



# Path Models

A Quantitative Methods Consulting Center Workshop



Mary Frances Early  
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# Quantitative Methods Consulting Center (QMC)

- QMC purpose is to provide quantitative research support and training for members of the MFECOE
- QMC Team



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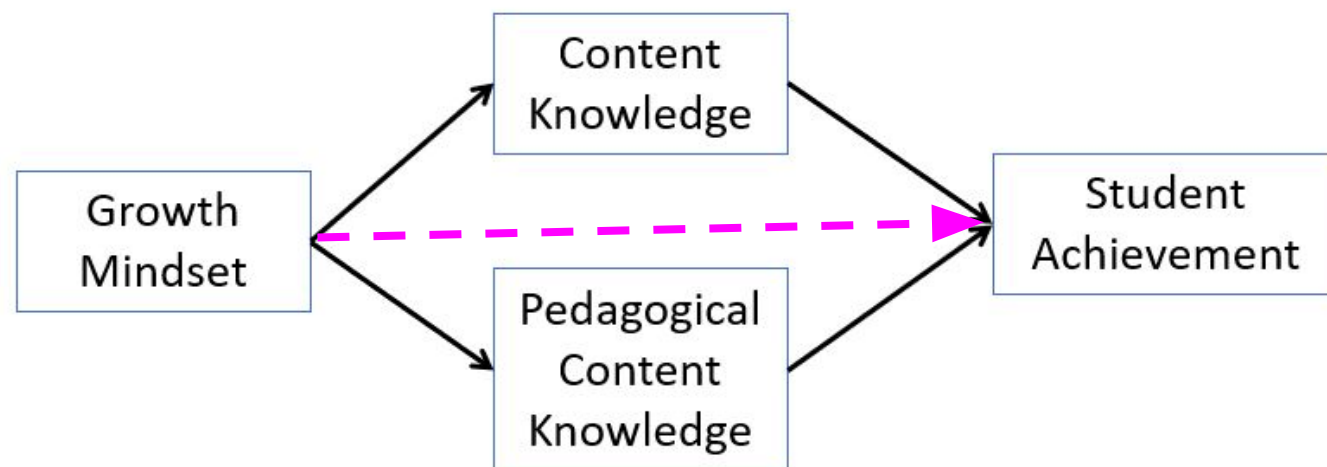
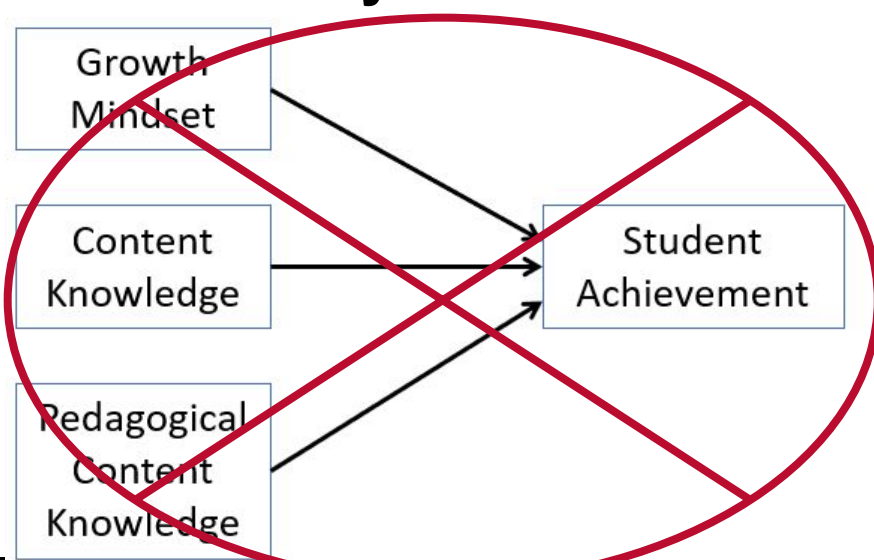
Ph.D. Student in  
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Methodology,  
QMC Research  
Assistant



# QMC Fall Methods Workshop Series

- “Basics of Measurement Modeling”
  - Introduction to *structural equation modeling* (SEM)
  - Slides and materials available at [matthewmadison.com/workshop](https://matthewmadison.com/workshop)
- SEM is comprised of two foundational methods:

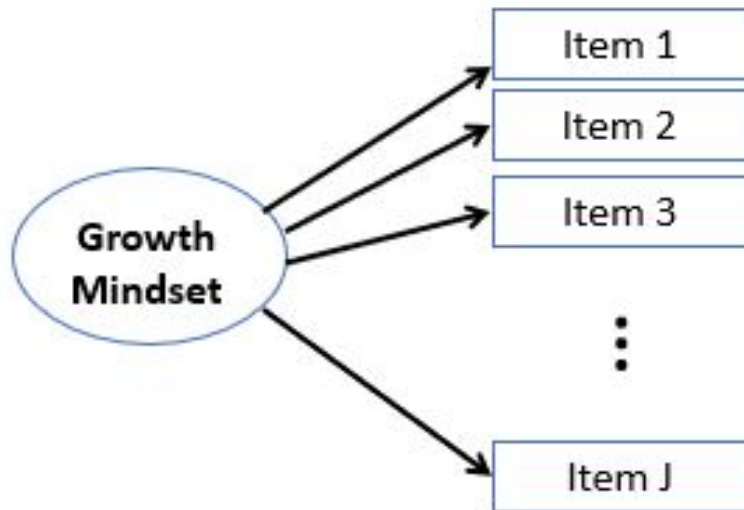
## 1. Path analysis



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## 2. Confirmatory Factor Analysis (CFA)

