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## Methods: Mind the Gap Webinar Series

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# Evaluating Synergies in Multilevel Interventions: Mental Health in Schools as an Exemplar

Presented by:  
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# Evaluating Synergies in Multilevel Interventions: Mental Health in Schools as an Exemplar

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<https://doi.org/10.1007/s11121-023-01626-x>

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# A Hybrid Pragmatic and Factorial Cluster Randomized Controlled Trial for an Anti-racist, Multilevel Intervention to Improve Mental Health Equity in High Schools

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# Design and Analytic Methods to Evaluate Multilevel Interventions to Reduce Health Disparities: Rigorous Methods Are Available

David M. Murray<sup>1</sup>  · Melody S. Goodman<sup>2</sup>

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# Overview of Presentation

- Systemic Racism & Mental Health in Schools
- Hypothetical Multilevel Intervention
- Evaluation Design, Measures, and Analytic Sample
- Sample Size Considerations
- Conclusions
- Q&A

# Systemic Racism & Mental Health in Schools

# Addressing Systemic Racism

- Systemic racism
  - Inclusive of internalized, interpersonal, and institutional racism
  - Impact of policies and procedures that facilitate and empower organizations to engage in discriminatory acts
  - Pervasive in US society
  - Should be the focus of interventions aiming to reduce health inequities
  - Requires multilevel intervention approaches

# Systemic Racism Impacts Mental Health in Schools

- Systemic racism is a fundamental cause of poor health outcomes
- Black and Hispanic/Latino youth experience inequities within schools and report greater unmet mental health needs than White children
- Addressing racism and discrimination is key to promoting positive mental health of racial and ethnic minoritized youth
- Schools are an environment in which multilevel factors combine to influence mental health

# Challenges of Evaluating Multilevel Interventions

- Students within 1 school likely to be impacted by school-level intervention
  - Cluster randomized controlled trials (cRCTs) are gold standard

# Challenges of Evaluating Multilevel Interventions (cont'd)

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- Macro-level interventions may not be optimized for cRCTs
  - Pragmatic pre-post design followed by cRCT

# Challenges of Evaluating Multilevel Interventions (cont'd)

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  - Pragmatic pre-post design followed by cRCT
- Micro-level interventions within schools result in contamination
  - Minimize and measure contamination

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- Macro-level interventions may not be optimized for cRCTs
  - Pragmatic pre-post design followed by cRCT
- Micro-level interventions within schools result in contamination
  - Minimize and measure contamination
- Interventions involve complex interacting components
  - Conceptually hypothesized to interact
  - Standard cRCTs don't test interactions
  - Understanding interactions important for maximizing constrained resources

# Synergies Unexplored in Standard Study Designs

<b>Multilevel Intervention (AB)</b>	No	Mean No AB
	Yes	Mean Yes AB

<b>Multilevel Intervention (AB)</b>	No	25
	Yes	10

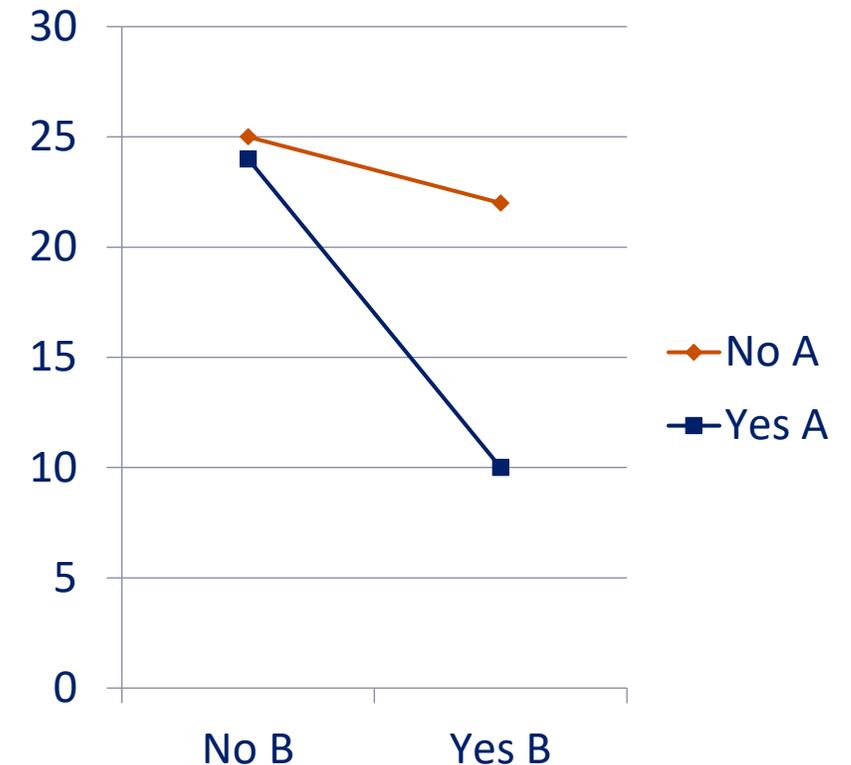


# Factorial Cluster RCTs (cRCTs)

- Allow the evaluation of two or more intervention components
- Powerful yet underutilized design for multilevel interventions

