UiO : Universitetet i Oslo

Directed Acyclic Graphs- solutions to exercises

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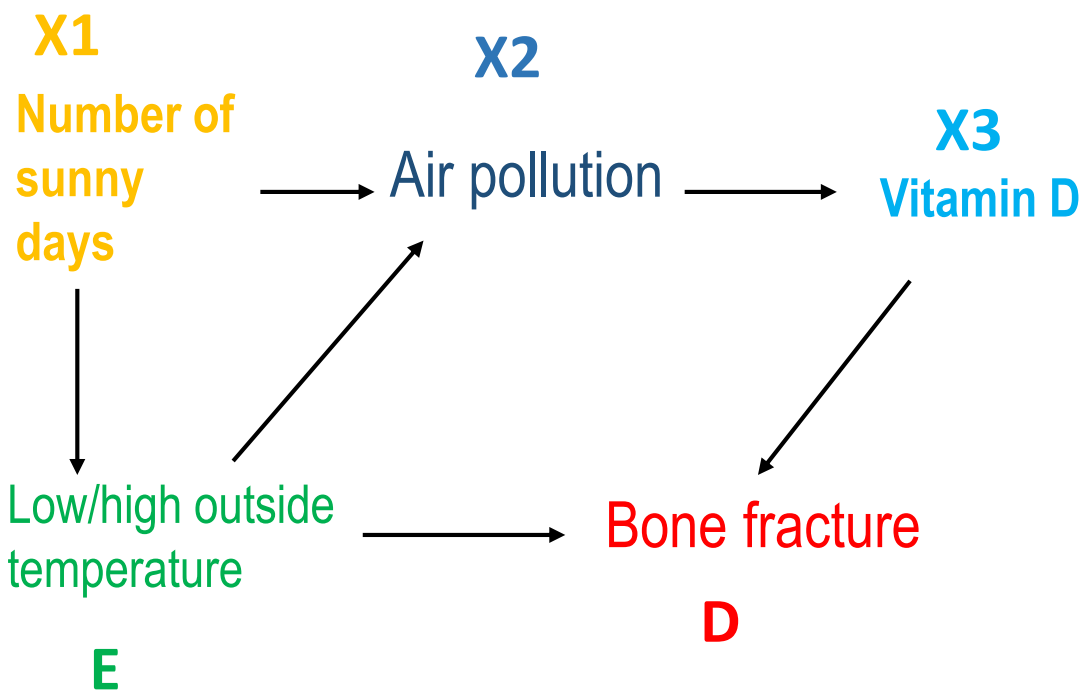
Exercise 1a: Temperature and the risk of bone fracture in older adults



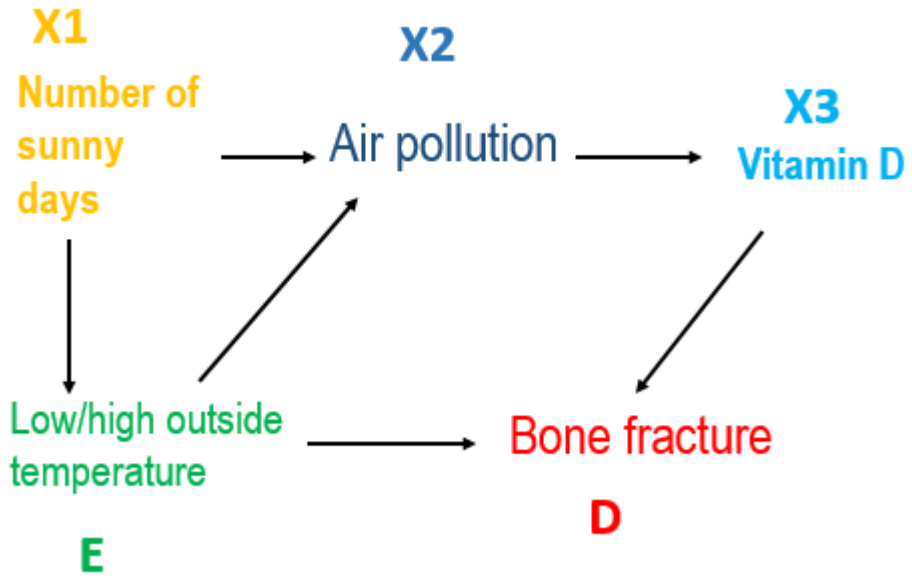
Low temperature= Mean yearly temp<10°C
High temperature=Mean yearly temp >10°C