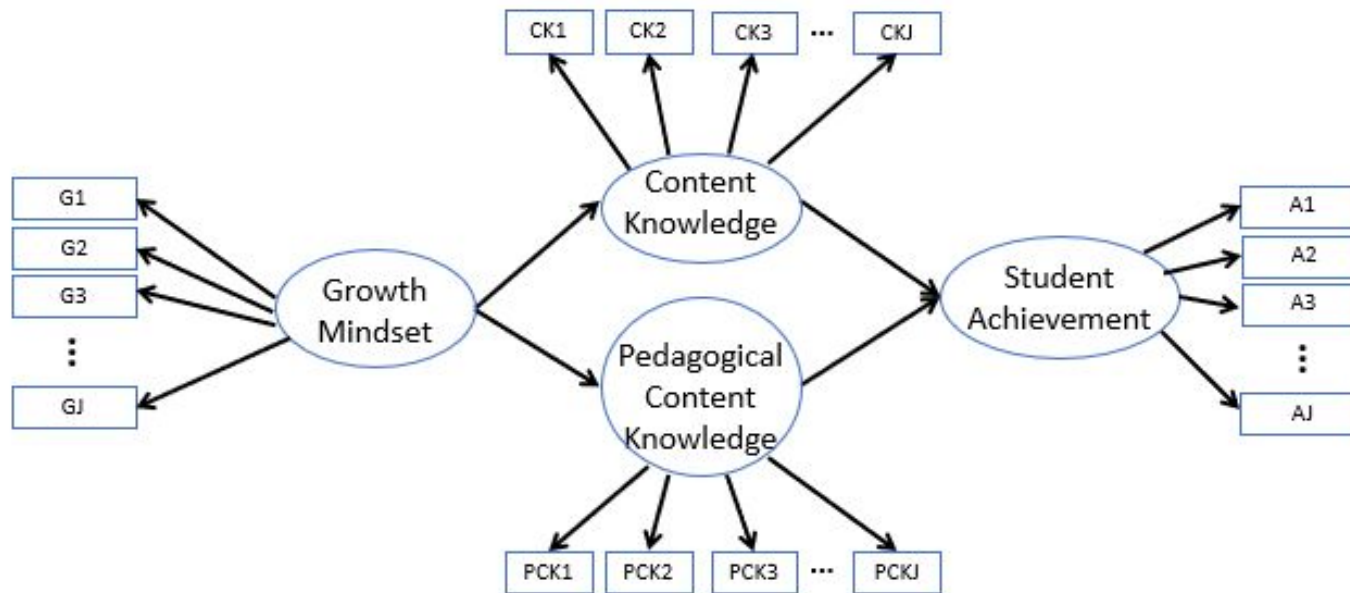


- **Benefits of CFA**
  - Properly model latent variables
  - Assess instrument reliability
  - Assess item quality

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## 3. SEM = path analysis + CFA



- **Benefits of SEM**
  - Model complex relationships, test nuanced theories
  - Handle measurement error appropriately
  - Improved power and inferential accuracy
  - SEM is foundational for many other methods and techniques



# Path Models

A Quantitative Methods Consulting Center Workshop

*Ashley Heady, EdM Measurement & Evaluation*



Mary Frances Early  
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# About Me - Ashley Heady

- BS Supply Chain, Information, & Analytics
- MEd Measurement & Evaluation
- 1st year PhD in Quantitative Methodology
- Hobbies - card games, conspiracy theories, & cooking



# Agenda

1. Brief Review of Multiple Regression
2. Overview of Path Models
3. Building a Path Model
4. Estimating Path Models using R
  - a. Evaluating & tuning model fit
5. Resources & Extras



# Data Example

2014 live birth data from the CDC

1000 observations

11 variables, 5 binary variables

- Fathers age
- Mothers age
- Weeks of pregnancy
- Premature birth status (B)
- Doctor visits during pregnancy
- Weight gained during pregnancy
- Birthweight of the baby
- Baby's sex (B)
- Mothers smoking status (B)
- Mothers marital status (B)
- Mothers race (B)

