaders. *Transl. Behav. Med.* 7 (3), 557–566.
- Costello, E.J., Compton, S.N., Keeler, G., Angold, A., 2003. Relationships between poverty and psychopathology: a natural experiment. *Jama* 290 (15), 2023–2029.
- Costello, E.J., Erkanli, A., Copeland, W., Angold, A., 2010. Association of family income supplements in adolescence with development of psychiatric and substance use disorders in adulthood among an American Indian population. *Jama* 303 (19), 1954–1960.
- Cummins, S., Flint, E., Matthews, S.A., 2014. New neighborhood grocery store increased awareness of food access but did not alter dietary habits or obesity. *Health Aff.* 33 (2), 283–291.
- D’Angelo, H., Ramsey, A.T., Rolland, B., Chen, L.S., Bernstein, S.L., Fucito, L.M., et al., 2020. Pragmatic application of the RE-AIM framework to evaluate the implementation of tobacco cessation programs within NCI-designated cancer centers. *Front Public Health* 8, 221.
- Esmail, L.C., Barasky, R., Mittman, B.S., Hickman, D.H., 2020. Improving comparative effectiveness research of complex health interventions: standards from the patient-centered outcomes research institute (PCORI). *J. Gen. Intern. Med.* 35 (2), 875–881.
- Fernandez, M.E., Ten Hoor, G.A., van Lieshout, S., Rodriguez, S.A., Beidas, R.S., Parcel, G., et al., 2019. Implementation mapping: using intervention mapping to develop implementation strategies. *Front Public Health* 7, 158.
- Flay, B.R., Petraitis, J., 1991. Methodological issues in drug use prevention research: theoretical foundations. *NIDA Res. Monogr.* 107, 81–109.
- Glasgow, R.E., 2013. What does it mean to be pragmatic? Pragmatic methods, measures, and models to facilitate research translation. *Health Educ. Behav.* 40 (3), 257–265.
- Glasgow, R.E., Brownson, R.C., Kessler, R.S., 2013. Thinking about health-related outcomes: what do we need evidence about? *Clin. Transl. Sci.* 6 (4), 286–291.
- Glass, T.A., McAtee, M.J., 2006. Behavioral science at the crossroads in public health: extending horizons, envisioning the future. *Soc. Sci. Med.* 62 (7), 1650–1671.

- Hailemariam, M., Bustos, T., Montgomery, B., Barajas, R., Evans, L.B., Drahota, A., 2019. Evidence-based intervention sustainability strategies: a systematic review. *Implement. Sci.* 14 (1), 57.
- Harden, S.M., Smith, M.L., Ory, M.G., Smith-Ray, R.L., Estabrooks, P.A., Glasgow, R.E., 2018. RE-AIM in clinical, community, and corporate settings: perspectives, strategies, and recommendations to enhance public health impact. *Front Public Health* 6, 71.
- Hawe, P., Shiell, A., Riley, T., 2009. Theorising interventions as events in systems. *Am. J. Community Psychol.* 43 (3–4), 267–276.
- Huynh, A.K., Hamilton, A.B., Farmer, M.M., Bean-Mayberry, B., Stirman, S.W., Moin, T., et al., 2018. A pragmatic approach to guide implementation evaluation research: strategy mapping for complex interventions. *Front Public Health* 6, 134.
- Jilcott Pitts, S.B., Wu, Q., McGuirt, J.T., Sharpe, P.A., Rafferty, A.P., 2018a. Impact on dietary choices after discount supermarket opens in low-income community. *J. Nutr. Educ. Behav.* 50 (7), 729–735.
- Jilcott Pitts, S.B., Wu, Q., Truesdale, K.P., Haynes-Maslow, L., McGuirt, J.T., Ammerman, A., et al., 2018b. One-year follow-up examination of the impact of the North Carolina healthy food small retailer program on healthy food availability, purchases, and consumption. *Int. J. Environ. Res. Publ. Health* 15 (12).
- Johnson, C.A., 2016. CARA: Policy Designed to Prevent & Effectively Treat Heroin Addiction through Multidimensional Strategies. Cleveland State University School of Social Work.
- Kale, M.S., Wisnivesky, J., Taioli, E., Liu, B., 2019. The landscape of US lung cancer screening services. *Chest* 155 (5), 900–907.