		Intervention Component B		
		No	Yes	
Intervention Component A	No	A, B	A, B	Mean No A
	Yes	A, B	A, B	Mean Yes A
		Mean No B	Mean Yes B	

		Intervention Component B		
		No	Yes	
Intervention Component A	No	25	22	23.5
	Yes	24	10	16
		24.5	17	



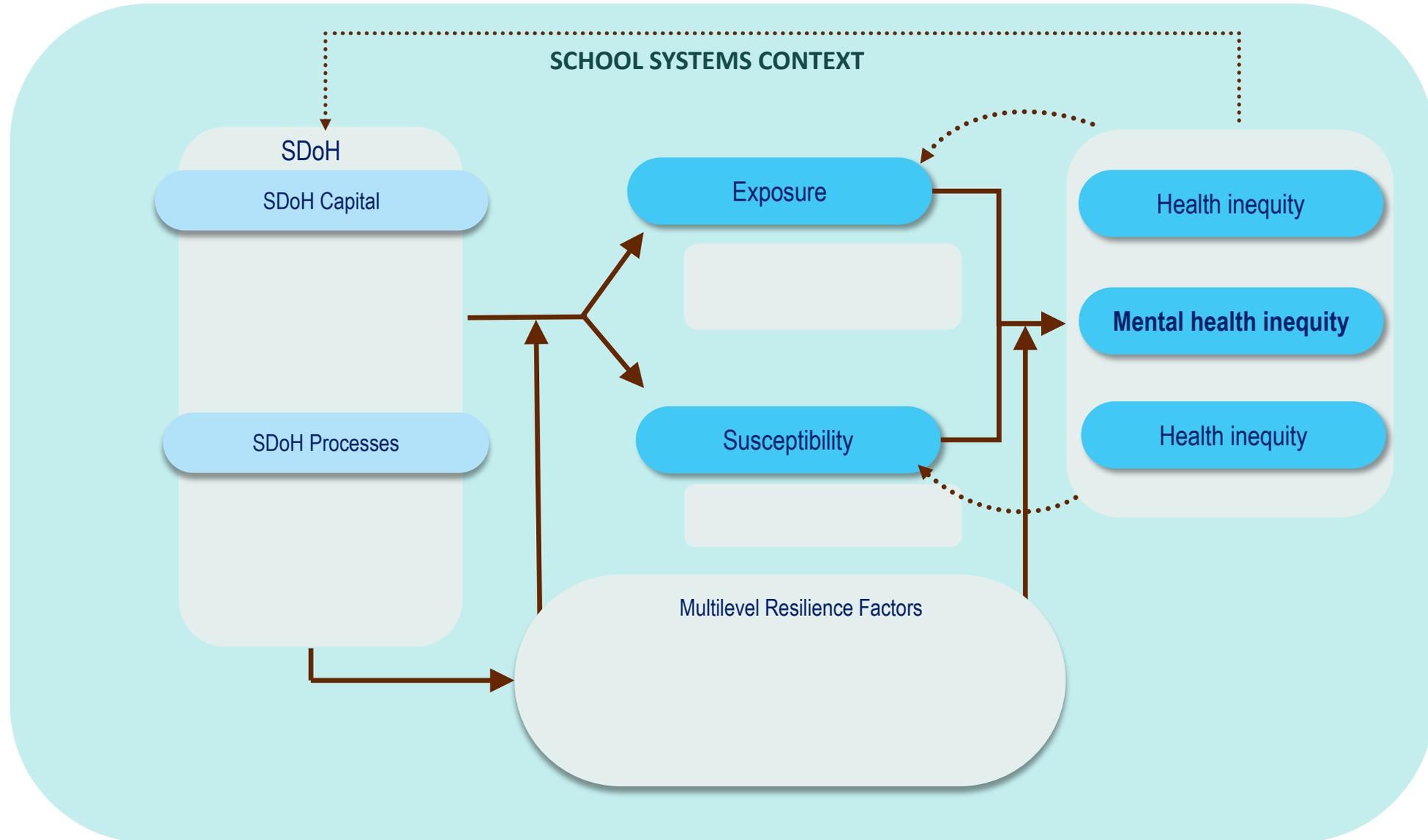
Source: Mdege et al., 2014

# Limitations and Strengths of Factorial cRCTs

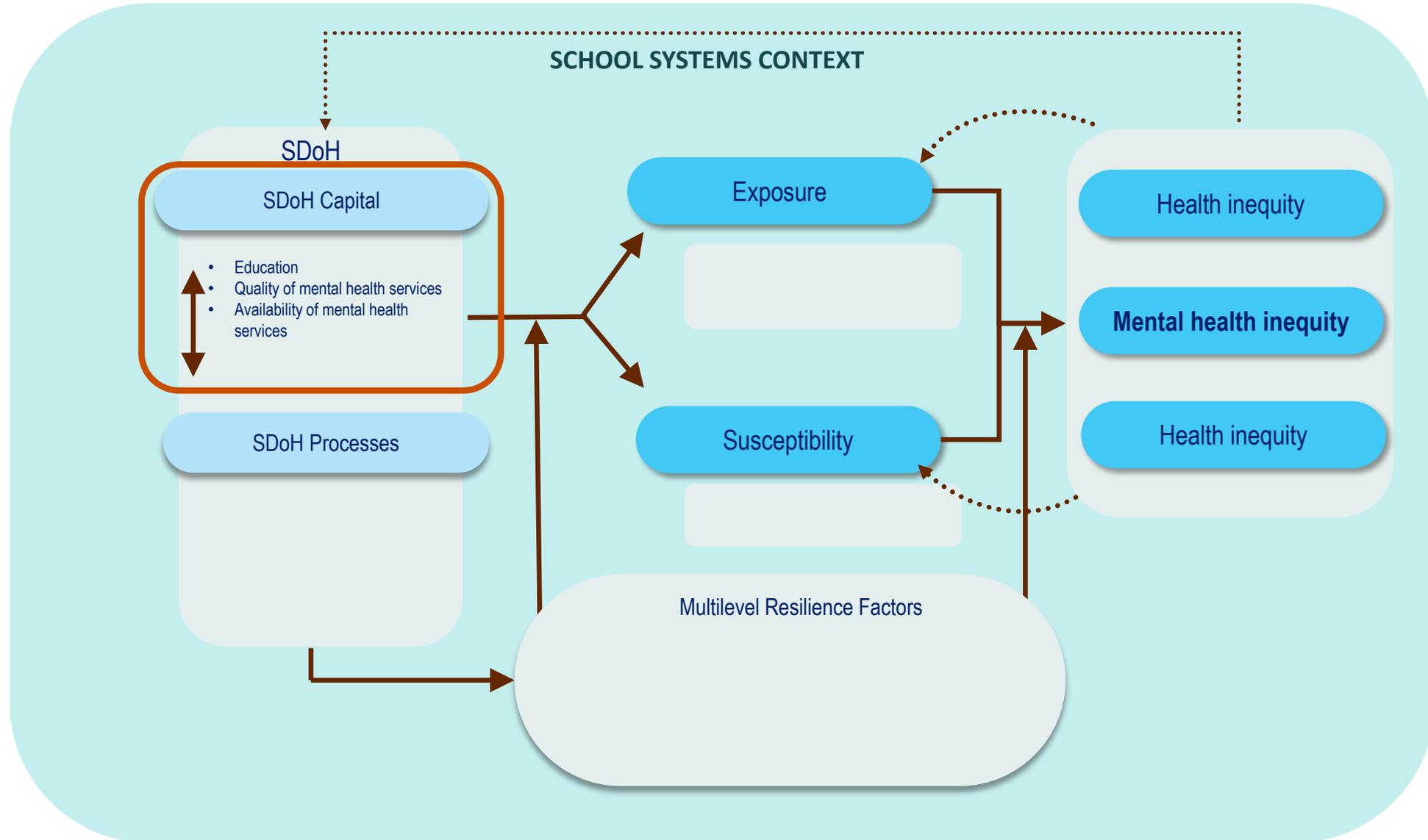
- Limitations
  - Complexity in design and analysis
  - Increased sample size requirements
  - Risk of contamination
- Strengths
  - Efficient use of resources
  - Examine interactions between interventions at different levels
  - Larger proportion of clusters randomized to receive at least one intervention component