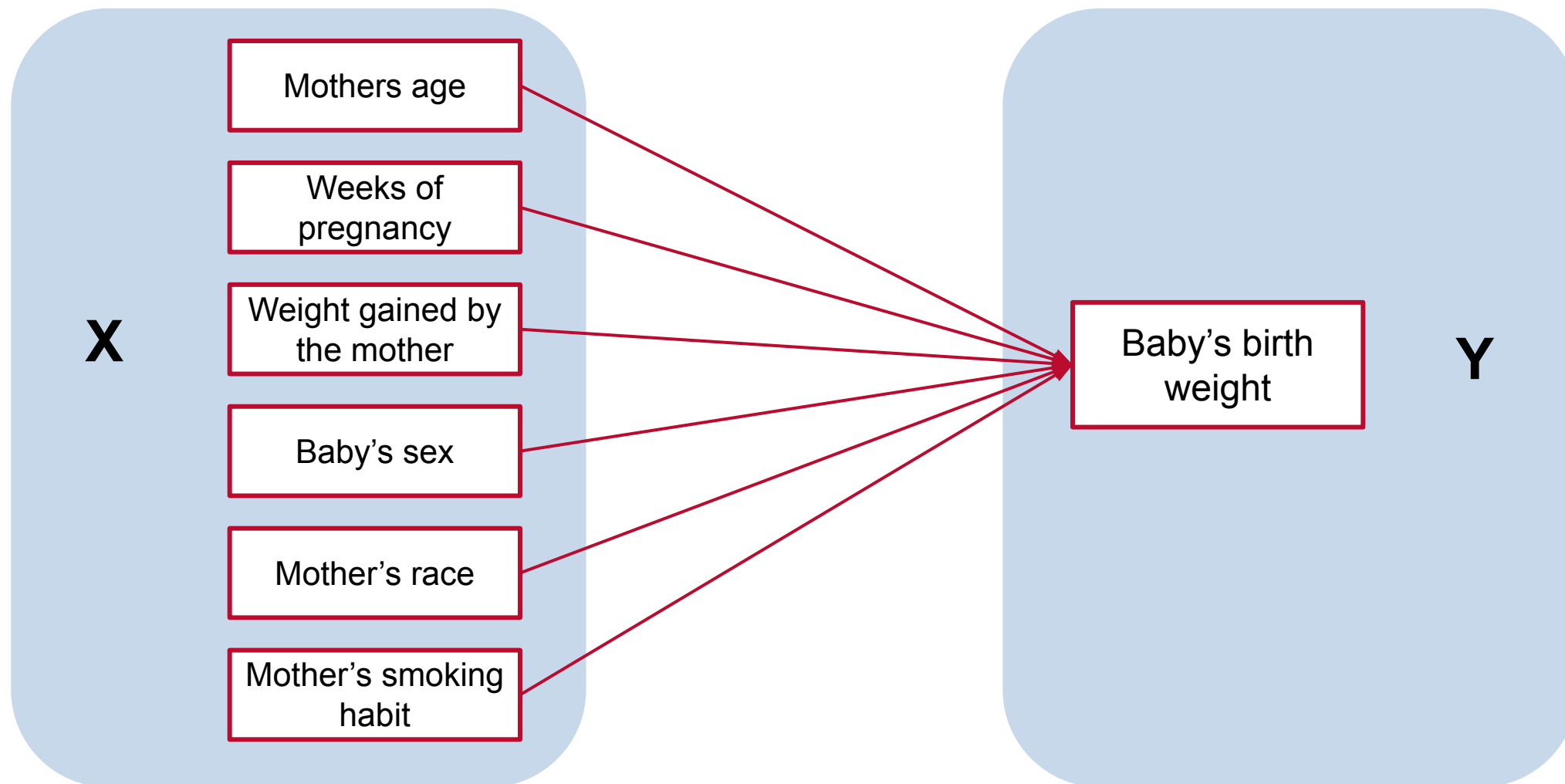


# Multiple Regression

$$\begin{aligned} \text{Baby's birth weight} = & \alpha + \beta_1 \text{ mothers age} + \beta_2 \text{ weeks of pregnancy} \\ & + \beta_3 \text{ weight gained by the mother} \\ & + \beta_4 \text{ baby's sex} + \beta_5 \text{ mothers race} \\ & + \beta_6 \text{ smoking habit} + \varepsilon \end{aligned}$$

