Age, Agency, and Epidemics

Linking psychological variation, behavioral heterogeneity, and transmission

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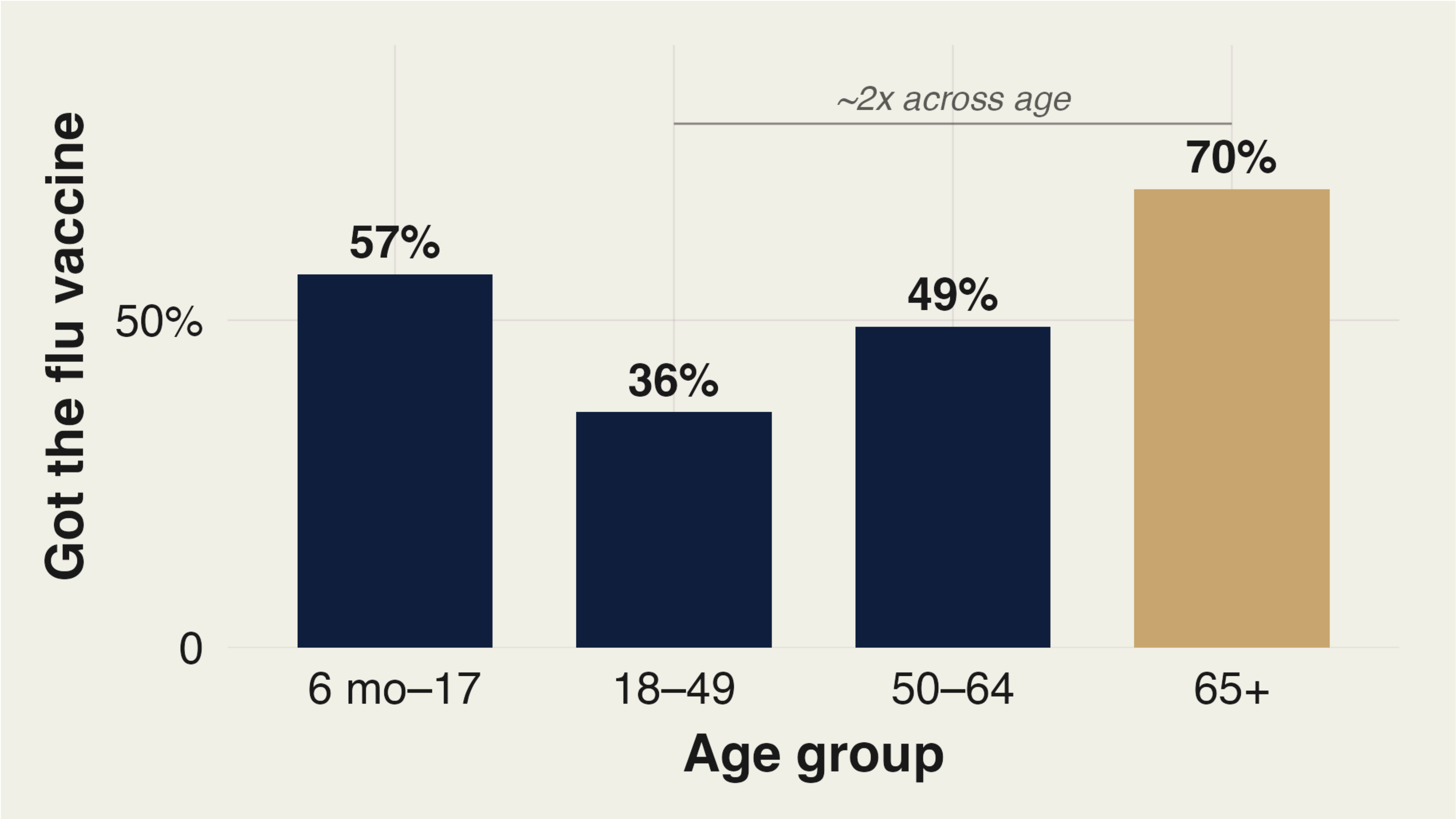
One recommendation, a whole range of responses

One vaccine, one recommendation — and uptake splits sharply by age.



Influenza vaccination coverage runs roughly twofold across age — about 36% in younger adults to about 70% at 65 and over — under the same recommendation. Source: US CDC FluVaxView.

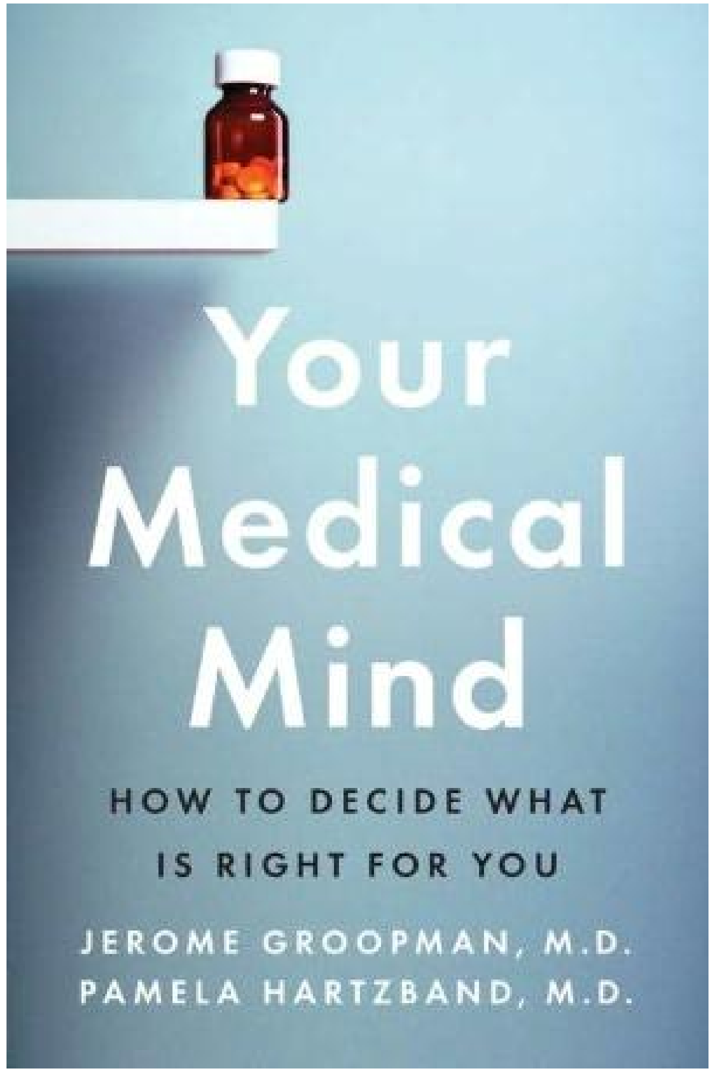
The usual explanations predict a lot, but not all of it

- **Politics** and partisanship
- **Trust** in institutions and providers
- Risk perception — of the disease, of the vaccine
- Information and **misinformation**

Each of these is supported by our data (not shown). But the impulse behind them — the idea of an **information-deficit**, *tell people more and tell it better* — rarely changes behavior, because it fails to understand the problem.

None of these reaches the cognitive part: how a person prefers to make the decision in the first place.

The framework comes from *Your Medical Mind*



Glen Nowak

Groopman J. & Hartzband P. (2011). *Your Medical Mind: How to Decide What Is Right for You.* Penguin Press. The book describes the three orientations we carry through the talk.