1. Write down the paths
2. Are they causal/non-causal, open, closed?

3. How would you get the
   a) total effect
   b) direct effect

Solution 1a: Temperature and the risk of bone fracture in older adults

3.

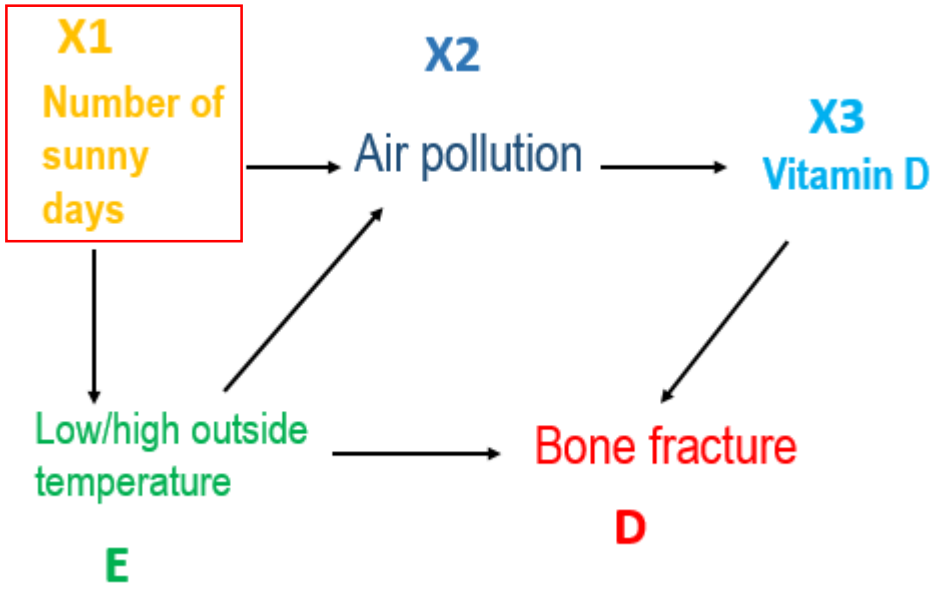


Path	Causal/non-causal	Open/closed
E ⟶ D	Causal	Open
E ⟶ X2 ⟶ X3 ⟶ D	Causal (indirect)	Open
E ⟵ X1 ⟶ X2 ⟶ X3 ⟶ D	Non-causal	Open

Solution 1a: Temperature and the risk of bone fracture in older adults

3.

a) Total effect: Adjust for X1



Path	Causal/non-causal	Open/closed
E ⟶ D	Causal	Open
E ⟶ X2 ⟶ X3 ⟶ D	Causal (indirect)	Open
E ⟵ [X1] ⟶ X2 ⟶ X3 ⟶ D	Non-causal	Closed

