

DEMI ALGORITHM

Direct Effect Estimation

Step 3 of the DEMI Pipeline — Backward Recursive Decomposition

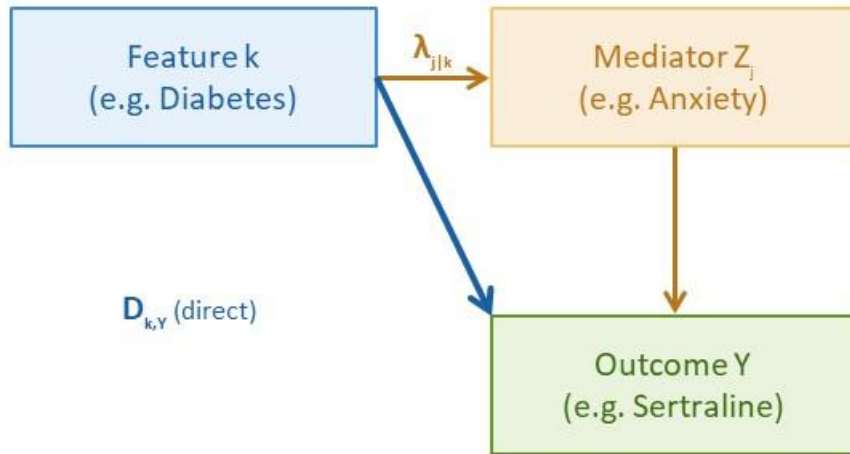


This video covers Step 3 only

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The Core Idea: Total = Direct + Indirect

Causal path diagram



Indirect path: $k \rightarrow Z_j \rightarrow Y$

Direct path: $k \rightarrow Y$ (bypasses Z_j)

The decomposition (Eq. 12)

$$T_{kY} = D_{kY} + I_{kY}$$

Total = Direct + Indirect

$D_{j,Y}$

T_{kY} : computed in Step 2 (log OR)

D_{kY} : what we solve for in Step 3

I_{kY} : mediated through downstream variables

3 Measuring the Indirect Path: Excess Probability

The indirect effect of Z_k (Eq. 13)

$$I_{kY} = \sum_{j \text{ downstream of } k \text{ (within same sign group)}} (\lambda_{j|k} - p_j) \times D_{j,Y}$$

where $\lambda_{j|k} = P(Z_j=1 \mid Z_k=1)$ and $p_j = P(Z_j=1)$

$\lambda_{j|k}$ (conditional probability)

p_j (marginal prevalence)

$\lambda_{j|k} - p_j$ (excess probability)

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Separating Risk-Increasing and Risk-Reducing Features

Recursion runs separately within K^+ and K^- . Cross-group mediation is assumed negligible.

K^+ — Risk-increasing

$$T_{k,Y} > 0 \quad (\text{OR} > 1)$$

Direct effect formula:

$$D_{k,Y} = \max(0, T_{k,Y} - I_{k,Y})$$

Floor at zero — direct effect cannot be negative for a risk-increasing feature.

K^- — Risk-reducing

$$T_{k,Y} < 0 \quad (\text{OR} < 1)$$

Direct effect formula:

$$D_{k,Y} = \min(0, T_{k,Y} - I_{k,Y})$$

Ceiling at zero — direct effect cannot be positive for a risk-reducing feature.

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The Backward Recursion: Step by Step

Working backward from last to first feature in temporal order

1 Assign last feature

$$D(\text{last}) = T(\text{last})$$

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$$D(\text{last}) = T(\text{last})$$

2 Move one step earlier

$$I = \sum (\lambda_{j|k} - p_j) \times D_{j,Y}$$

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Working backward from last to first feature in temporal order

1 Assign last feature

$$D(\text{last}) = T(\text{last})$$

2 Move one step earlier

$$I = \sum (\lambda_{j|k} - p_j) \times D_{j,Y}$$

3 Solve for direct effect

$$D_{k,Y} = \max(0, T_{k,Y} - I) \text{ for } K^+$$

$$D_{k,Y} = \min(0, T_{k,Y} - I) \text{ for } K^-$$

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$$D(\text{last}) = T(\text{last})$$

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$$I = \sum (\lambda_{j|k} - p_j) \times D_{j,Y}$$

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$$D_{k,Y} = \max(0, T_{k,Y} - I) \text{ for } K^+$$

$$D_{k,Y} = \min(0, T_{k,Y} - I) \text{ for } K^-$$

4 Go to Step 2

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Worked Example: Setup

Predicting sertraline response — 4 features in K^+

Feature	Temporal Order	Total Effect	OR
Diabetes	1st (earliest)	0.85	2.34
Anxiety	2nd	0.62	1.86
Prior SSRI use	3rd	0.44	1.55
Depression	4th (latest)	0.30	1.35

$$\lambda(Z_2 | Z_1) = 0.60 \quad p(Z_2) = 0.30 \quad \rightarrow \quad \text{excess} = 0.30$$

$$\lambda(Z_3 | Z_1) = 0.50 \quad p(Z_3) = 0.20 \quad \rightarrow \quad \text{excess} = 0.30$$

$$\lambda(Z_3 | Z_2) = 0.55 \quad p(Z_3) = 0.20 \quad \rightarrow \quad \text{excess} = 0.35$$

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Results: Direct vs Total Effects

Feature	Total Effect	Indirect	Direct Effect	% Mediated
Depression	0.30	0.00	0.30	0%

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Results: Direct vs Total Effects

Feature	Total Effect	Indirect	Direct Effect	% Mediated
Depression	0.30	0.00	0.30	0%
Prior SSRI use	0.44	0.045	0.395	10%

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Results: Direct vs Total Effects

Feature	Total Effect	Indirect	Direct Effect	% Mediated
Depression	0.30	0.00	0.30	0%
Prior SSRI use	0.44	0.045	0.395	10%
Anxiety	0.62	0.183	0.437	30%

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Results: Direct vs Total Effects

Feature	Total Effect	Indirect	Direct Effect	% Mediated
Depression	0.30	0.00	0.30	0%
Prior SSRI use	0.44	0.045	0.395	10%
Anxiety	0.62	0.183	0.437	30%
Diabetes	0.85	0.280	0.570	33%

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Results: Direct vs Total Effects

Feature	Direct Effect
Depression	0.30
Prior SSRI use	0.395
Anxiety	0.437
Diabetes	0.570