# Hypothetical Multilevel Intervention

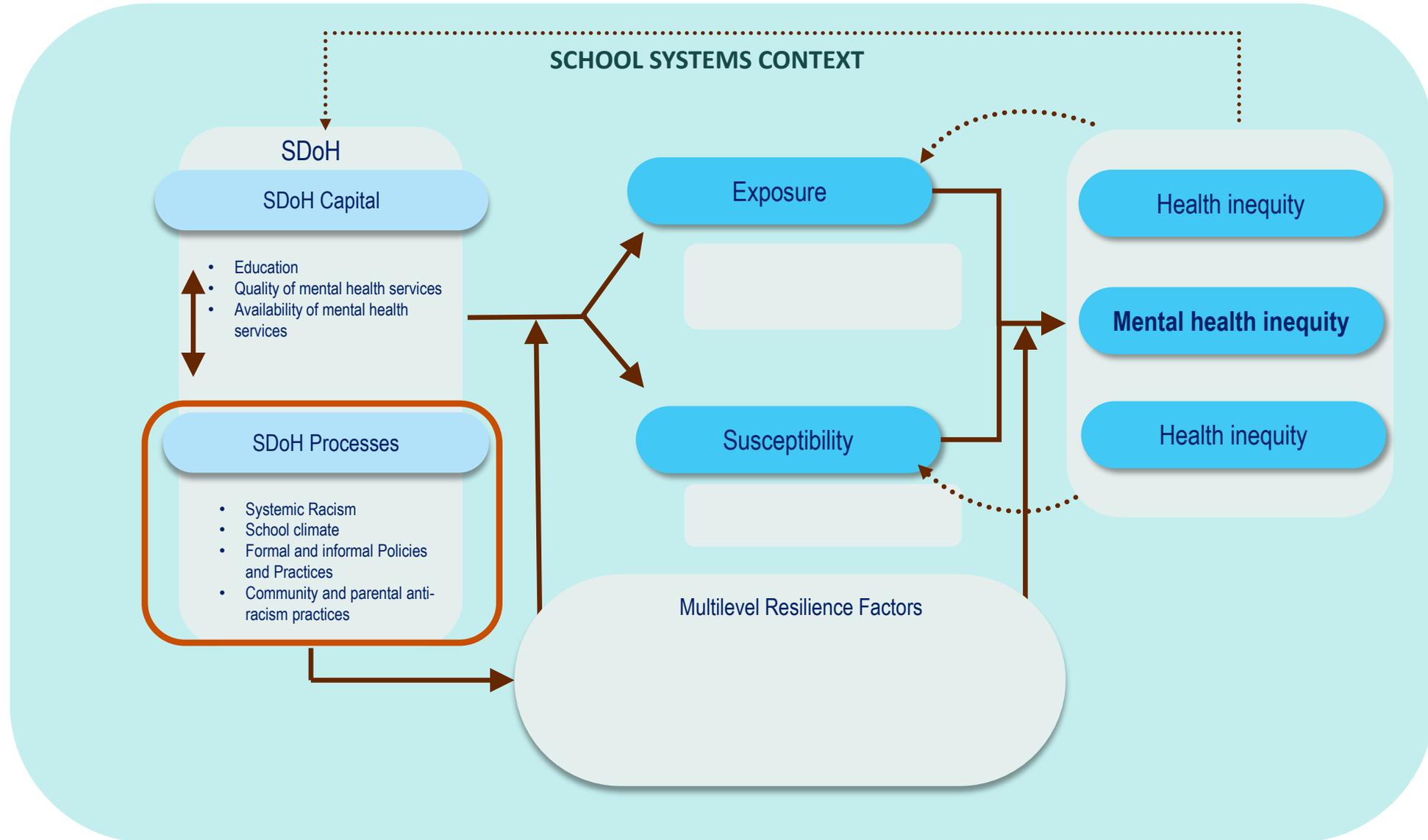
# Adapted Heuristic Framework Informing Intervention



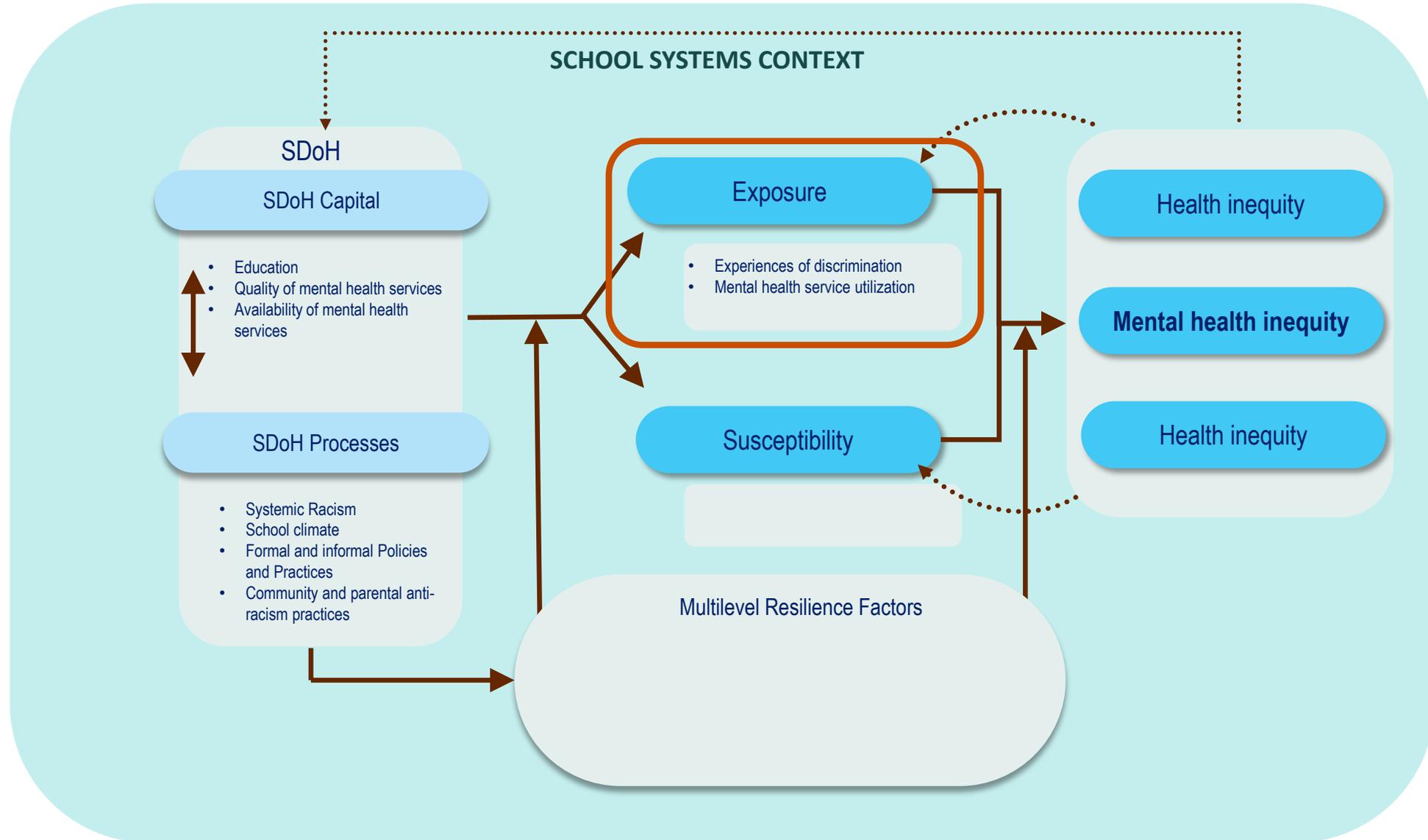
## Adapted Heuristic Framework Informing Intervention (cont'd)