- Kasman, M.H.R., 2021. Up Front [Internet] [cited 2021]. Available from: <https://www.brookings.edu/blog/up-front/2021/03/30/how-embracing-complexity-can-reduce-health-disparities-and-advance-social-justice/>.
- Kemp, C.G., Wagenaar, B.H., Haroz, E.E., 2019. Expanding hybrid studies for implementation research: intervention, implementation strategy, and context. *Front Public Health* 7, 325.
- Kozlowski, S., Klein, K., 2012. A multilevel approach to theory and research in organizations: contextual, temporal, and emergent processes. Multi-level theory, research, and methods in organizations: Foundations, extensions, and new directions.
- Land, T., Rigotti, N.A., Levy, D.E., Paskowsky, M., Warner, D., Kwass, J.A., et al., 2010. A longitudinal study of medicaid coverage for tobacco dependence treatments in Massachusetts and associated decreases in hospitalizations for cardiovascular disease. *PLoS Med.* 7 (12), e1000375.
- O’Cathain, A., Croot, L., Duncan, E., Rousseau, N., Sworn, K., Turner, K.M., et al., 2019. Guidance on how to develop complex interventions to improve health and healthcare. *BMJ Open* 9 (8), e029954.
- Paskett, E., Thompson, B., Ammerman, A.S., Ortega, A.N., Marsteller, J., Richardson, D., 2016. Multilevel interventions to address health disparities show promise in improving population health. *Health Aff.* 35 (8), 1429–1434.
- Pawson, R., Greenhalgh, T., Harvey, G., Walshe, K., 2005. Realist review—a new method of systematic review designed for complex policy interventions. *J. Health Serv. Res. Pol.* 10 (1), 21–34.
- Phibbs, S., Kenney, C., Rivera-Munoz, G., Huggins, T.J., Severinsen, C., Curtis, B., 2018. The inverse response law: theory and relevance to the aftermath of disasters. *Int. J. Environ. Res. Publ. Health* 15 (5).
- Reskin, B.F., 2012. The race discrimination system. *Annu. Rev. Sociol.* 38, 17–35.
- Resnicow, K., Page, S.E., 2008. Embracing chaos and complexity: a quantum change for public health. *Am. J. Publ. Health* 98 (8), 1382–1389.
- Richard, L., Gauvin, L., Raine, K., 2011. Ecological models revisited: their uses and evolution in health promotion over two decades. *Annu. Rev. Publ. Health* 32, 307–326.
- Scholmerich, V.L., Kawachi, I., 2016. Translating the social-ecological perspective into multilevel interventions for family planning: how far are we? *Health Educ. Behav.* 43 (3), 246–255.
- Senior, L., McBride, C.M., Ramsey, A.T., Bonham, V.L., Chambers, D.A., 2019. Blending insights from implementation science and the social sciences to mitigate inequities in screening for hereditary cancer syndromes. *Int. J. Environ. Res. Publ. Health* 16 (20).
- Shelton, R.C., Chambers, D.A., Glasgow, R.E., 2020. An extension of RE-AIM to enhance sustainability: addressing dynamic context and promoting health equity over time. *Front Public Health* 8, 134.
- Taplin, S.H., Yabroff, K.R., Zapka, J., 2012. A multilevel research perspective on cancer care delivery: the example of follow-up to an abnormal mammogram. *Canc. Epidemiol. Biomarkers Prev.* 21 (10), 1709–1715.
- Tehrani, P., Neugut, A.I., Phelan, J.C., Link, B.G., Liao, Y., Desai, M., et al., 2009. Medical advances and racial/ethnic disparities in cancer survival. *Canc. Epidemiol. Biomarkers Prev.* 18 (10), 2701–2708.
- Tehrani, P., Goyal, A., Phelan, J.C., Link, B.G., Liao, Y., Fan, X., et al., 2016. Age at cancer diagnosis, amenability to medical interventions, and racial/ethnic disparities in cancer mortality. *Cancer Causes Control* 27 (4), 553–560.
- Wiener, R.S., Rivera, M.P., 2019. Access to lung cancer screening programs in the United States: perpetuating the inverse care law. *Chest* 155 (5), 883–885.
- Williams, D.R., Purdie-Vaughns, V., 2016. Needed interventions to reduce racial/ethnic disparities in health. *J. Health Polit. Policy Law* 41 (4), 627–651.