# Multiple Regression

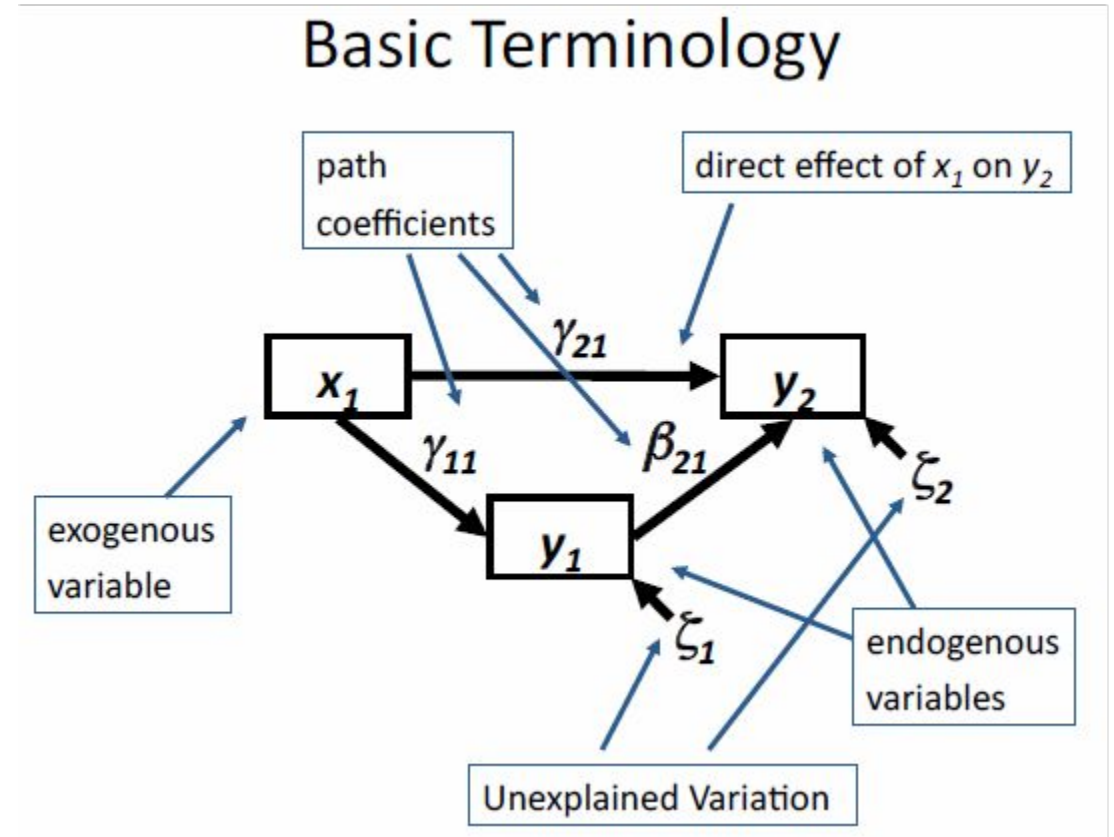
R-squared = 0.33



# The Basics of Path Analysis