Agency is how people decide, not what they know

Minimalist ⟷ Maximalist

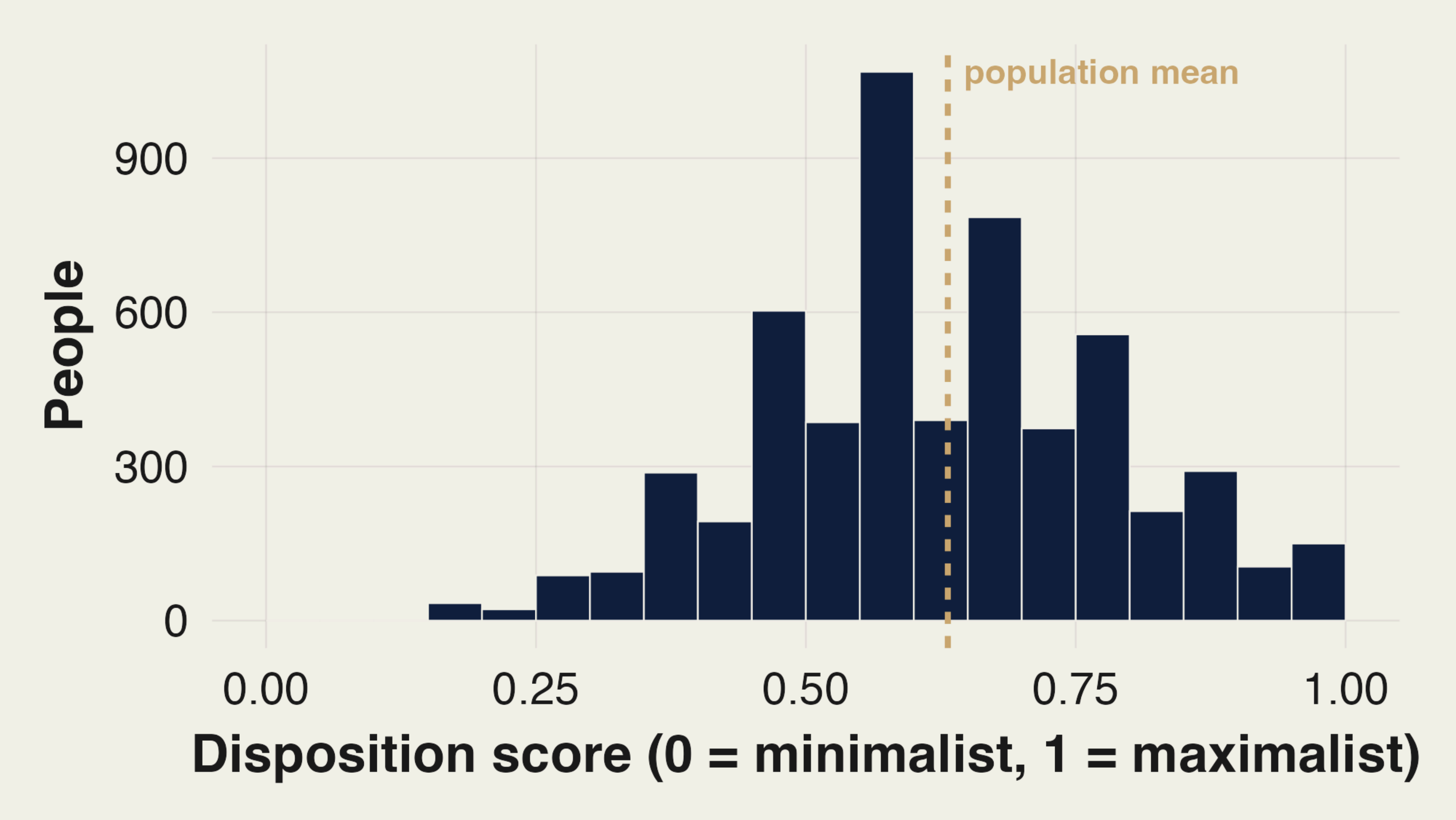
Naturalist ⟷ Technologist

Doubter ⟷ Believer

The “medical mind”: three stable dimensions of how a person engages a health decision.

Agency and Age

Disposition is measurable, and spread across the population



A nationally representative NORC AmeriSpeak survey places each adult on the three continua; the combined score spreads broadly across the population (mean ≈ 0.63). To our knowledge, the only representative measurement of vaccine decision-making spanning the entire US adult population.

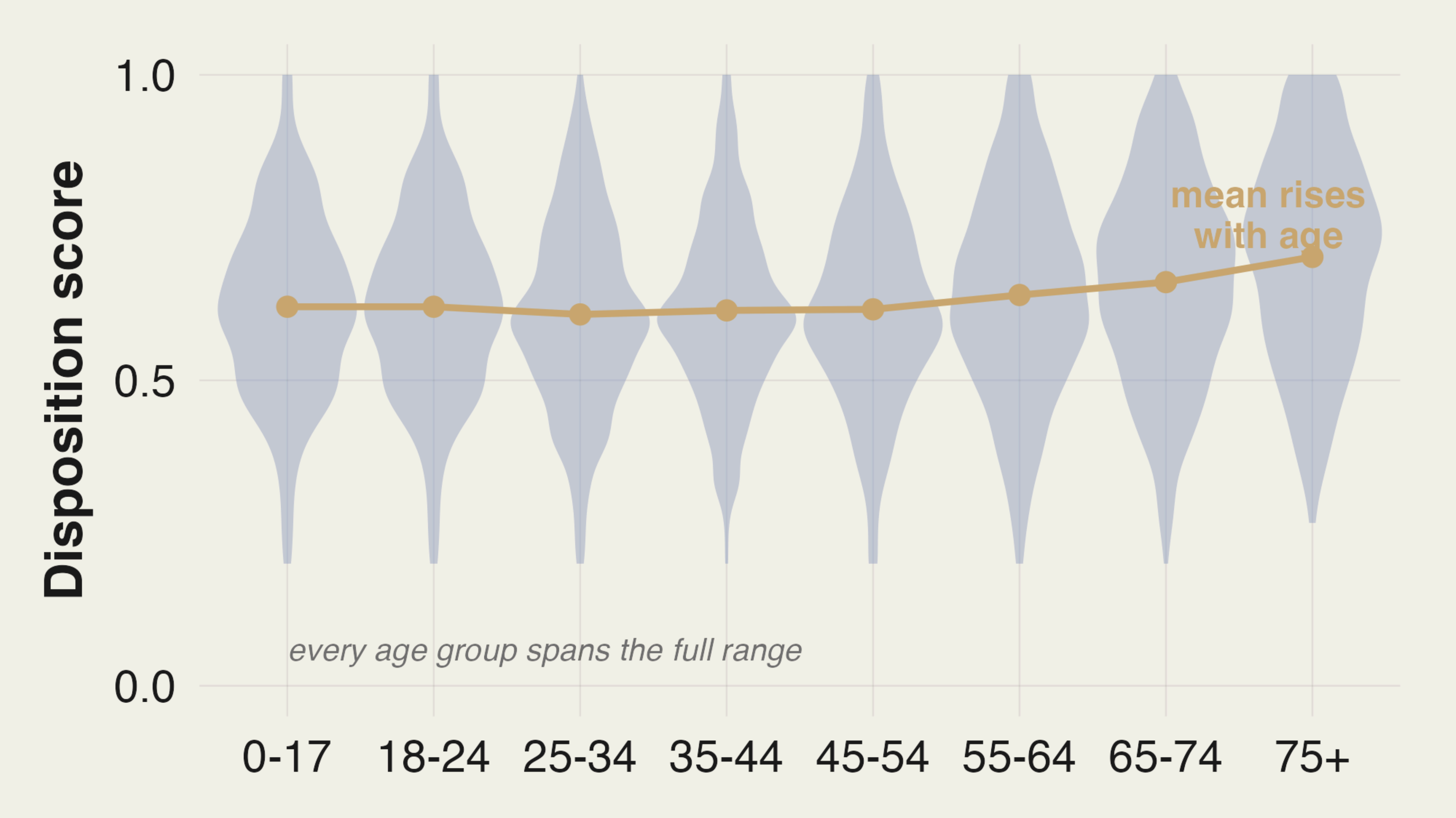
Disposition predicts vaccine confidence and hesitancy, beyond the usual determinants

In hierarchical regression on two nationally representative samples, decision-making preference is entered **last** — after demographics, perceived knowledge, physician recommendation, and other vaccine attitudes — and still adds independent signal:

- **Vaccine confidence** — positive, $p < 0.001$ in both 2016 and 2018 ($\Delta R^2 \approx$ 4–7%)
- **Vaccine hesitancy** — negative and significant in both years
- Recent vaccination and next-season intent — significant in 2016