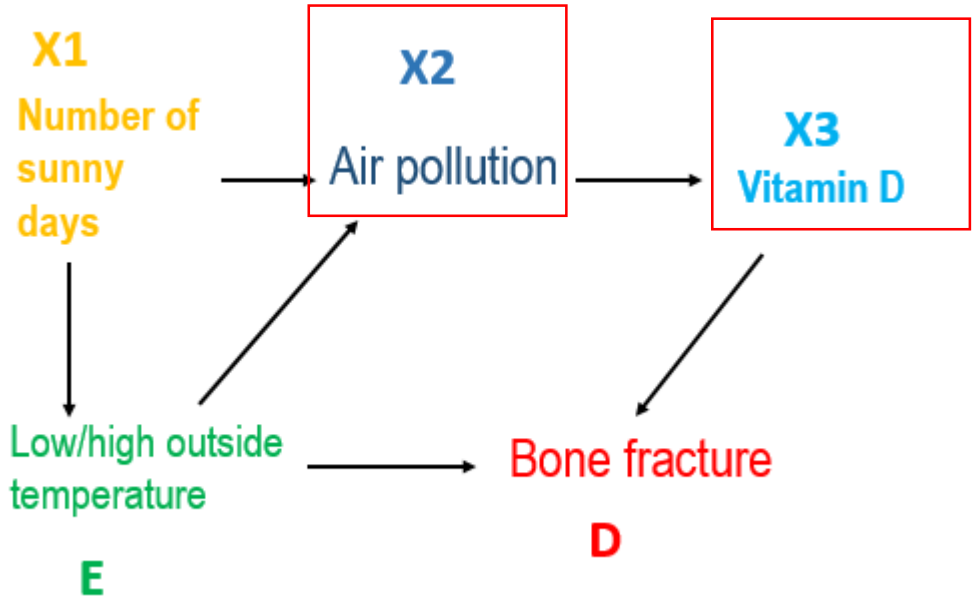
Solution 1a: Temperature and the risk of bone fracture in older adults

3.

a) Total effect: Adjust for X1

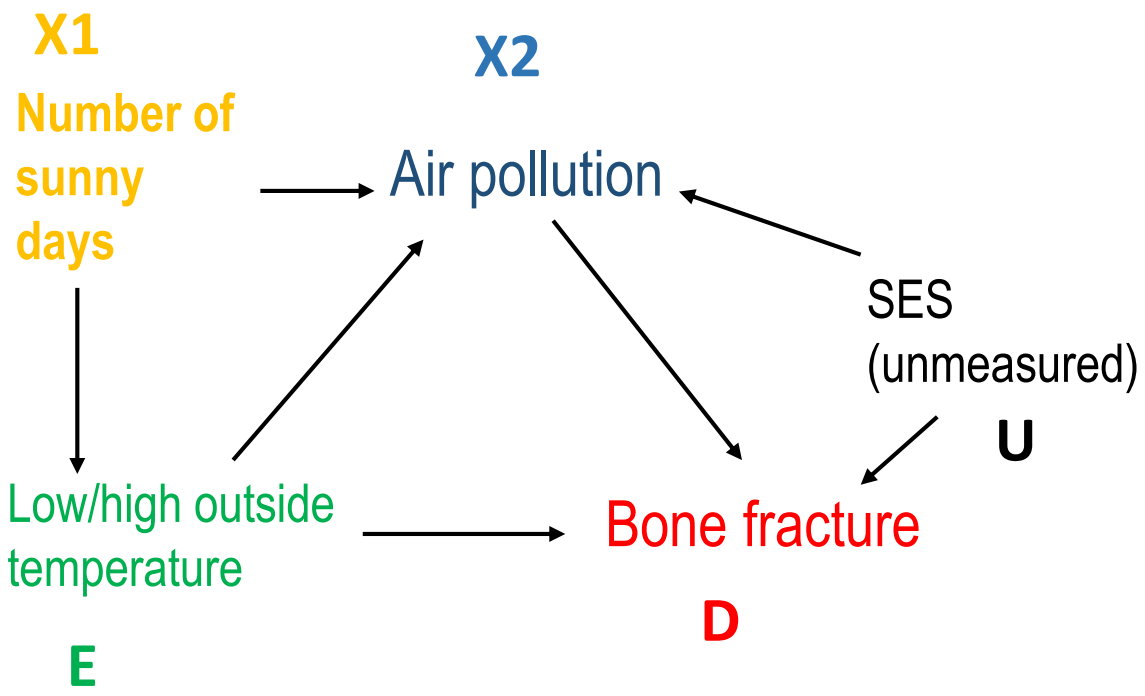
b) Direct effect: adjust for **X2** or **X3**

Also X1??



