# Using SPSS for Multiple Regression

UDP 520 Lab 7

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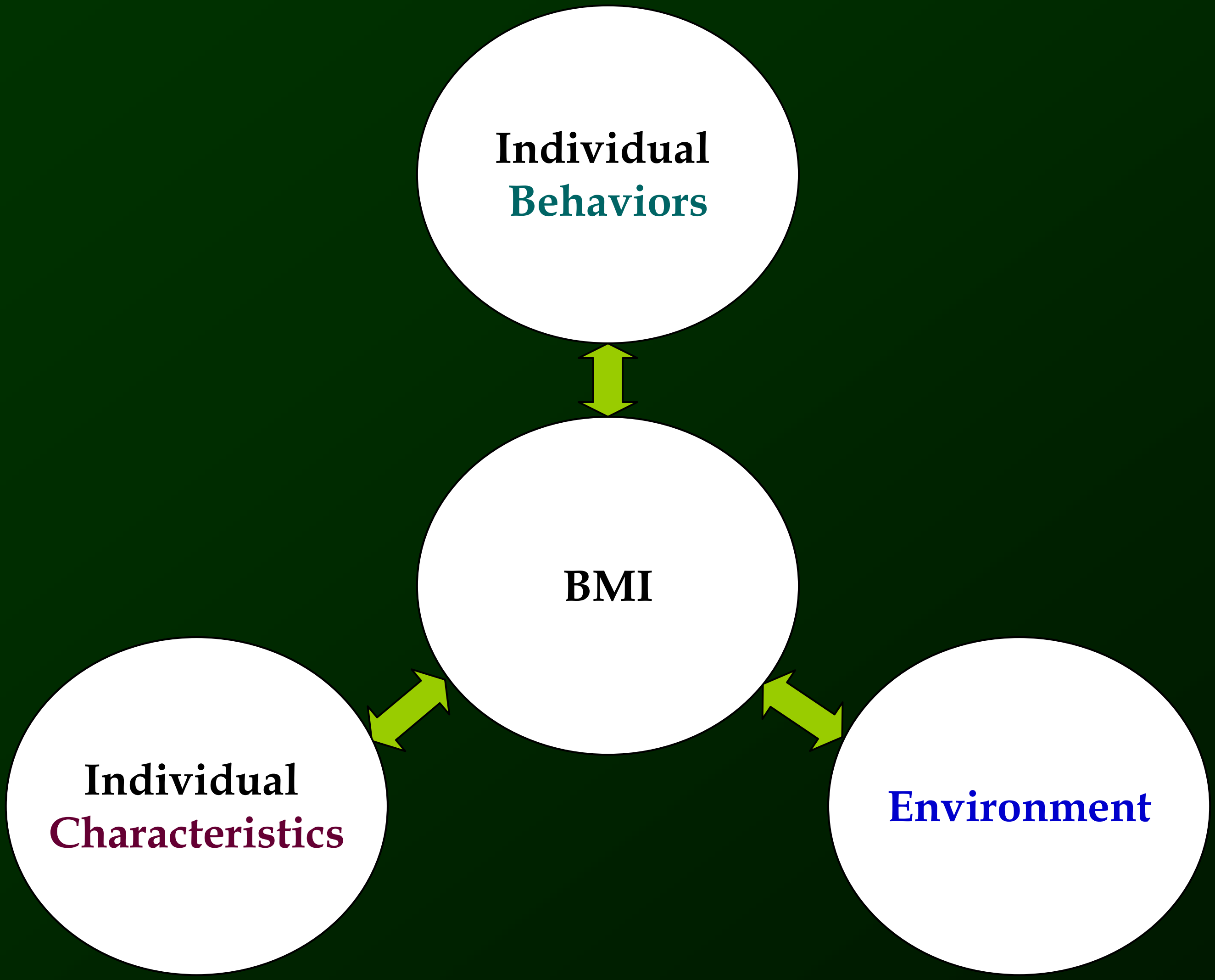
# Step 1 — Define Research Question

- What factors are associated with BMI?
- Predict BMI.