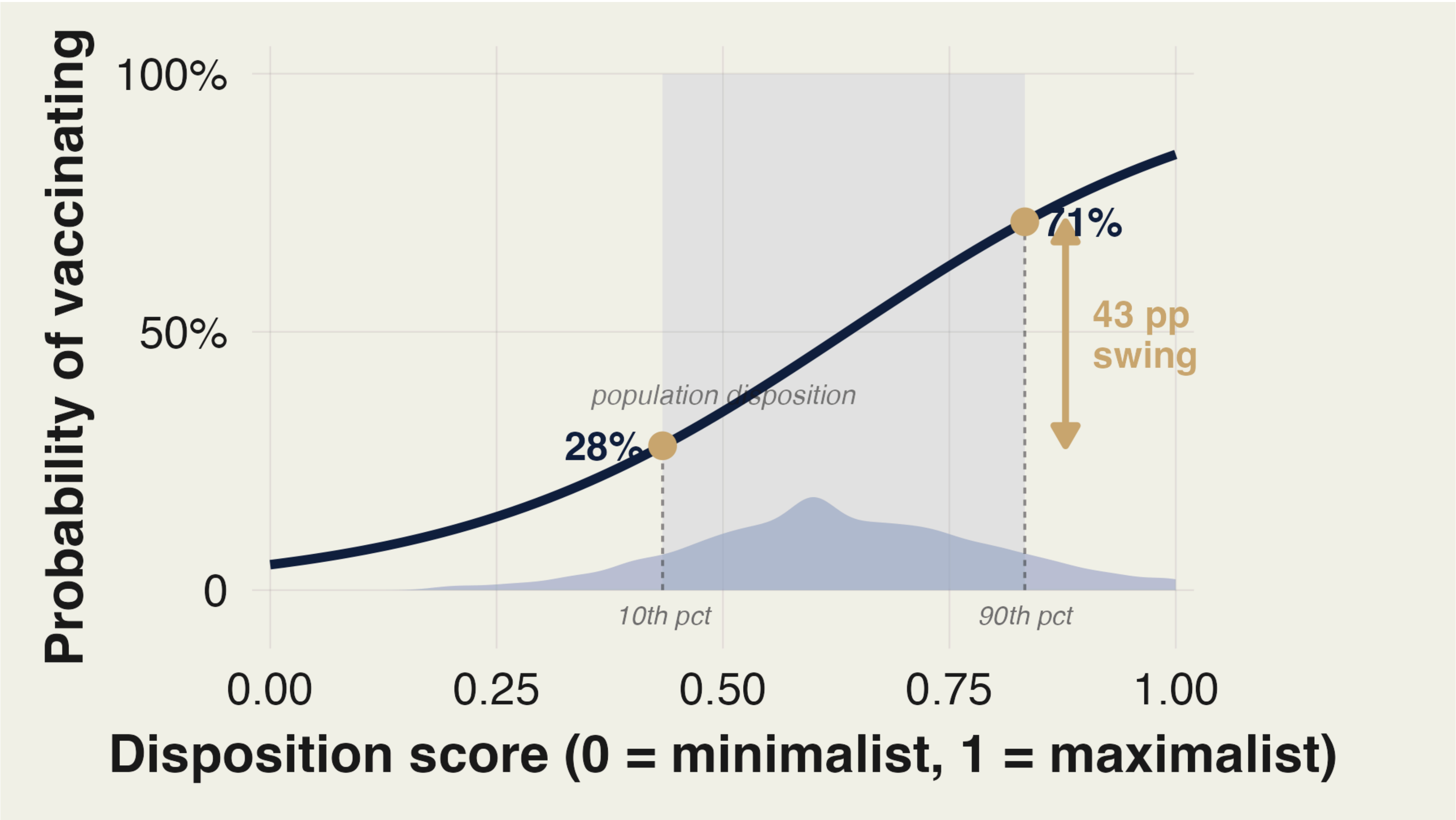
Anderson, Nowak, Cacciatore, Rohani & Drake (2025), *Vaccine* 65:127804. OLS hierarchical regression; NORC AmeriSpeak national samples (2016, $N \approx 1000$; 2018, $N \approx 1015$).

Disposition is correlated with age



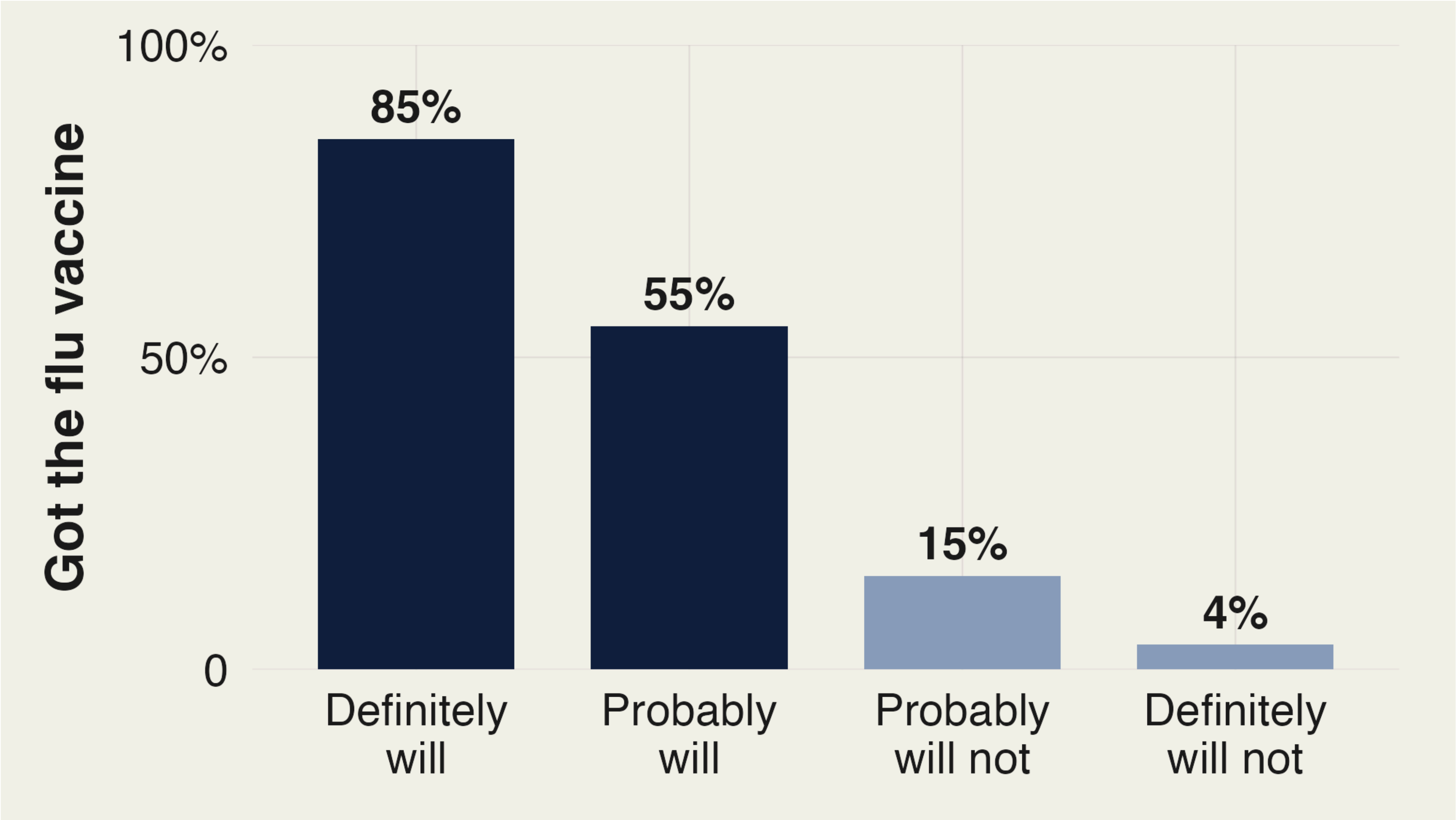
Mean disposition is modestly higher in older age groups, while every age group spans nearly the full range — measured across people at one time.