Path	Causal/non-causal	Open/closed
E ⟶ D	Causal	Open
E ⟶ [X2] ⟶ X3 ⟶ D	Causal (indirect)	Closed
E ⟵ X1 ⟶ [X2] ⟶ X3 ⟶ D	Non-causal	Closed

Exercise 1b: Temperature and the risk of bone fracture in older adults



Low temperature= Mean yearly temp<10°C
High temperature=Mean yearly temp >10°C

1. Write down the paths
2. Are they causal/non-causal, open, closed?

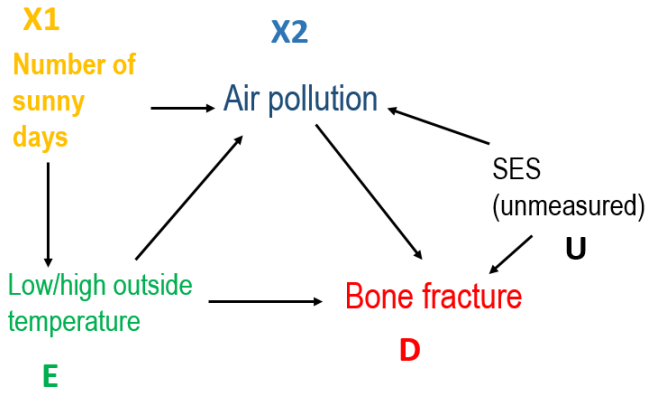
3. How would you get the
    1. total effect
    2. direct effect

Solution 1b: Temperature and the risk of bone fracture in older adults

3.

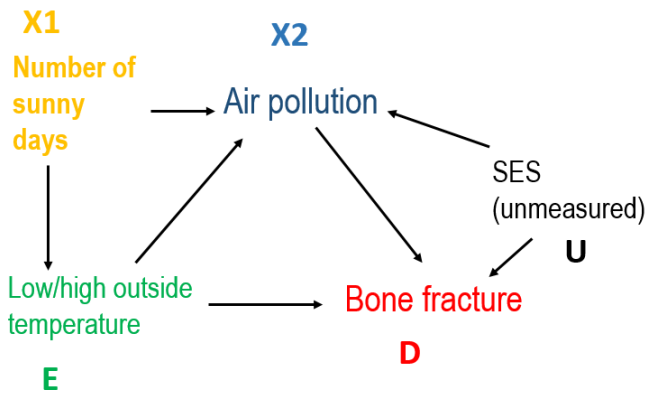
a)

b)



Path	Causal/non-causal	Open/closed
E ⟶ D	Causal	Open
E ⟶ X2 ⟶ D	Causal (indirect)	Open
E ⟶ X2 ⟵ U ⟶ D	Non-causal	Closed (Collider)
E ⟵ X1 ⟶ X2 ⟶ D	Non-causal	Open
E ⟵ X1 ⟶ X2 ⟵ U ⟶ D	Non-causal	Closed (Collider)

Solution 1b: Temperature and the risk of bone fracture in older adults



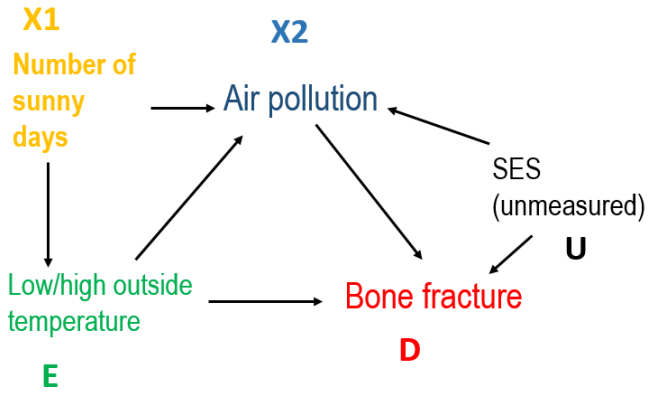
3.

a)Total effect: Adjust for **X1**

b) Direct effect:

Path	Causal/non-causal	Open/closed
E ⟶ D	Causal	Open
E ⟶ X2 ⟶ D	Causal (indirect)	Open
E ⟶ X2 ⟵ U ⟶ D	Non-causal	Closed
E ⟵ [X1] ⟶ X2 ⟶ D	Non-causal	Closed
E ⟵ [X1] ⟶ X2 ⟵ U ⟶ D	Non-causal	Closed

Solution 1b: Temperature and the risk of bone fracture in older adults



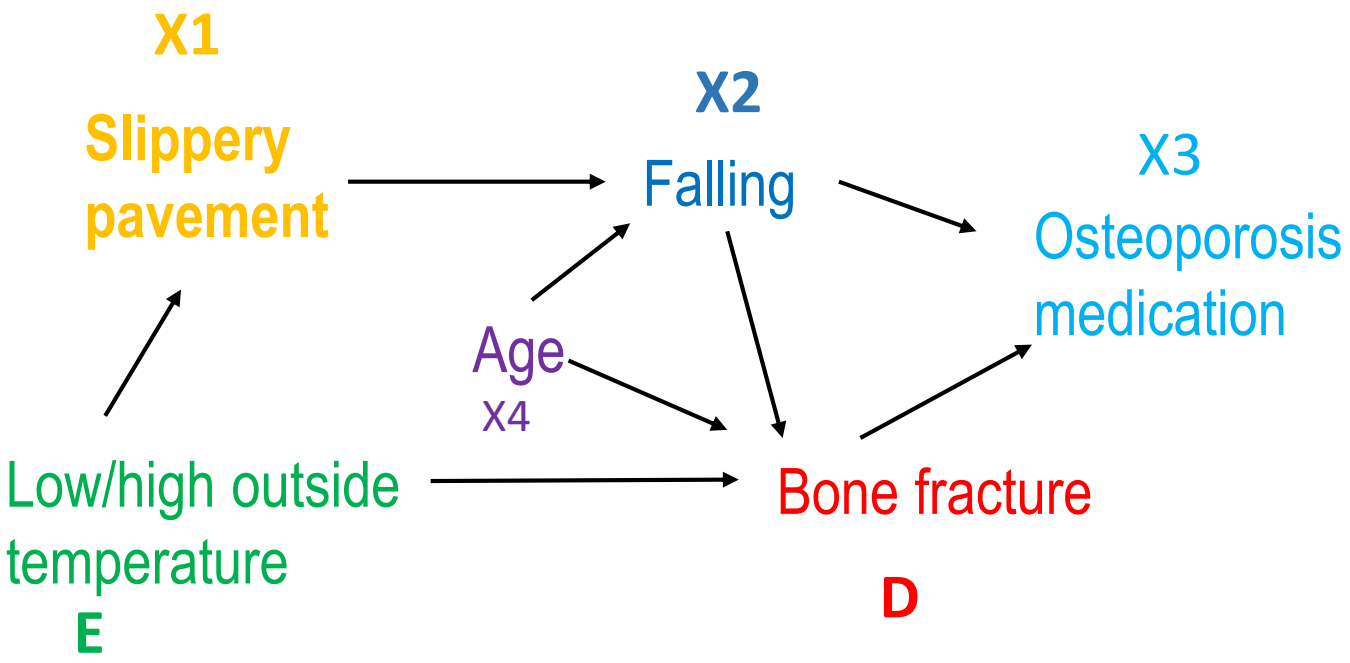
3.