# Step 2 — Conceptualizing Problem (Theory)



# Step 2 — Conceptualizing Problem (Theory)

- Individual behaviors are associated with BMI.
- Individual characteristics are associated with BMI.
- Environment is associated with BMI.

# Step 3 & 4 — Operationalizing and Hypothesizing

- Individual behaviors are associated with BMI.
  - Eating behavior: daily calorie intake is positively associated with BMI
  - Exercising behavior: level of exercise is negatively associated with BMI.
- Individual characteristics are associated with BMI.
  - Sex
  - Income
  - Education level
  - Occupation
- Environment is associated with BMI.
  - Physical environment
  - Social environment

# Step 5 – Collecting Data

- 1000 adults aged 18+ (males and females) were recruited to study factors associated with BMI (BMI)

- Variables
  - BMI (before WLTP)
  - Sex (female=1) – individual characteristics
  - Calorie (calorie intake daily) – individual behaviors
  - Exercise (minutes of exercise per week) – individual behaviors
  - Income (monthly salary in dollars $) – individual characteristics
  - Expenditure on food (monthly food expense in dollars $) – individual behaviors
  - Education (education level in years) – individual characteristics
  - Residential density (high, median, low) – physical environment

# Step 6 – Developing OLS Equation

- Multiple regression

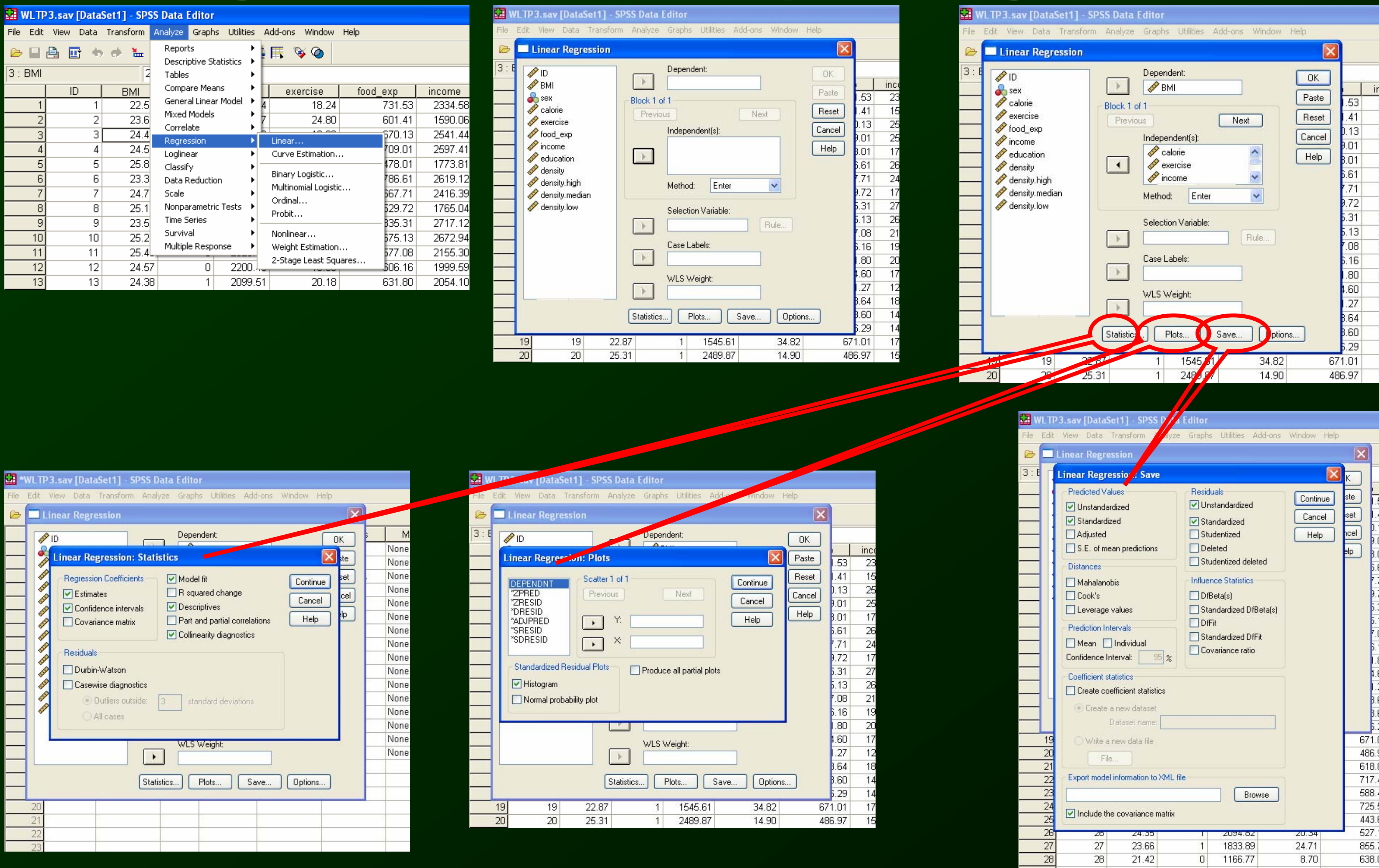
$$
\begin{aligned}
Y_{\text{BMI}} = \beta_0 &+ \beta_1 x_{\text{calorie}} + \beta_2 x_{\text{exercise}} + \beta_3 x_{\text{sex}} \\
&+ \beta_4 x_{\text{income}} + \beta_5 x_{\text{education}} + \beta_6 x_{\text{built environment}} \\
&+ \varepsilon
\end{aligned}
$$