A small shift in the mean, a large shift in who vaccinates



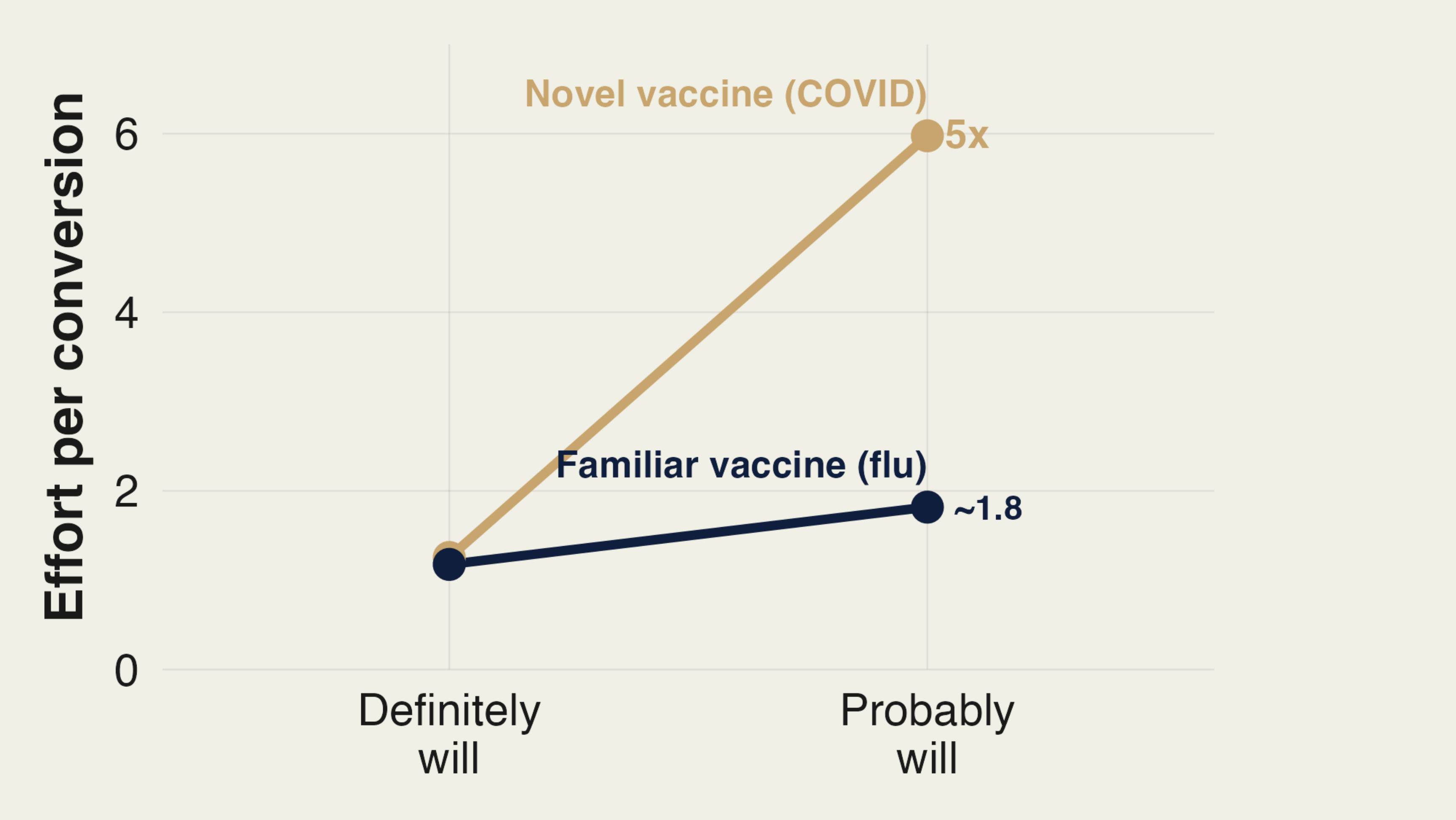
Disposition maps onto vaccination through a steep logistic curve. Holding age fixed, a person at the 10th percentile of disposition vaccinates with probability 28%, one at the 90th percentile with probability 71% — a 43-point swing within the population. The shift in group means across age, by contrast, moves it only about 9 points.

Behavior falls short of intent, more so as intent weakens



Flu vaccination by stated intent, from a 2023→2024 panel (intent measured in 2023, vaccination behavior in the same people in 2024): ~85% of those who say they will “definitely” get one do, versus ~55% of “probably,” ~15% of “probably not,” and ~4% of “definitely not.”

The cost of reaching the reluctant depends on the vaccine



Implied effort to convert one person (the inverse of the conversion rate), by stated intent, for two vaccines. The familiar flu vaccine stays cheap from the willing (~1.2) to the merely probable (~1.8); a novel vaccine — the updated COVID shot — climbs about fivefold (~1.25 to ~6).

We cannot yet separate age from cohort

Everything so far is **cross-sectional**: disposition by age, measured across people at one time.

That cannot distinguish a *life-course* effect (people change as they age) from a *cohort* effect (generations differ). The two are confounded.

Separating them needs **longitudinal data** that follows people over time.

If it is cohort, the population's disposition mix is non-stationary — uptake will drift as generations replace one another.

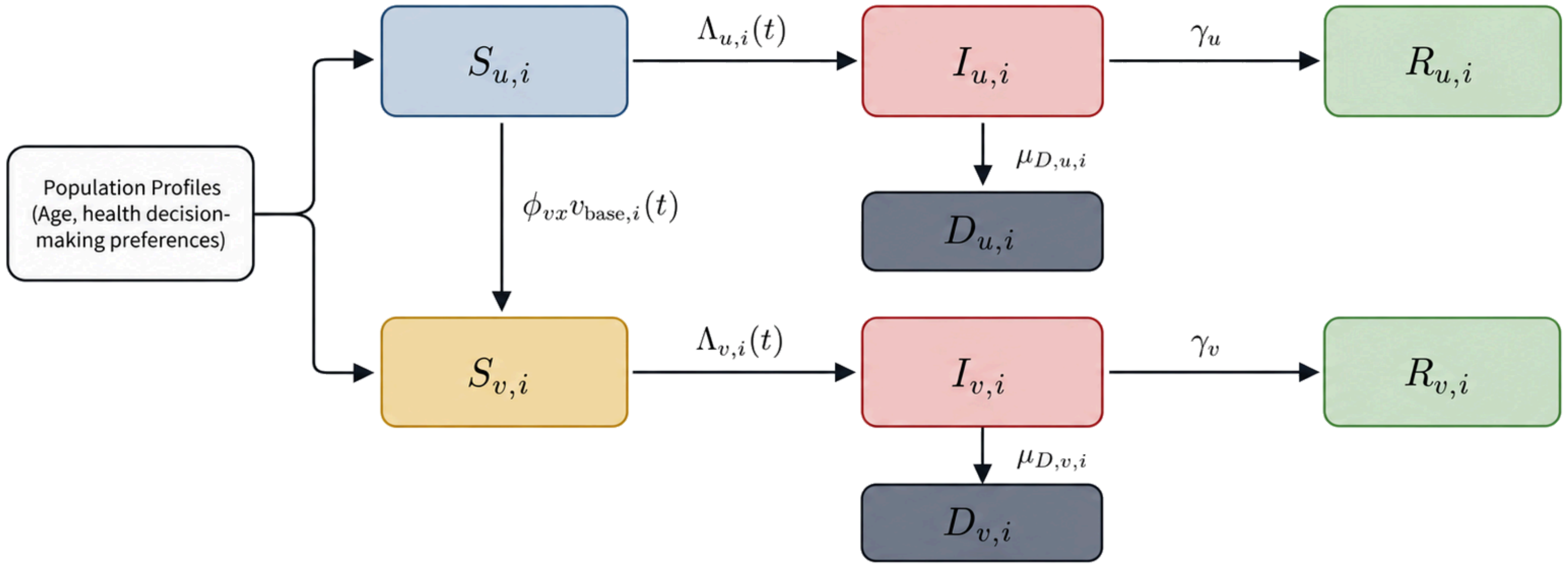
From persons to populations

Do small differences in agency scale up, or wash out?

Hypothesis: Small, age-graded differences in disposition → modest shifts in coverage → changes in epidemic timing, size, and mortality?

Following that chain requires a model that carries **individuals**, not group averages.

A compartmental model averages disposition within each age group



$$\frac{dS_{u,i}}{dt} = B(t) \cdot \mathbb{I}_{i=1} - \left(\Lambda_{u,i} + \phi_{vx} v_{\text{base},i}(t) + \mu_i\right) S_{u,i} \qquad \frac{dI_{u,i}}{dt} = \Lambda_{u,i} S_{u,i} - \left(\gamma_u + \mu_{D,u,i} + \mu_i\right) I_{u,i} \qquad \frac{dR_{u,i}}{dt} = \gamma_u I_{u,i} - \mu_i R_{u,i} \qquad \frac{dD_{u,i}}{dt} = \mu_{D,u,i} I_{u,i}$$

$$\frac{dS_{v,i}}{dt} = \phi_{vx} v_{\text{base},i}(t) S_{u,i} - \left(\Lambda_{v,i} + \mu_i\right) S_{v,i} \qquad \frac{dI_{v,i}}{dt} = \Lambda_{v,i} S_{v,i} - \left(\gamma_v + \mu_{D,v,i} + \mu_i\right) I_{v,i} \qquad \frac{dR_{v,i}}{dt} = \gamma_v I_{v,i} - \mu_i R_{v,i} \qquad \frac{dD_{v,i}}{dt} = \mu_{D,v,i} I_{v,i}$$

$$v_{\text{base},i}(t) = \frac{-\log\left(1 - P_{\text{pred},i}(t)\right)}{T} \qquad \Lambda_{u,i}(t) = \sum_{j=1}^{N_A} C_{ij}(t) \cdot \beta_j \cdot \frac{I_j(t)}{N_j(t)} \qquad \Lambda_{v,i}(t) = (1 - \epsilon_{inf}) \cdot \Lambda_{u,i}(t) \qquad \mu_{D,v,i} = \mu_{D,u,i} \cdot (1 - \epsilon_{sev})$$

The age-structured SIRVD compartments split each age group only by vaccination status, so disposition enters as a single group-level rate — the within-age spread has nowhere to live.