a)Total effect: Adjust for **X1**

b) Direct effect: not possible

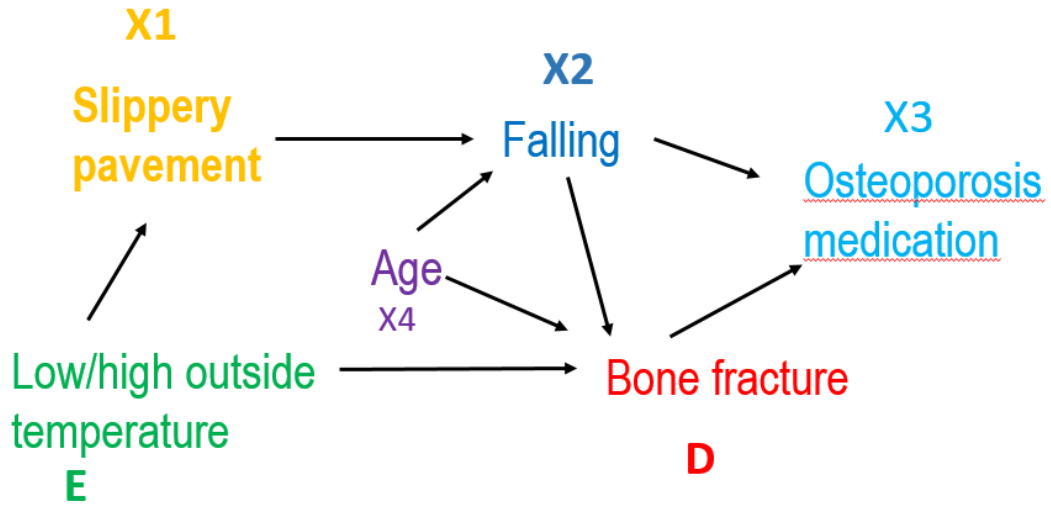
Path	Causal/non-causal	Open/closed
E ⟶ D	Causal	Open
E ⟶ [X2] ⟶ D	Causal (indirect)	Open
E ⟶ [X2] ⟵ U ⟶ D	Non-causal	**Open** BIAS!
E ⟵ [X1] ⟶ [X2] ⟶ D	Non-causal	Closed
E ⟵ [X1] ⟶ [X2] ⟵ U ⟶ D	Non-causal	Closed (confounder adjustment)

Exercise 2. Temperature and the risk of bone fracture in older adults



1. Write down all the paths
2. Are they open or closed, causal or non-causal?
3. How would you get the total effect of Outside temperature on Bone fracture?
4. Optional: How would you get the direct effect ?

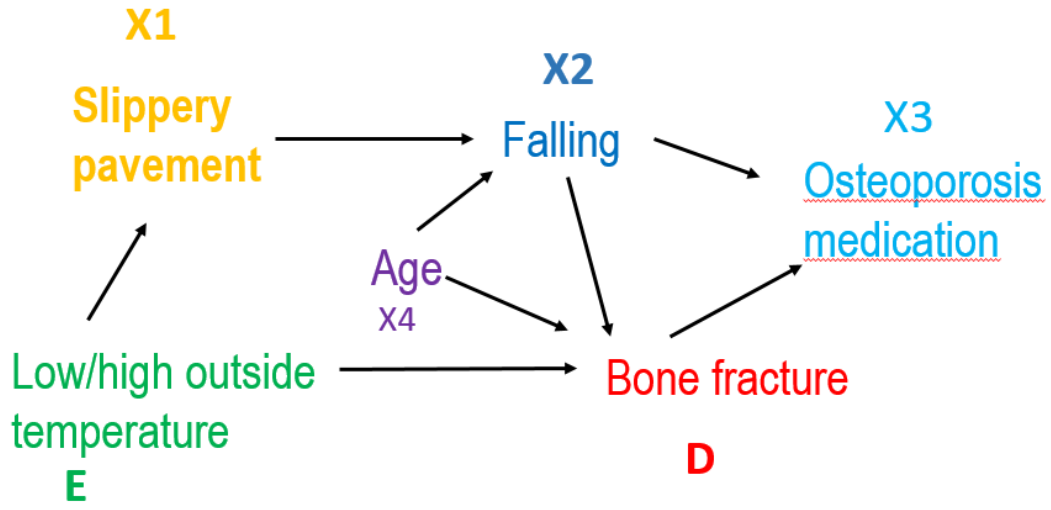
Solution 2. Temperature and the risk of bone fracture in older adults



3. Total effect: No adjustment necessary

Path	Causal/non-causal	Open/closed
E → D	Causal	Open
E → X1 → X2 → D	Causal	Open
E → X1 → X2 → X3 ← D	Non-causal	Closed
E → X1 → X2 ← X4 → D	Non-causal	Closed