# OLS Equation for SPSS

- Multiple regression Model 1

$$Y_{\text{BMI}} = \beta_0 + \beta_1 x_{\text{calorie}} + \beta_2 x_{\text{exercise}} + \beta_4 x_{\text{income}} + \beta_5 x_{\text{education}} + \varepsilon$$

# Using SPSS for Multiple Regression



# SPSS Output Tables

Descriptive Statistics

| | Mean | Std. Deviation | N |
|---|---|---|---|
| BMI | 24.0674 | 1.28663 | 1000 |
| calorie | 2017.7167 | 513.71981 | 1000 |
| exercise | 21.7947 | 7.66196 | 1000 |
| income | 2005.1981 | 509.49088 | 1000 |
| education | 19.95 | 3.820 | 1000 |

Correlations

| | | BMI | calorie | exercise | income | education |
|---|---|---|---|---|---|---|
| Pearson Correlation | BMI | 1.000 | .784 | -.310 | .033 | .011 |
| | calorie | .784 | 1.000 | -.193 | -.009 | .004 |
| | exercise | -.310 | -.193 | 1.000 | -.030 | -.046 |
| | income | .033 | -.009 | -.030 | 1.000 | .069 |
| | education | .011 | .004 | -.046 | .069 | 1.000 |
| Sig. (1-tailed) | BMI | . | .000 | .000 | .148 | .361 |
| | calorie | .000 | . | .000 | .391 | .451 |
| | exercise | .000 | .000 | . | .175 | .072 |
| | income | .148 | .391 | .175 | . | .014 |
| | education | .361 | .451 | .072 | .014 | . |
| N | BMI | 1000 | 1000 | 1000 | 1000 | 1000 |
| | calorie | 1000 | 1000 | 1000 | 1000 | 1000 |
| | exercise | 1000 | 1000 | 1000 | 1000 | 1000 |
| | income | 1000 | 1000 | 1000 | 1000 | 1000 |
| | education | 1000 | 1000 | 1000 | 1000 | 1000 |

Variables Entered/Removed(b)

| Model | Variables Entered | Variables Removed | Method |
|---|---|---|---|
| 1 | education, calorie, income, exercise(a) | . | Enter |

a All requested variables entered.
b Dependent Variable: BMI

Model Summary(b)

| Model | R | R Square | Adjusted R Square | Std. Error of the Estimate |
|---|---|---|---|---|
| 1 | .801(a) | .642 | .641 | .77095 |

a Predictors: (Constant), education, calorie, income, exercise
b Dependent Variable: BMI