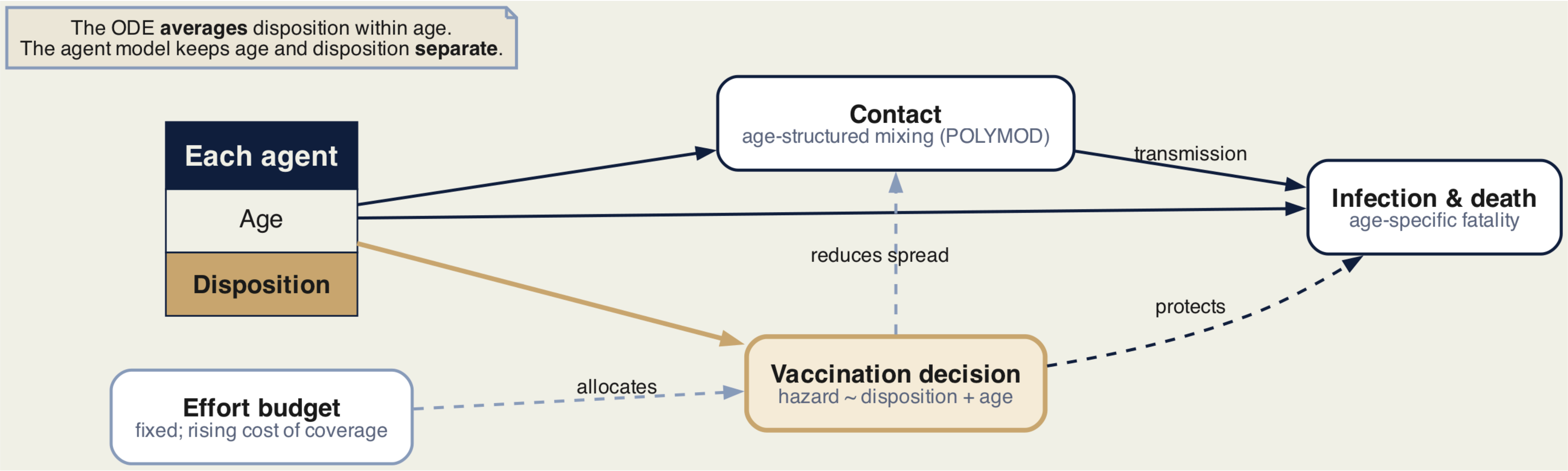
An agent based model carries each person's age and disposition

50,000 agents. Each carries **age and disposition**.

- **Contacts** — age-structured mixing (POLYMOD)
- **Disease** — age-specific infection fatality
- **Vaccination** — a hazard driven by disposition and age
- **Effort** — a fixed budget, allocated under the cost of coverage

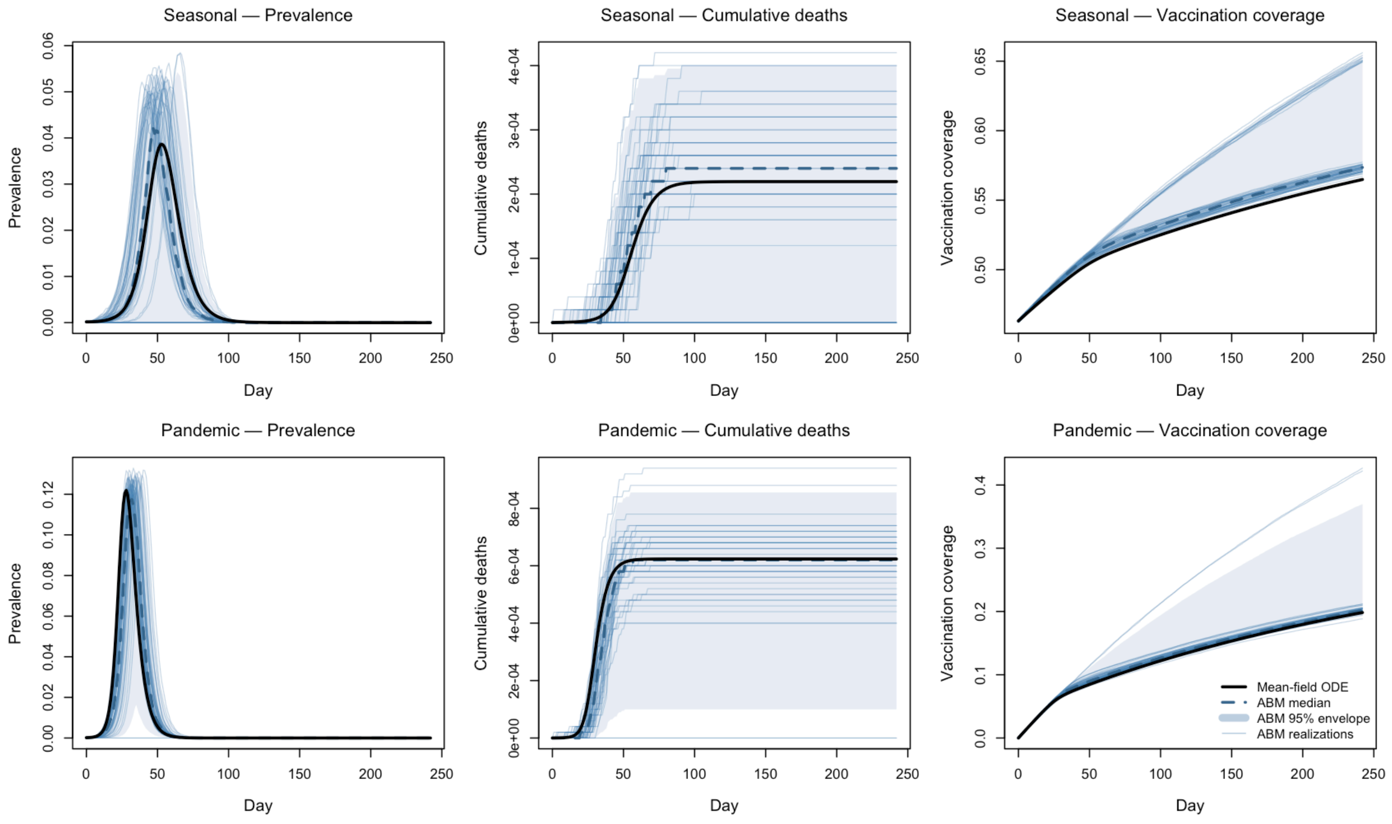
The ODE had to *average* disposition within age. The agent model keeps age and disposition separate.

The agent model



Each agent's age and disposition feed contact, infection and death, and the vaccination decision; a fixed budget pays the cost of coverage. The ODE must average disposition within age; the agent model keeps them separate.

With heterogeneity turned off, the agent model and the equations agree



Agent-based model: N = 50,000 agents · 51 replicates per scenario | R0 = 2.0 · exponential infectious period (mean 3 days) · age-averaged disposition, no targeting

Seasonal and pandemic share one virus — the same transmissibility (R_0 = 2.0) — and differ only in the population's immunity: the **seasonal** epidemic meets prior immunity and a pre-vaccinated public (effective $R \approx 1.4$), the **pandemic** a fully susceptible one (effective R = 2.0). The pandemic is worse not because the pathogen changed but because the population is susceptible.

With disposition averaged within age and no targeting, the compartmental trajectory falls inside the agent model's stochastic envelope. Agent model: 50,000 agents, 51 replicates per scenario; R_0 = 2.0, exponential infectious period (mean 3 days).