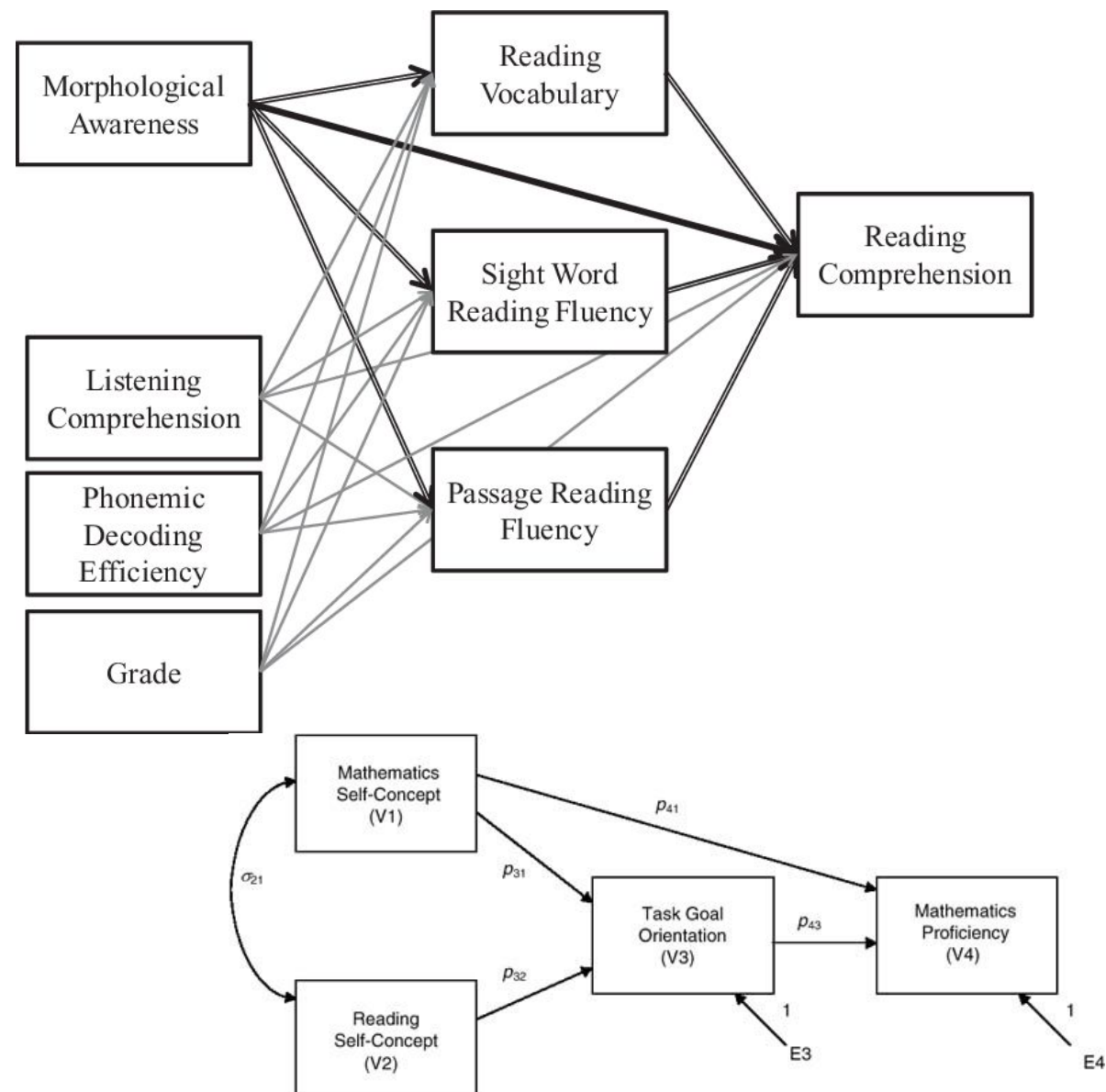
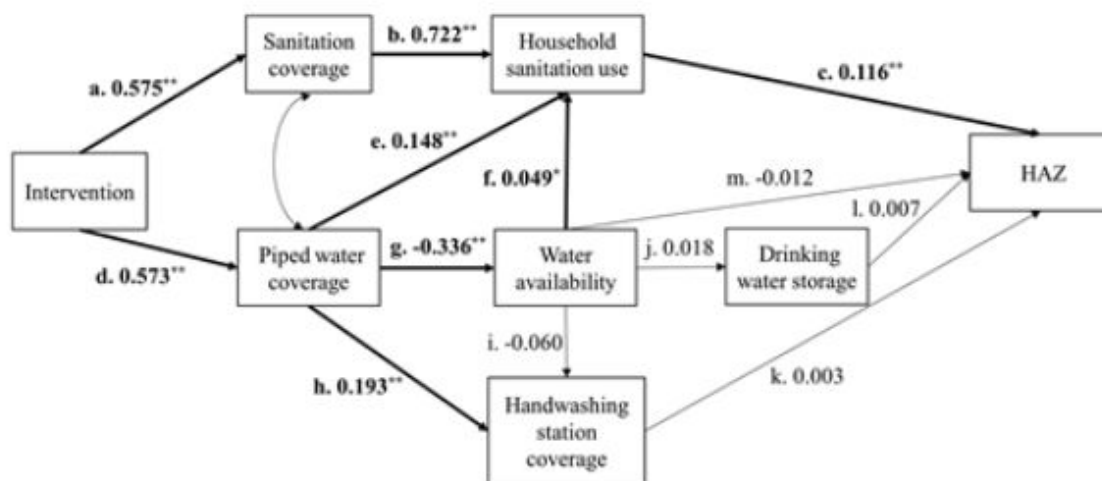
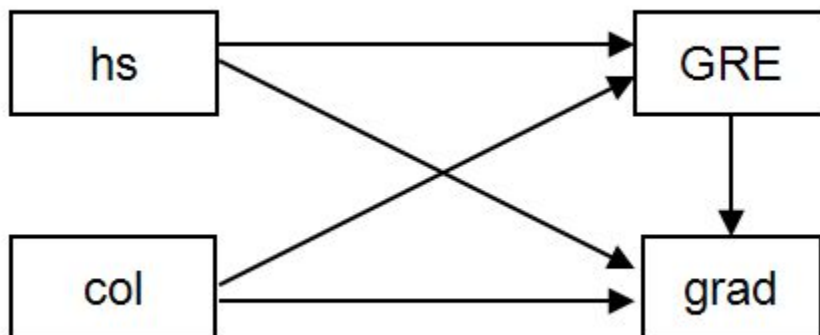
## *Why do path analysis?*