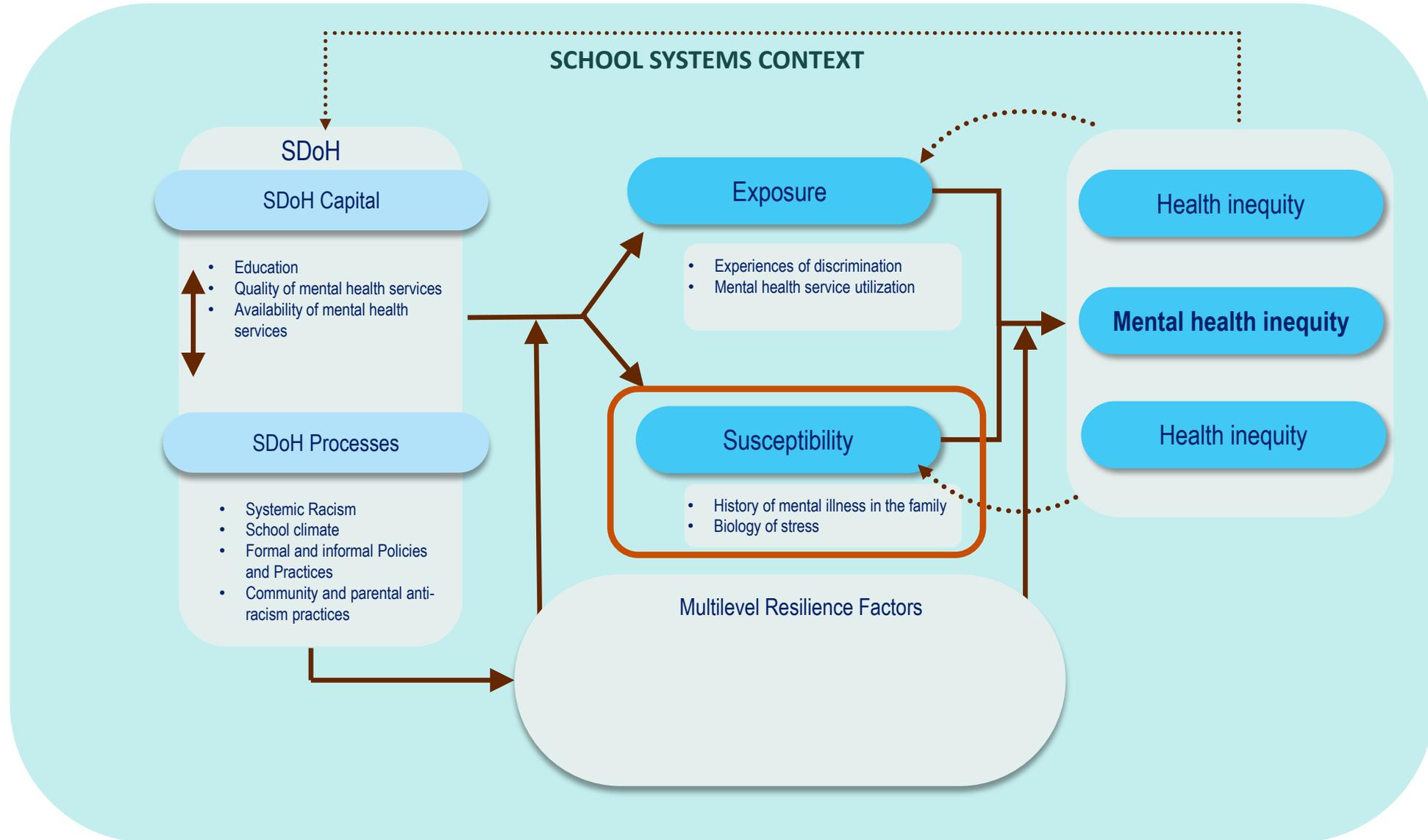
# Adapted Heuristic Framework Informing Intervention (cont'd)