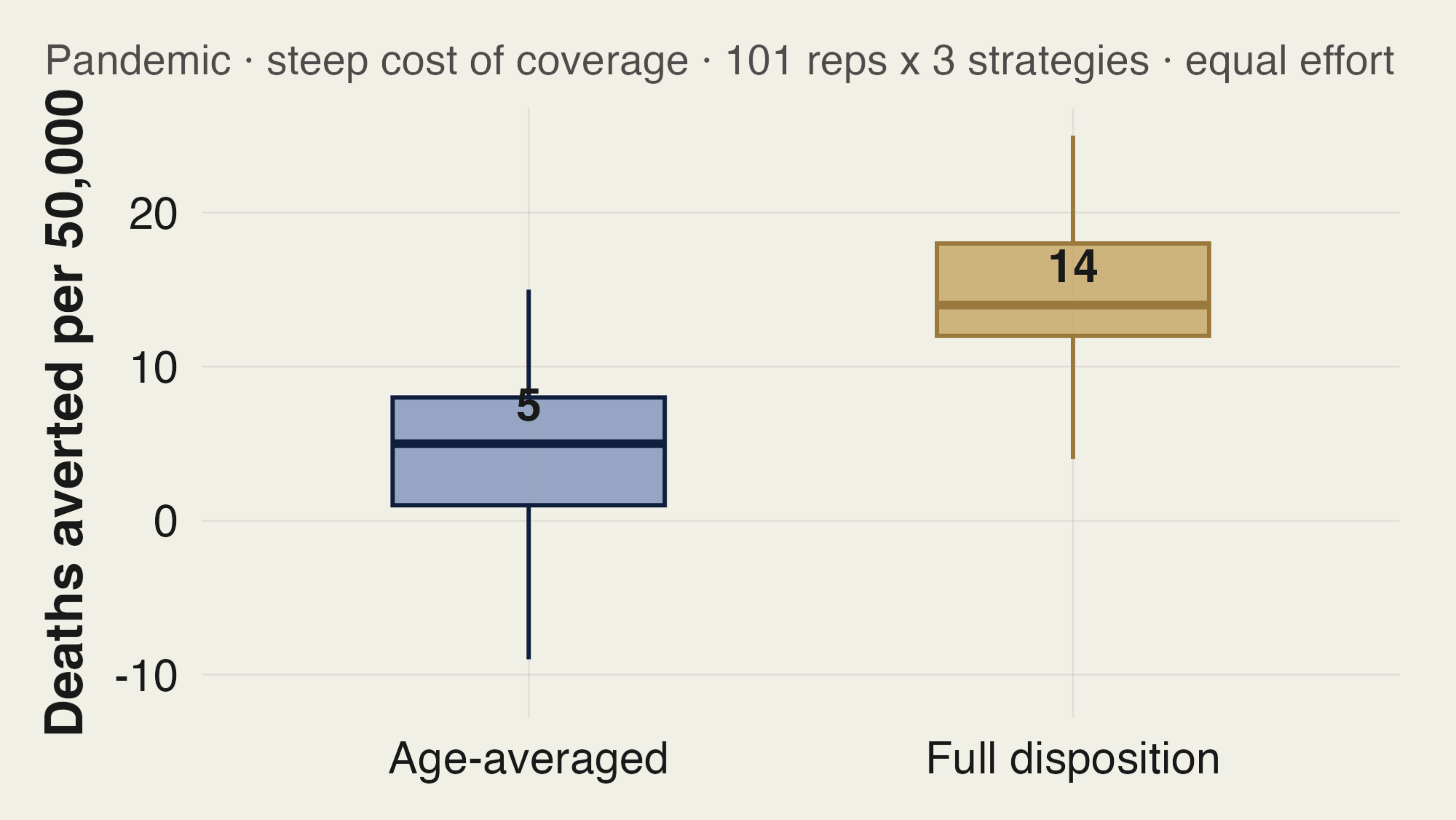
Three ways to spend the same vaccination effort

The experiment crosses two factors — how we **represent** people, and how we **target** the campaign. Three targeting rules, each spending the same total effort:

- **Broad** — a small uniform lift across all adults
- **Priority** — extra effort to the age groups with the lowest baseline uptake
- **Behavioral** — extra effort to the people most disposed to vaccinate

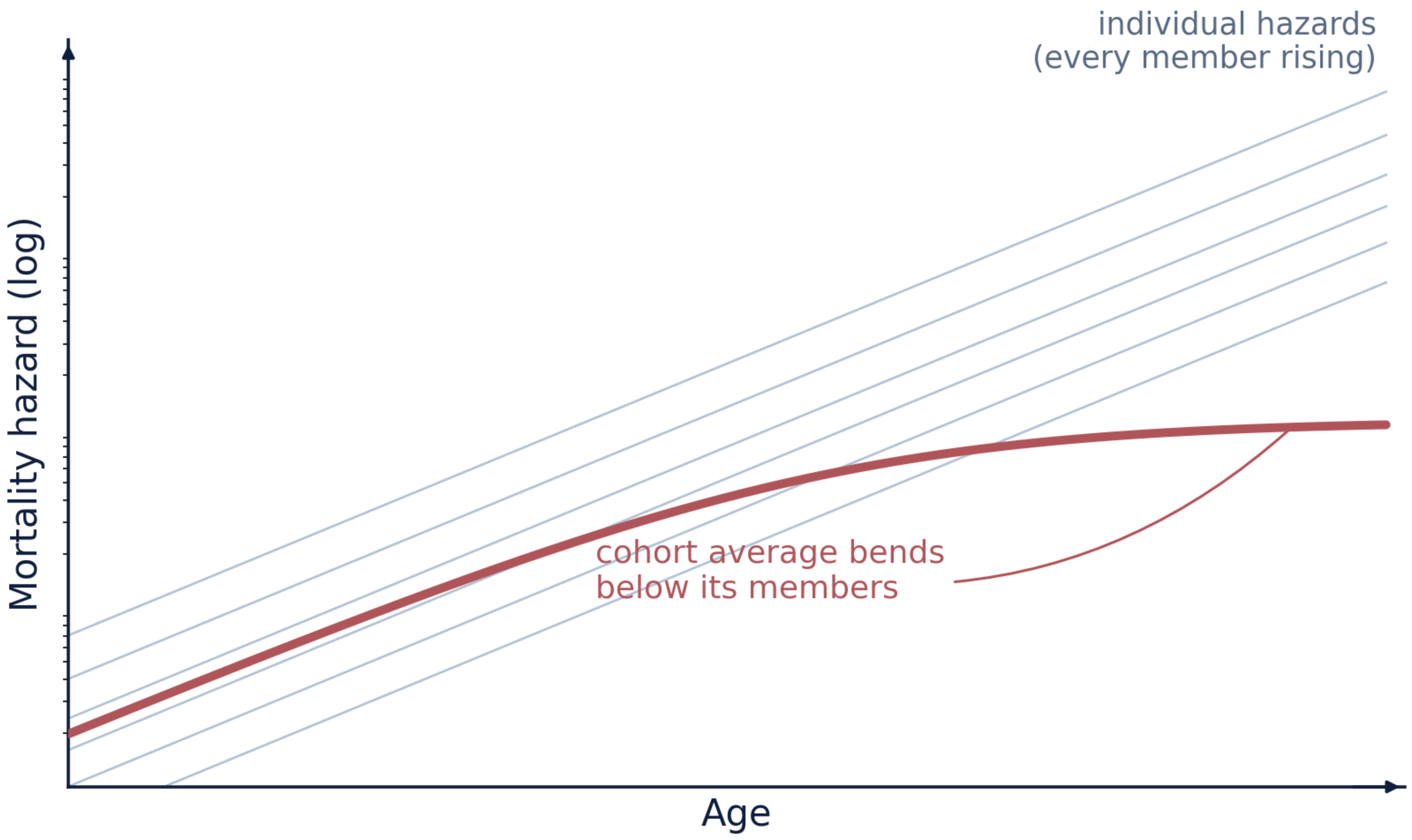
They differ only in *where* the effort goes, not how much.

Averaging by age understates the deaths a campaign can avert



Under pandemic conditions with a steep cost of coverage, the same vaccination effort averts about three times as many deaths when individual disposition is represented (median 14 per 50,000) as when it is averaged within age (median 5).

Heterogeneity's ruses, in behavioral form



Frailty selection makes a cohort's mortality hazard bend below every member's still-rising hazard (Vaupel & Yashin 1985); averaging disposition within an age group hides behavioral variation in exactly the same way.

Conclusion: Agency is a demographic variable

Agency is an age-structured demographic trait

Two age-structured layers run through this talk: **behavior** — who contacts whom, measured by POLYMOD, and who gets vaccinated, measured by the NORC survey — and **cognition**, how a person is disposed to decide. Cognition is upstream of behavior, and it is where our interventions land.

Decision-making disposition — the overlooked, cognitive layer — is itself patterned by age: a trait to set beside the mortality and fertility schedules demographers study.