- More complex models than multiple regression
  - Y's can predict Y's
- Ability to compare models to find the best fit
- Ability to refine a theorized model
- Understanding path analysis helps understand structural equation modeling (SEM)!



\*Streiner, D. L. (2005). Finding Our Way: An Introduction to Path Analysis. The Canadian Journal of Psychiatry, 50(2), 115–122.  
<https://doi.org/10.1177/070674370505000207>

# Path Model Examples

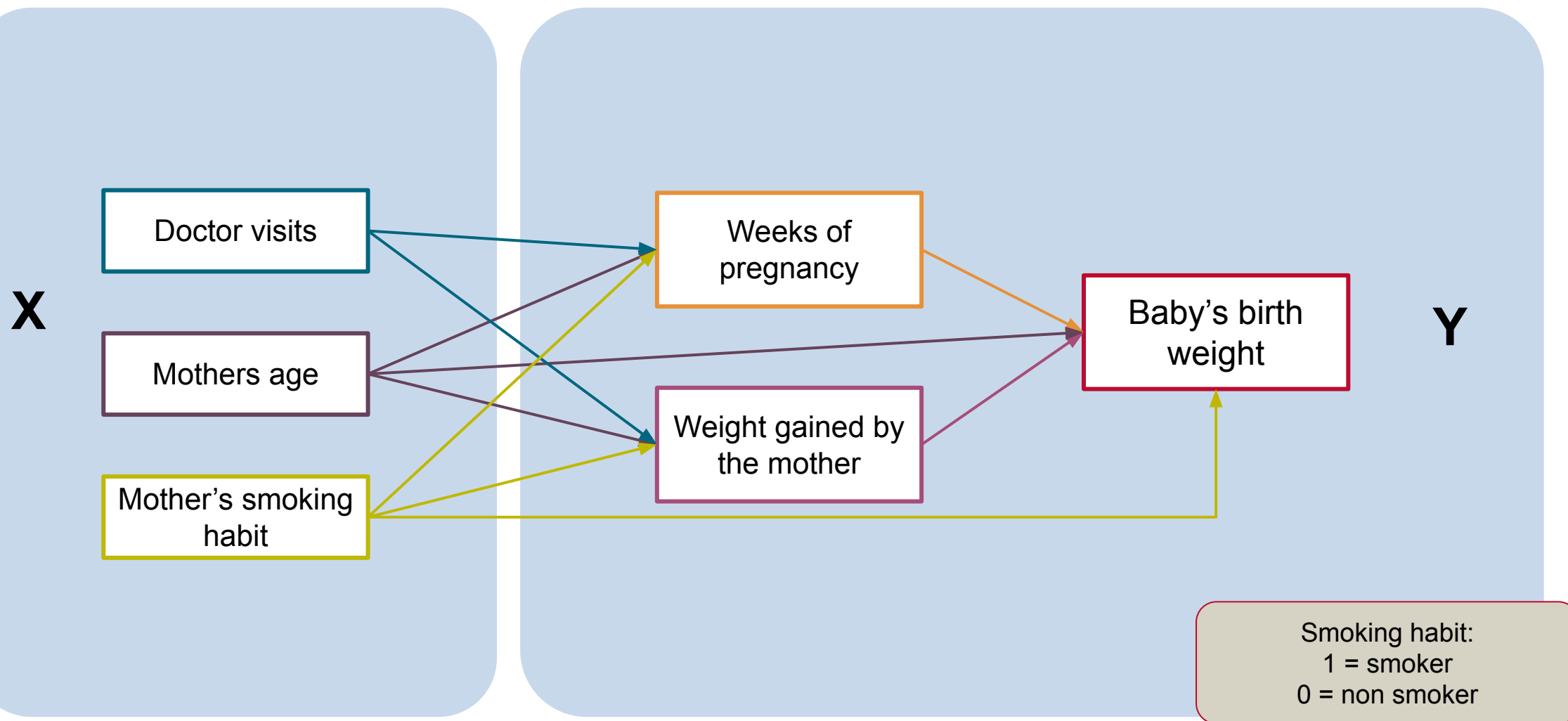


# So what are we doing?

- > We're assuming there's an underlying model and relationship between the variables and we're trying to draw that out
- > Those relationships are expressed in covariances between our observations



# Path Model



# Writing up the path analysis equations

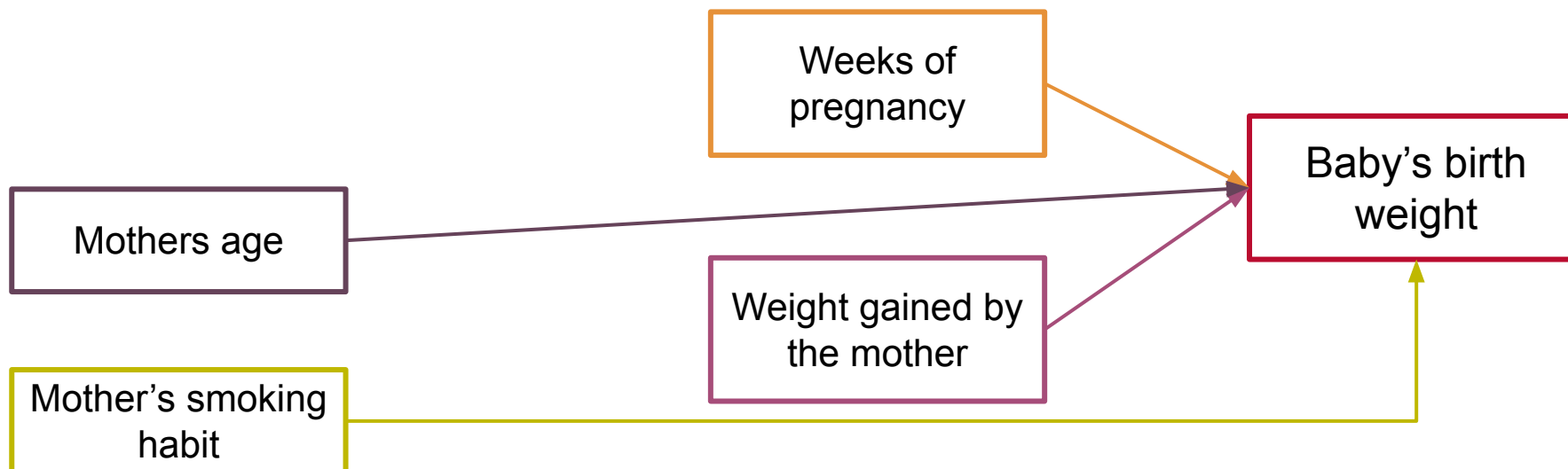
- Baby's birth weight = weeks of pregnancy + weight gained + smoking habit + mothers age
- Mothers weight gain = smoking habit + mothers age + doctor visits
- Weeks of pregnancy = smoking habit + mothers age + doctor visits

Smoking habit:  
1 = smoker  
0 = non smoker



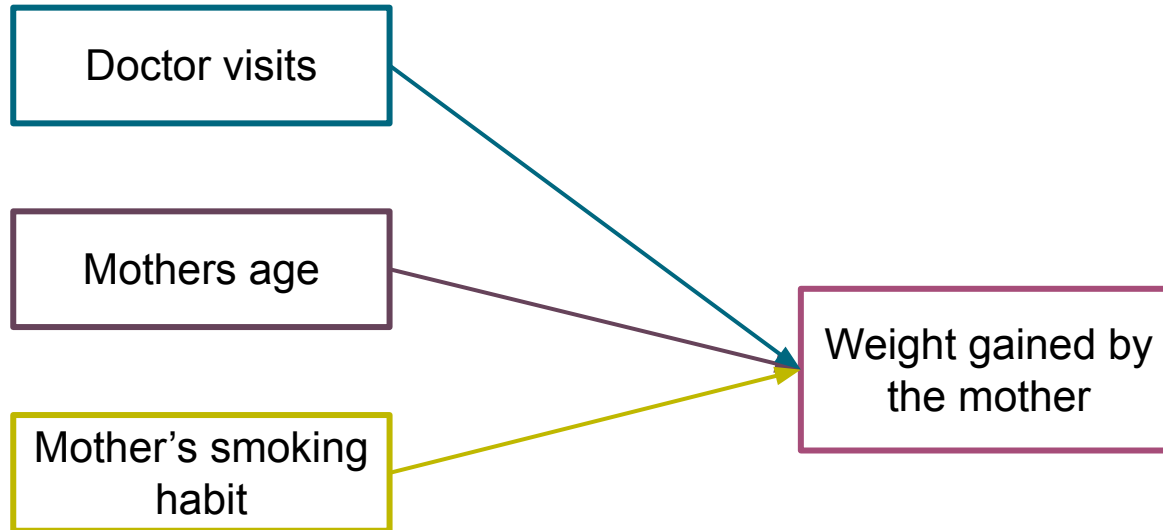
# Path Model - Baby's birth weight equation