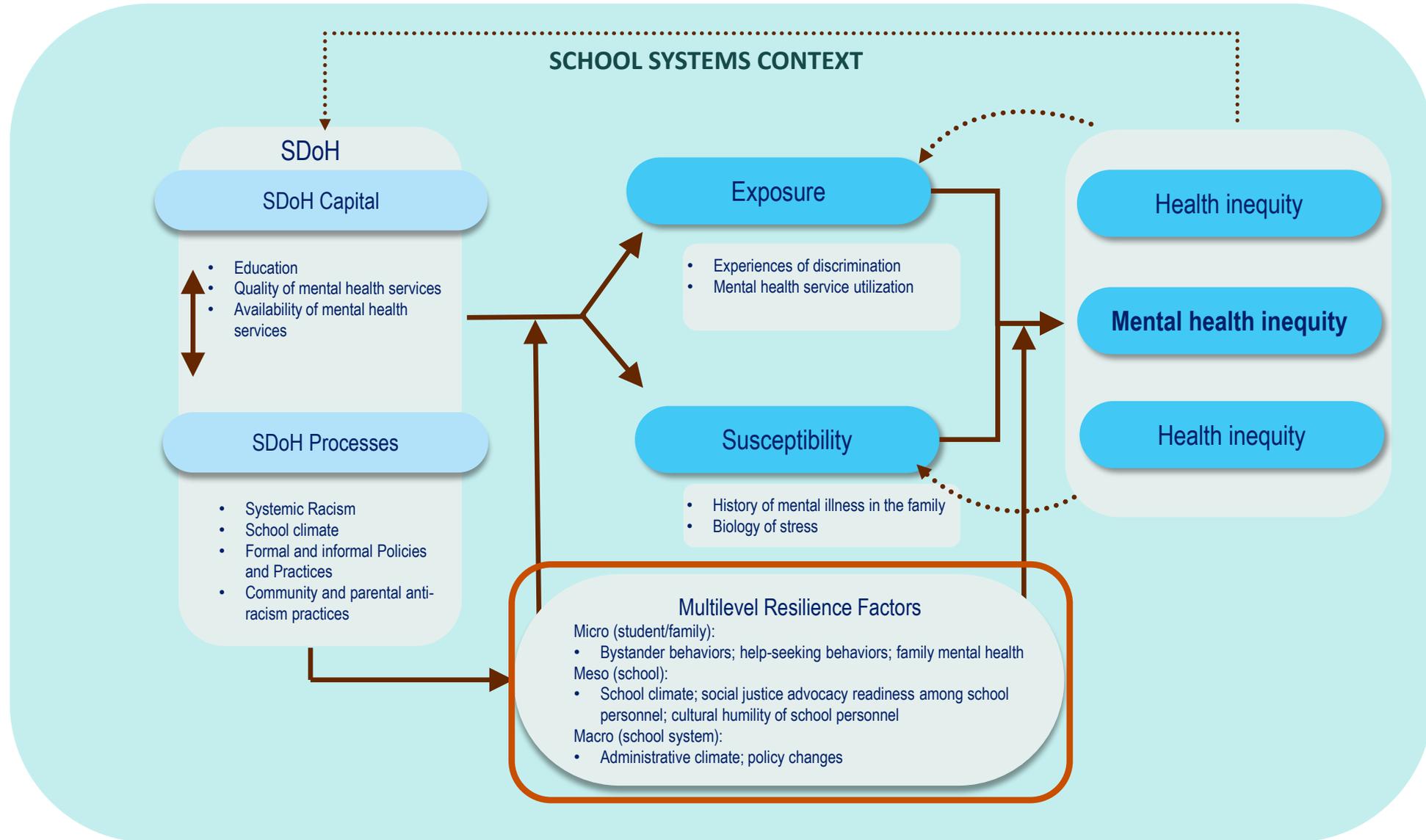
# Adapted Heuristic Framework Informing Intervention (cont'd)



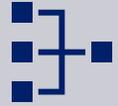
# Adapted Heuristic Framework Informing Intervention (cont'd)



# Adapted Heuristic Framework Informing Intervention (cont'd)



# Overview of Multilevel Intervention



Macro: **Public School System**

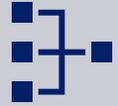


Meso: **High School**



Micro: **Home**

# Macro: Public School System



Macro: **Public School System**

- Restorative Justice Talking Circles
- Racial Equity Impact Assessment (REIA)

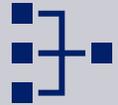


Meso: **High School**



Micro: **Home**

# Meso: High School



Macro: **Public School System**

- Restorative Justice Talking Circles
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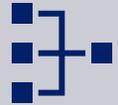
Meso: **High School**

- Training in racial justice, cultural humility, mental health first aid for school personnel



Micro: **Home**

# Micro: Home



## Macro: **Public School System**

- Restorative Justice Talking Circles
- Racial Equity Impact Assessment (REIA)



## Meso: **High School**

- Training in racial justice, cultural humility, mental health first aid for school personnel