What it points to:

- communication matched to how people decide, not only to what they know
- a measurable, age-graded price for moving cognition — without the trials that measuring behavior would demand
- whether disposition is age or cohort

Thank you

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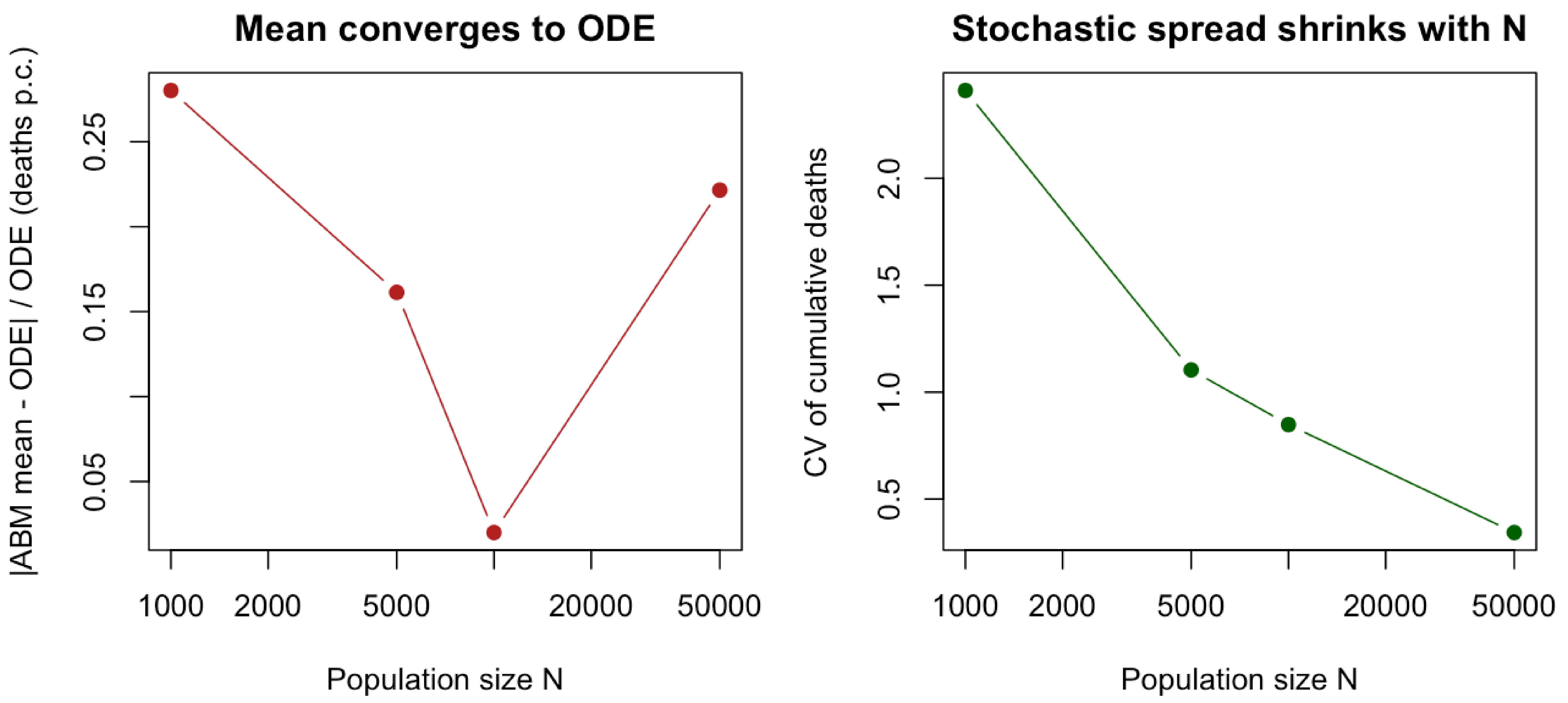
Backup

Replicate variability falls with N but persists at 50,000



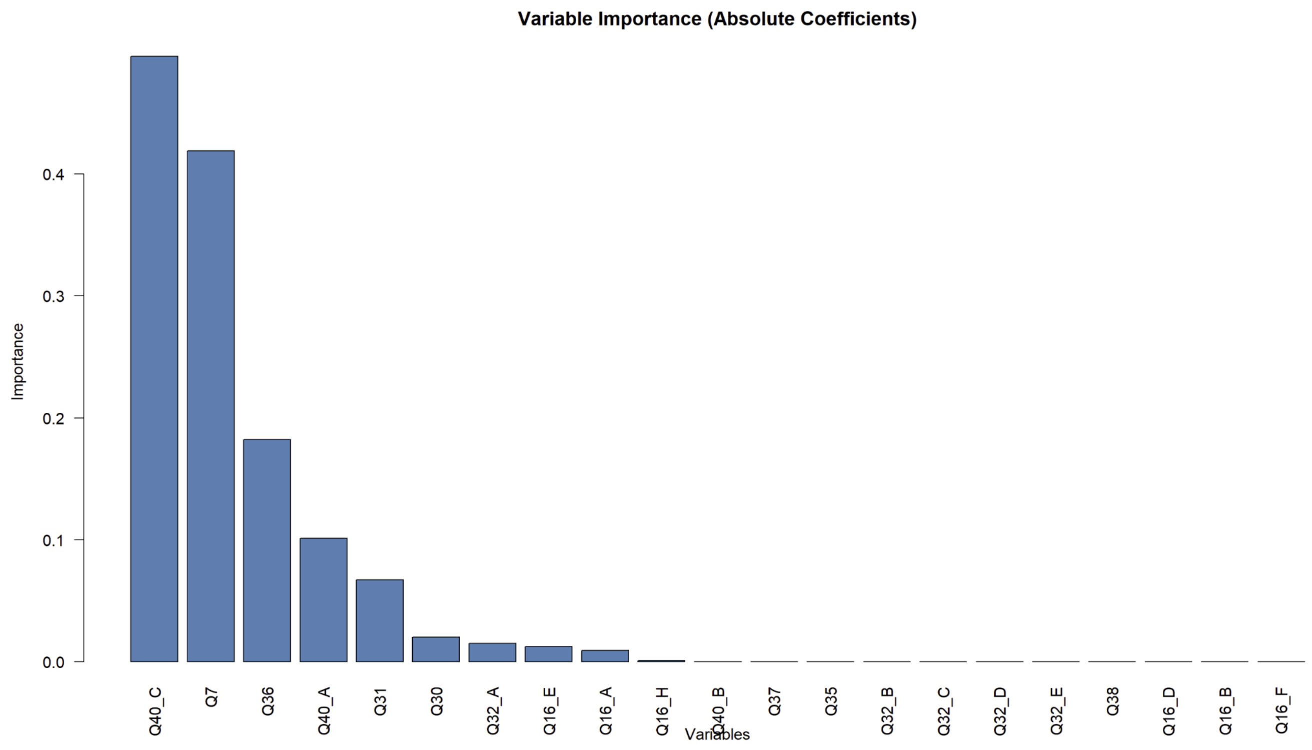
Replicate-to-replicate variability falls as population size grows but remains substantial at N = 50,000.

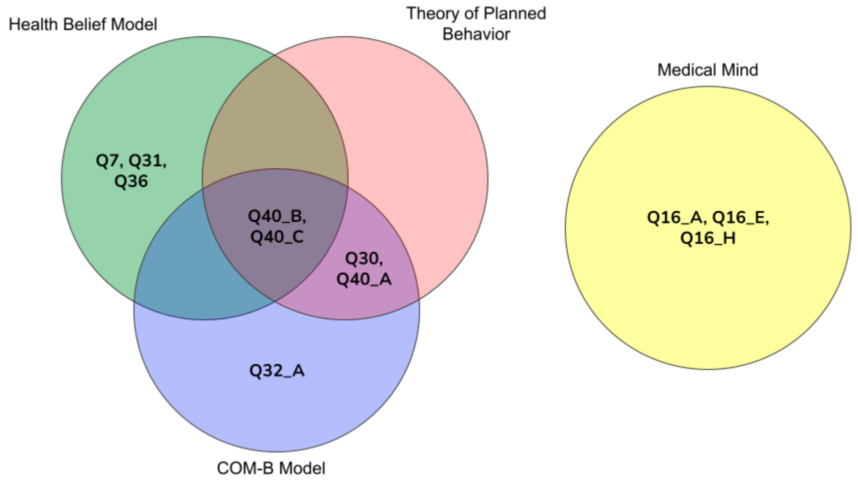
The survey items behind the three continua

(a)	Naturalist	Technologist
(a1)	"I prefer natural ways to prevent and treat illness"	"I prefer mainstream medicine approaches to prevent and treat illness"
(a2)	"I prefer complementary or alternative medicine approaches to staying healthy and treating disease"	"I prefer science and evidence-based medicine approaches to staying healthy and treating illnesses"
(b)	**Doubter**	**Believer**
(b1)	"I am most interested in the risks and potential side effects of a recommended drug or medicine"	"I am most interested in the benefits and value of a recommended drug or medicine"
(b2)	"I usually doubt health and medical advice from doctors and experts"	"I usually trust health and medical advice from doctors and experts"
(c)	**Minimalist**	**Maximalist**
(c1)	"When sick or ill, I prefer as little medicine or treatment as possible"	"When sick or ill, I prefer as much medicine or treatment as possible"
(c2)	"I usually wait until I have an illness or health problem and then take steps or actions to treat it"	"I usually take steps or actions in advance to prevent an illness or health problem"

Two items anchor each continuum: Naturalist–Technologist, Doubter–Believer, Minimalist–Maximalist.