Baby's birth weight = weeks of pregnancy + weight gained  
+ smoking habit + mothers age



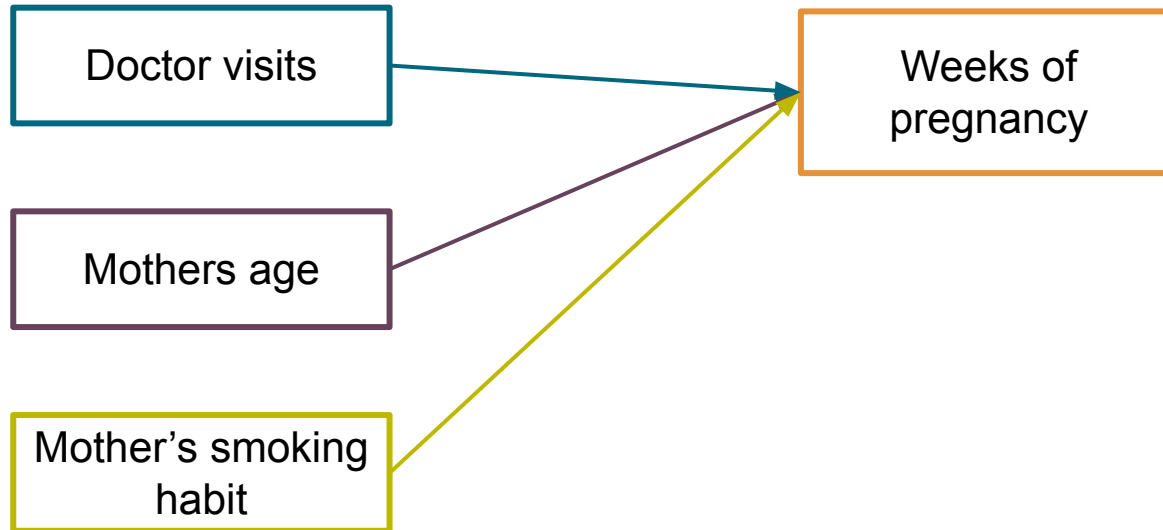
# Path Model - Mothers weight gain equation

Mothers weight gain = smoking habit + mothers age + doctor visits



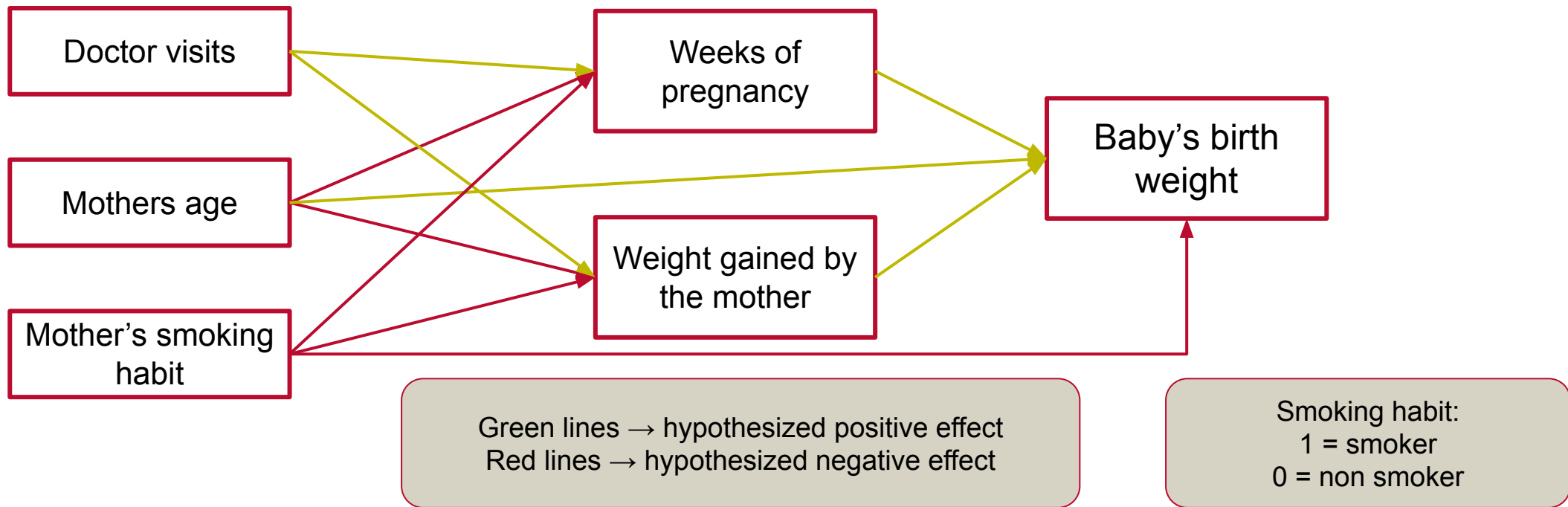
# Path Model - Weeks of pregnancy equation

Weeks of pregnancy = smoking habit + mothers age + doctor visits



# Before we run the model

- Make some assumptions about how the relationships might work
- Remember any relationships you don't estimate are automatically set to zero
  - Meaning no direct effect!