## Micro: **Home**

- Mental health first aid

# Evaluation Design, Measures, and Analytic Sample

# Proposed Design

- Multiphase, hybrid pragmatic and factorial cRCT
  - 1-year pretest–posttest pragmatic trial to evaluate the school system’s policy change at the macro-level
  - 1-year  $2 \times 2$  cross-level factorial cRCT to evaluate the effects of the meso- and micro-level interventions
- Both phases will be conducted with 30 clusters (i.e., high schools in three school systems)

# Overview of Multilevel Intervention and Study Design

Phase	Level	Socio-Cultural Context	Intervention	Intervention Participants	Outcome - Concept	Outcome - Measure
I	Macro	Public School System	Talking circles & REIA	School board members School administrators School personnel	Administrative climate, * Perceived policy changes	Surveys Survey and interviews with Faculty, students, staff
					Adolescent mental health	Children's Depression Inventory (CDI), Reynolds Children's Manifest Anxiety Scale (RCMAS)
	Meso	High Schools	Training in racial justice, cultural humility, mental health first aid for school personnel	School administrators Faculty Staff	Racial equity, knowledge, attitudes, beliefs, self-efficacy	Multifactor Racial Inventory
					Cultural humility	Cultural humility Scale
II	Micro	Home	Mental health first aid	Families Students	Social Justice advocacy readiness	Social Justice, Advocacy Readiness questionnaire
					School Climate	Interviews with Faculty, students, staff
	Micro	Home	Mental health first aid	Families Students	*Adolescent mental health	Children's Depression Inventory (CDI), Reynolds Children's Manifest Anxiety Scale (RCMAS)
					Family mental health	The Family Health Scale
Micro	Home	Mental health first aid	Families Students	Bystander behaviors; Self efficacy	Situational Attitudes Scale	
				Adolescent psychological wellbeing; Connectedness; Hopefulness	Ryff Psychological Wellbeing Scale, Engagement, Perseverance, Optimism, Connectedness & Happiness Measure	
Micro	Home	Mental health first aid	Families Students	*Adolescent mental health	Children's Depression Inventory (CDI), Reynolds Children's Manifest Anxiety Scale (RCMAS)	

\* Denotes the primary outcome for the corresponding intervention level

# Overview of Analytic Methods – Phase I

Level / Unit of Analysis	Schema of Random Sampling	Key Factor	Main Outcome	Covariates	Analytic Method
<b>1 (Time)</b>	Pretest-posttest measures	Time	Policy change perceived		
<b>2 (Individuals: students/families, school personnel, or school system administrators)</b>	<ul style="list-style-type: none"> <li>• 450 students/families (15 from each of 30 schools)</li> <li>• 300 school personnel (10 from each of 30 schools)</li> <li>• 30 school system administrators (10 from each of the 3 school systems)</li> </ul>		by: <ul style="list-style-type: none"> <li>• Students</li> <li>• Families</li> <li>• School personnel</li> <li>• School system administrators</li> </ul>	Individual characteristics	<ul style="list-style-type: none"> <li>• 3-level MLM (for student, family, or school personnel outcomes separately)</li> <li>• Qualitative analysis (for school system administrators)</li> </ul>
<b>3 (Schools)</b>	All 30 schools receiving intervention			School characteristics including the indicator of the 3 school systems	

Source: Davis et al., 2019; Grant et al., 2013

# Analysis for Phase I

- 3-level multilevel modeling (MLM) to assess effect of the macro intervention on school system's policy change
- 3-level MLM of students' perceptions of school system's policy changes can be specified as follows:

$$Y_{tij} = \mu + \alpha_j + \theta \times Time_{tj} + \sum_{p=1}^P \gamma^{(p)} \times S_j^{(p)} + \sum_{q=1}^Q \varphi^{(q)} \times C_{ij}^{(q)} + \varepsilon_{tij}$$

- Mixed-methods study will integrate findings from qualitative interviews with key constituents with the quantitative results

# Overview of Analytic Methods – Phase II

Level / Unit of Analysis	Schema of Random Sampling	Key Factor	Main Outcome	Covariates	Analytic Method
<b>1 (Individuals: students/families or school personnel)</b>	<ul style="list-style-type: none"> <li>1,530 students/families (51 from each of the 30 schools) receiving Micro intervention + 1,530 students/families (51 from each of the 30 schools) receiving no intervention</li> <li>450 school personnel (15 from each of the 30 schools)</li> </ul>	<ul style="list-style-type: none"> <li>MESO</li> <li>MICRO</li> <li>MESO×MICRO</li> </ul>	Posttest assessment of <ul style="list-style-type: none"> <li>Adolescent mental health</li> <li>Family mental health</li> <li>School personnel cultural humility, social justice &amp; advocacy, and school climate</li> </ul>	Individual characteristics including perceived school system's policy change estimated from Phase I (MACRO)	<ul style="list-style-type: none"> <li>2-level MLM (for student, family, or school personnel outcomes separately) with controlling for pretest assessment at Level 1.</li> </ul>
<b>2 (Schools)</b>	15 schools receiving Meso intervention + 15 schools receiving no intervention			School characteristics including the indicator of the 3 school systems	