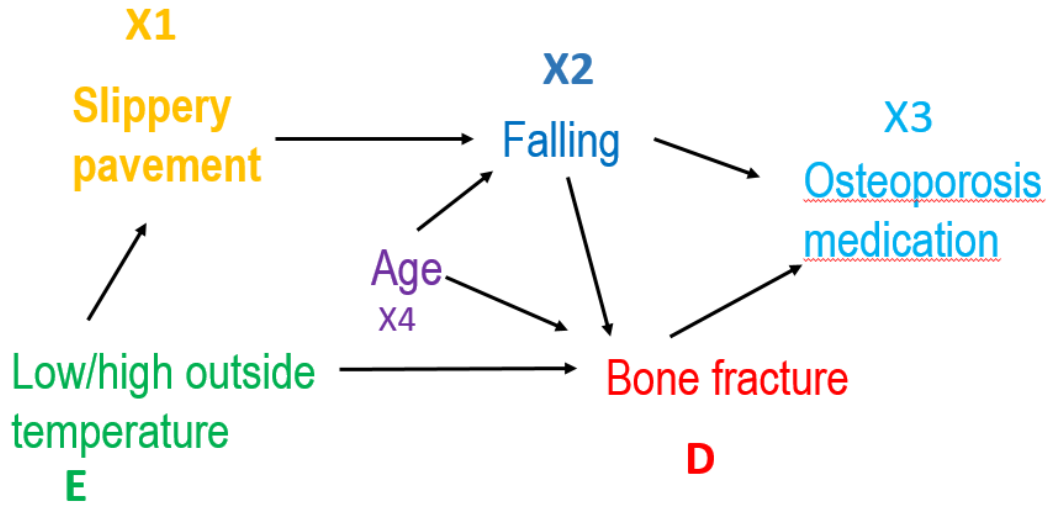
Solution 2. Temperature and the risk of bone fracture in older adults



3. Total effect: No adjustment necessary
4. Direct effect (optional): Adjust for X1 **or** for X2 and X4

Path	Causal/non-causal	Open/closed
E → D	Causal	Open
E → [X1] → X2 → D	Causal	Closed
E → [X1] → X2 → X3 ← D	Non-causal	Closed
E → [X1] → X2 ← X4 → D	Non-causal	Closed

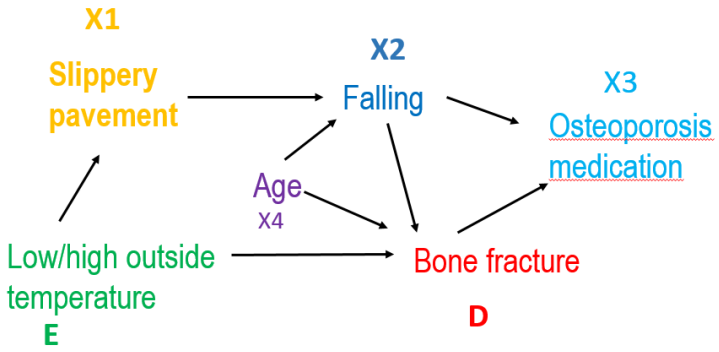
Solution 2. Temperature and the risk of bone fracture in older adults