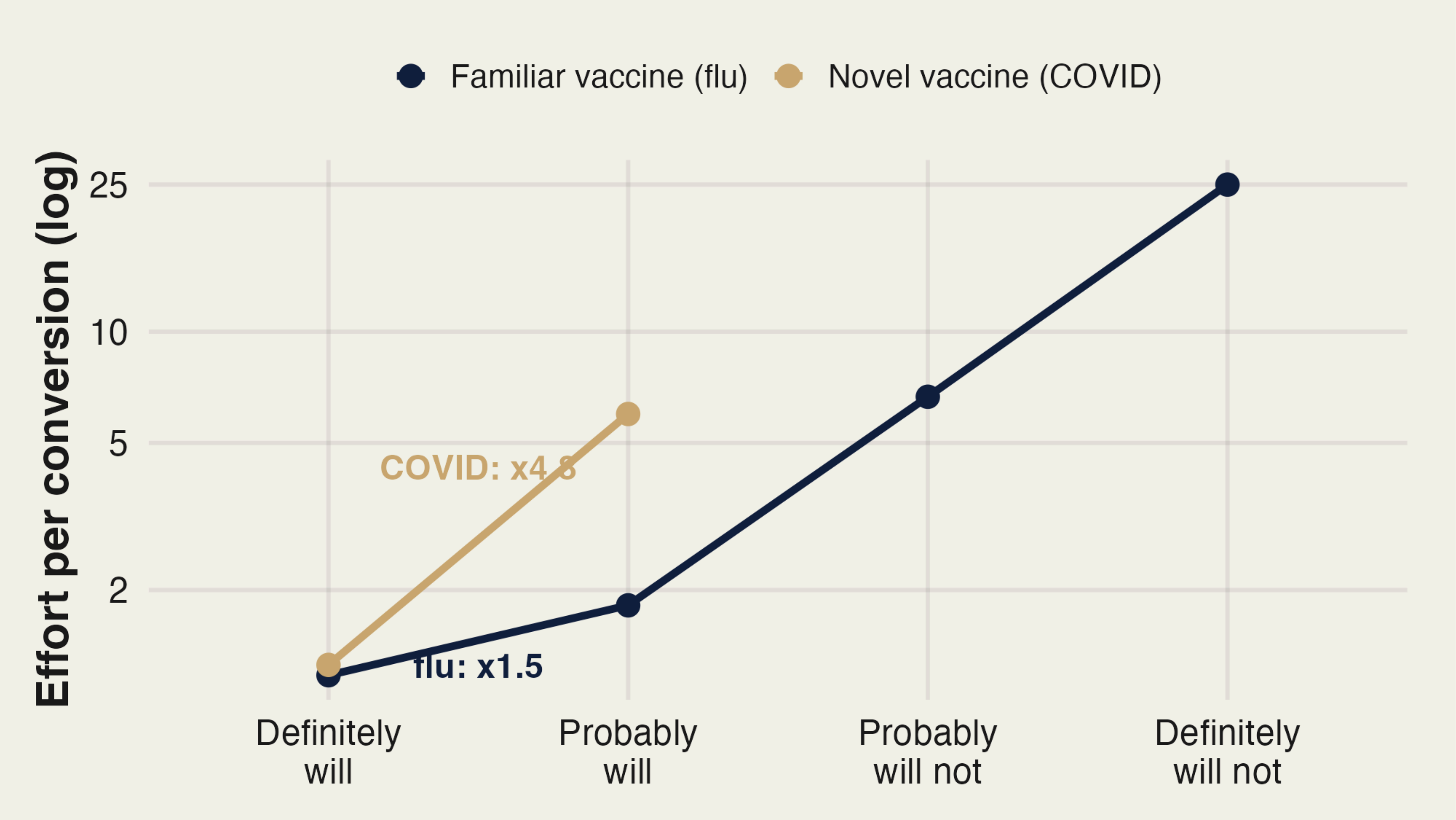
A lasso retains disposition items, distinct from the usual theories





Left: lasso variable importance for stated vaccination intent (overall R^2 = 0.62) — retained predictors draw from all four frameworks, including the Medical Mind disposition items (Q16). Right: survey items mapped to the Health Belief Model, Theory of Planned Behavior, and COM-B, with the Medical Mind items forming a construct of their own. Survey analysis: Anderson et al.

Why the cost of coverage is steeper for a novel vaccine



Implied effort to convert one person (the inverse of the conversion rate), by stated intent, for a familiar (flu) and a novel (COVID) vaccine. Across the willing, cost rises ~1.5x for flu but ~4.8x for COVID; the familiar curve is flat, then jumps — the piecewise shape the model carries.

Full hierarchical regression — 2016

PREDICTOR	CONFIDENCE	HESITANCY	HISTORY	INTENT
Block 1 — Demographics				
Gender (M=1; F=2)	0.04	0.24**	-0.09	-0.15*
Age	0.00	0.00	0.02***	0.02***
Race (Non-Wht=0; Wht=1)	-0.17***	-0.28**	-0.10	-0.16*
Household Income	-0.01	-0.01	0.00	-0.01
Education	-0.01	-0.13***	-0.03	0.00
R^2 (%)	*2.7****	*7.5****	*14.5****	*14.5****
Block 2 — Information				
Perceived Flu Knowledge	0.22***	-0.05	0.23***	0.18***
Healthcare Rec. (Y=1; N=2)	-0.20**	0.27**	-0.58***	-0.55***
Inc. R^2 (%)	*9.4****	*5.6****	*17.1****	*15.6****
Block 3 — Flu Impacts				
Flu Seriousness	0.13**	0.06	0.16***	0.25***
Flu Spread	0.04	-0.14**	0.15***	0.11*
Inc. R^2 (%)	*2.8****	*1.8****	*4.6****	*5.3****
Block 4 — Vaccine Attitudes				
Vaccine Confidence	N.A.	-0.52***	0.23***	0.31***
Vaccine Hesitancy	-0.30***	N.A.	-0.22***	-0.26***
Access Difficulty	0.16**	0.00	-0.01	-0.01
Inc. R^2 (%)	*15.9****	*15.4****	*11.5****	*15.2****
Block 5 — Health Decision-Making Preferences				
Decision-Making Preferences	0.27***	-0.13*	0.13**	0.17***
Inc. R^2 (%)	*3.5****	*0.45**	*0.49***	*0.65****
Total R^2 (%)	**34.3**	**30.8**	**48.2**	**51.2**

Anderson, Nowak, Cacciatore, Rohani & Drake (2025), *Vaccine* 65:127804. OLS hierarchical regression, NORC AmeriSpeak 2016; standardized coefficients, blocks entered in order. *N* = 1001 (Confidence, Intent), 998 (Hesitancy), 978 (History). N.A. = outcome itself enters as a predictor. *p*<0.05, ***p*<0.01,** *p*<0.001.

Full hierarchical regression — 2018

PREDICTOR	CONFIDENCE	HESITANCY	HISTORY	INTENT
Block 1 — Demographics				
Gender (M=1; F=2)	-0.03	0.02	-0.02	0.06
Age	-0.01***	-0.01*	0.01***	0.01***
Race (Non-Wht=0; Wht=1)	-0.11*	-0.22**	-0.03	-0.06
Household Income	0.00	0.00	0.00	0.00
Education	-0.02	-0.04	0.05*	0.04
R^2 (%)	*0.70*	*3.3****	*8.1****	*7.3****
Block 2 — Information				
Perceived Flu Knowledge	0.14**	-0.01	0.19**	0.18**
Healthcare Rec. (Y=1; N=2)	-0.20***	0.11	-0.64***	-0.59***
Inc. R^2 (%)	*9.7****	*6.0****	*16.8****	*15.6****
Block 3 — Flu Impacts				
Flu Seriousness	0.09*	-0.06	0.17***	0.21***
Flu Spread	0.04	-0.07	0.16***	0.16***
Inc. R^2 (%)	*3.6****	*3.2****	*5.4****	*6.3****
Block 4 — Vaccine Attitudes				
Vaccine Confidence	N.A.	-0.73***	0.24***	0.34***
Vaccine Hesitancy	-0.39***	N.A.	-0.24***	-0.32***
Access Difficulty	0.10*	0.02	-0.06	-0.15*
Inc. R^2 (%)	*31.8****	*32.1****	*13.7****	*20.5****
Block 5 — Health Decision-Making Preferences				
Decision-Making Preferences	0.41***	-0.14**	0.00	0.04
Inc. R^2 (%)	*6.6****	*0.4***	*0.0*	*0.0*
Total R^2 (%)	**52.4**	**45.0**	**44.0**	**49.7**

Anderson, Nowak, Cacciatore, Rohani & Drake (2025), *Vaccine* 65:127804. OLS hierarchical regression, NORC AmeriSpeak 2018; standardized coefficients, blocks entered in order. *N* = 1015 (all outcomes). N.A. = outcome itself enters as a predictor. *$p<0.05$*, ***$p<0.01$***, *p*<0.001.