# Analysis for Phase II

- 2-level MLM to assess primary outcome, adolescent mental health, at the posttest controlling for the pretest assessment
  - Efficiently estimate cross-level intervention effects between the meso- and micro-levels
  - Incorporate the estimated students' perceptions of school system's policy changes due to the macro-level intervention
- The 2-level MLM for the primary outcome can be specified as follows:

$$Y_{ij}^{(1)} = \mu + \alpha_j + Y_{ij}^{(0)} + \beta_j \times MICRO_{ij} + \theta^{(1)} \times MESO_j + \theta^{(2)} \times MICRO_{ij} + \theta^{(3)} \times MESO_j \times MICRO_{ij} \\ + \sum_{p=1}^P \gamma^{(p)} \times S_j^{(p)} + \varphi^{(0)} \times MACRO_{ij} + \sum_{q=1}^Q \varphi^{(q)} \times C_{ij}^{(q)} + \varepsilon_{ij}$$

# Sample Size Considerations

# Power Analysis for Phase I

- Results of power analysis using PASS for Phase I's Level-1 pretest-posttest pragmatic intervention effect before adjusting the nesting effect of Level 2 with Level 3
- Required number of students/families that are nested within 30 schools is  $199 \times [1 + 0.04 \times (30 - 1)] = 430$

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**Paired Means Power Analysis**

**Numeric Results for Paired T-Test**  
Null Hypothesis: Mean of Paired Differences = 0, Alternative Hypothesis: Mean of Paired Differences  $\neq$  0  
Unknown standard deviation.

Power	N	Alpha	Beta	Mean of Paired Differences	S	Effect Size
0.80169	199	0.05000	0.19831	0.2	1.0	0.200

**References**  
Machin, D., Campbell, M., Fayers, P., and Pinol, A. 1997. Sample Size Tables for Clinical Studies, 2nd Edition. Blackwell Science. Malden, MA.  
Zar, Jerrold H. 1984. Biostatistical Analysis (Second Edition). Prentice-Hall. Englewood Cliffs, New Jersey.

**Report Definitions**  
Power is the probability of rejecting a false null hypothesis.  
N is the number of pairs drawn from the population.  
Alpha is the probability of rejecting a true null hypothesis.  
Beta is the probability of accepting a false null hypothesis.  
Mean of Paired Differences is the mean difference at which the power and sample size are determined.  
S is the standard deviation of the paired differences for the population. It is assumed to be unknown.  
Effect Size,  $|\text{Mean of Paired Differences}|/\text{Sigma}$ , is the relative magnitude of the effect under the alternative.

**Summary Statements**  
A sample size of 199 achieves 80% power to detect a mean of paired differences of 0.2 with an estimated standard deviation of differences of 1.0 and with a significance level (alpha) of 0.05000 using a two-sided paired t-test.

# Power Analysis for Phase II

- Results of power analysis using H2x2Factorial for Phase II
  - $m_{\text{bar}}$  = the mean cluster size
  - $\text{delta}_{xz}$  = the effect size of the cross-level interaction effect of the 2 interventions
  - $\rho$  = the ICC
  - `estimand = "controlled"` indicating that the main effects are controlled
  - `test = "interaction"` indicating the cross-level interaction test for the two interventions

```
> library(H2x2Factorial)
>
> calc.H2x2Factorial(m_bar = 102, delta_xz = .20, rho = 0.04,
+                   estimand = "controlled", test = "interaction")
Type of treatment effect estimand:
Controlled (main) effect
Type of hypothesis test:
Interaction test
Effect size:
0.2 for the interaction effect
A Wald z-test is automatically used

Required number of clusters to achieve 0.8 power:
30
[1] 30
```

# Conclusions

# Conclusions

- Addressing systemic racism to improve mental health equity within schools requires rigorously tested multilevel interventions
- Factorial cRCT of the meso- and micro level interventions will allow for a nuanced understanding of the potential synergy resulting from the presence of both levels of intervention
- Methodological approach, including methods for sample size calculation, can be adapted to other multilevel interventions

Thank you!  
Questions?

# Methods: Mind the Gap Webinar Series

- Read the ODP-sponsored *Prevention Science* Supplemental Journal Issue, “Design and Analytic Methods to Evaluate Multilevel Interventions to Reduce Health Disparities” ([prevention.nih.gov/Prev-Sci-Methods-Issue](https://prevention.nih.gov/Prev-Sci-Methods-Issue))
  - Features Dr. Mulawa’s paper, “A Hybrid Pragmatic and Factorial Cluster Randomized Controlled Trial for an Anti-racist, Multilevel Intervention to Improve Mental Health Equity in High Schools”
- Updates on Research Methods Resources ([researchmethodsresources.nih.gov](https://researchmethodsresources.nih.gov))
  - Time-varying intervention effects in Stepped Wedge Designs
  - Group Regression Discontinuity Design section with background, key references, and a sample size calculator.