3. Total effect: No adjustment necessary
4. Direct effect (optional): Adjust for X1 **or** for X2 and X4

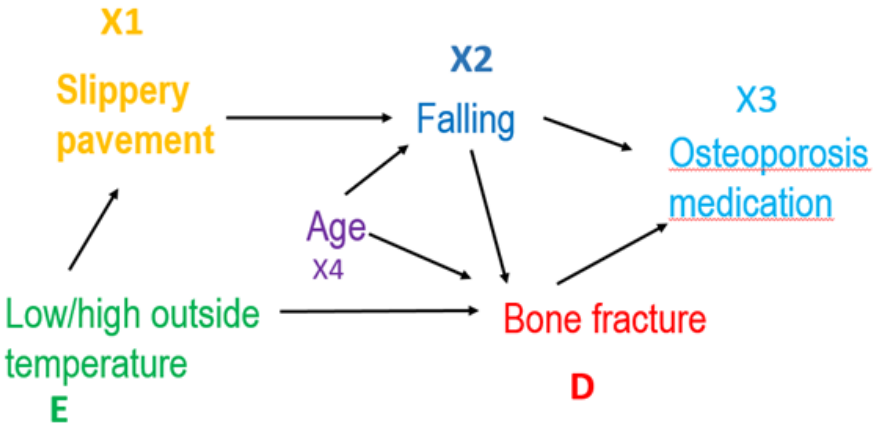
Path	Causal/non-causal	Open/closed
E → D	Causal	Open
E → X1 → [X2] → D	Causal	Closed
E → X1 → [X2] → X3 ← D	Non-causal	Closed
E → X1 → [X2] ← [X4] → D	Non-causal	Closed

Hypothetical analysis

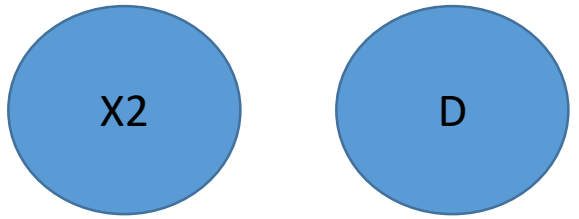


	Bone fracture				
	Yes	No	Total personyears	Rate	RD
Low outside temperature	84	9,916	10,000	0.0084	0.0
High outside temperature	84	9,916	10,000	0.0084	

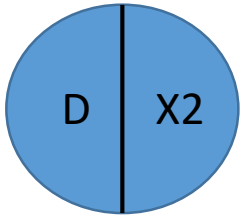
Sufficient causes for osteoporosis medication



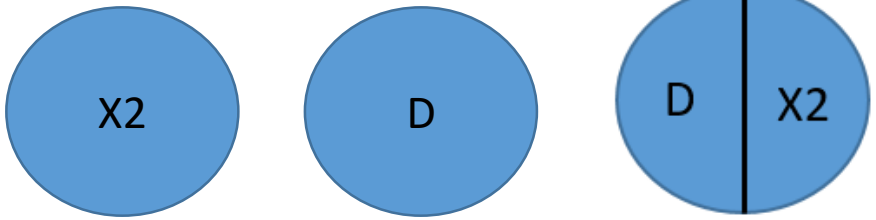
(Assuming that the effect of age on falling is small, and that there are no other causes of bone fractur)



Fall (as a result of low temperature) or bone fracture

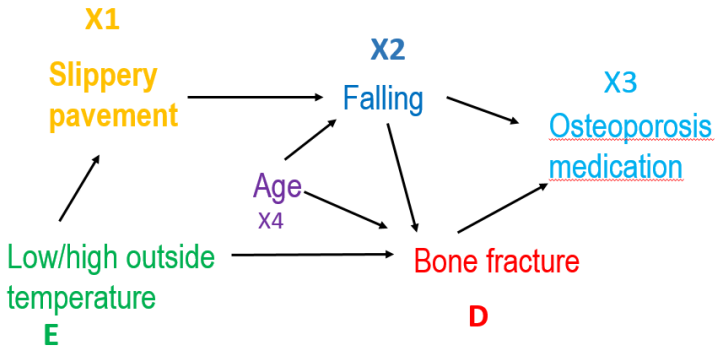


Fall and bone fracture



Fall or bone fracture and fall or bone fracture

Hypothetical analysis -restricting on X3



	Bone fracture				
	Yes	No	Total personyears	Rate	RD
Low outside temperature	84	9,916	10,000	0.0084	0.0
High outside temperature	84	9,916	10,000	0.0084	
Condition on X3 (medication use can only be due to falling as a result of slippery pavement from low outside temperature, or having experienced a bone fracture)					
Medication=yes					
Low outside temperature	84	9,916	10,000	0.0084	-0.99
High outside temperature	84	**0**	84	1.0	