# Estimating Path Models in R

# Estimating Path Models in R



**Install lavaan & open the library**



**Define the relationships**



**Run the model**



**Evaluate the fit**



# The Code

```
install.packages(lavaan); library(lavaan)
```

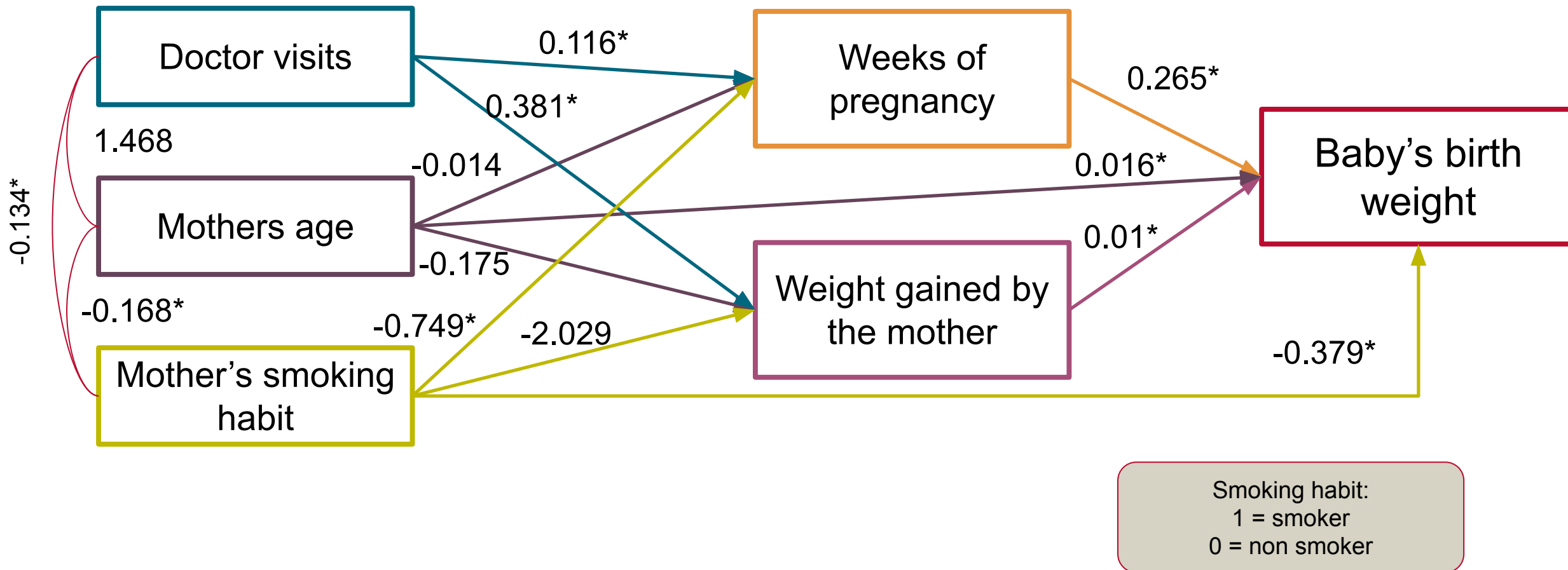
```
model_path <- '  
  weight ~ weeks + gained + habit_nonsmoker + mage  
  gained ~ habit_nonsmoker + mage + visits  
  weeks ~ habit_nonsmoker + mage + visits  
  
  visits ~~ mage  
  visits ~~ habit_nonsmoker  
  mage ~~ habit_nonsmoker  
'
```

```
fit <- sem(model_path, data = df)
```

```
summary(fit, fit.measures=TRUE, standardized=TRUE)  
resid(fit,type='normalized'); modindices(fit)
```



# Path Model with Estimates



# Model Fit Evaluation

## Chi-Squared

Null hypothesis  
is essentially  
“the model fits”

### Looking for:

- $p\text{-value} > 0.05$

## RMSEA

Two outputs:  
> RMSEA estimate  
> RMSEA Confidence  
Interval

### Looking for:

- $\text{RMSEA} \leq 0.05$

## CFI/TLI

CFI & TLI compare your  
proposed model to the  
baseline model

### Looking for:

- $\text{CFI \& TLI} \geq 0.90$



# Model Tuning

## Residuals

> Shows you the difference between your actual covariance matrix and the fitted model covariance

## Modification Indices

> Shows you paths and covariances that could be estimated in the model that would make the model fit better

### Looking for:

- Values  $> 2$  are problematic

### Looking for:

- Values  $> 4 \rightarrow$  let the model estimate



# Things to remember in path model analysis

- Complex models are hard to interpret & require lots of data! Keep it simple
- Remember to look at all the fit statistics, they come as a package (but remember chi-squared is very sensitive!)
- Your proposed model does not prove causality, it's just an assumption of how things work



# Resources & Extras

# Resources for Path Models & SEM

## **Lavaan Website**

[lavaan.ugent.be/](http://lavaan.ugent.be/)  
tutorials & resources

## **YouTube**

CenterStat,  
our QMC YouTube channel

## **ERSH 8750**

Introduction to  
Structural Equation  
Modeling

## **ERSH 8130**

Survey of  
Latent Variable  
Models



# More Questions?

Visit us at the Quantitative  
Methods Consulting Center!

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***Thanks for coming!***