ANOVA(b)

| Model | | Sum of Squares | df | Mean Square | F | Sig. |
|---|---|---|---|---|---|---|
| 1 | Regression | 1062.377 | 4 | 265.594 | 446.853 | .000(a) |
| | Residual | 591.394 | 995 | .594 | | |
| | Total | 1653.771 | 999 | | | |

a Predictors: (Constant), education, calorie, income, exercise
b Dependent Variable: BMI

Coefficients(a)

| Model | | Unstandardized Coefficients | | Standardized Coefficients | t | Sig. | 95% Confidence Interval for B | | Collinearity Statistics | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | B | Std. Error | Beta | | | Lower Bound | Upper Bound | Tolerance | VIF |
| 1 | (Constant) | 20.693 | .208 | | 99.404 | .000 | 20.285 | 21.102 | | |
| | calorie | .002 | .000 | .753 | 38.969 | .000 | .002 | .002 | .962 | 1.039 |
| | exercise | -.027 | .003 | -.163 | -8.434 | .000 | -.034 | -.021 | .960 | 1.042 |
| | income | 8.82E-005 | .000 | .035 | 1.837 | .067 | .000 | .000 | .994 | 1.006 |
| | education | -.001 | .006 | -.002 | -.086 | .932 | -.013 | .012 | .993 | 1.007 |

a Dependent Variable: BMI

Collinearity Diagnostics(a)

| Model | Dimension | Eigenvalue | Condition Index | Variance Proportions | | | | |
|---|---|---|---|---|---|---|---|---|
| | | | | (Constant) | calorie | exercise | income | education |
| 1 | 1 | 4.778 | 1.000 | .00 | .00 | .00 | .00 | .00 |
| | 2 | .110 | 6.584 | .00 | .10 | .72 | .02 | .01 |
| | 3 | .060 | 8.924 | .00 | .41 | .03 | .56 | .00 |
| | 4 | .041 | 10.842 | .01 | .21 | .05 | .26 | .55 |
| | 5 | .011 | 21.197 | .99 | .28 | .19 | .16 | .44 |

a Dependent Variable: BMI

Residuals Statistics(a)

| | Minimum | Maximum | Mean | Std. Deviation | N |
|---|---|---|---|---|---|
| Predicted Value | 21.8115 | 26.9475 | 24.0674 | 1.03123 | 1000 |
| Residual | -3.36145 | 4.91952 | .00000 | .76941 | 1000 |
| Std. Predicted Value | -2.188 | 2.793 | .000 | 1.000 | 1000 |
| Std. Residual | -4.360 | 6.381 | .000 | .998 | 1000 |

a Dependent Variable: BMI

# Step 7 – Checking for Multicollinearity

**Correlations**

| | | BMI | calorie | exercise | income | education |
|---|---|---|---|---|---|---|
| Pearson Correlation | BMI | 1.000 | .784 | -.310 | .033 | .011 |
| | calorie | .784 | 1.000 | -.193 | -.009 | .004 |
| | exercise | -.310 | -.193 | 1.000 | -.030 | -.046 |
| | income | .033 | -.009 | -.030 | 1.000 | .069 |
| | education | .011 | .004 | -.046 | .069 | 1.000 |
| Sig. (1-tailed) | BMI | . | .000 | .000 | .148 | .361 |
| | calorie | .000 | . | .000 | .391 | .451 |
| | exercise | .000 | .000 | . | .175 | .072 |
| | income | .148 | .391 | .175 | . | .014 |
| | education | .361 | .451 | .072 | .014 | . |
| N | BMI | 1000 | 1000 | 1000 | 1000 | 1000 |
| | calorie | 1000 | 1000 | 1000 | 1000 | 1000 |
| | exercise | 1000 | 1000 | 1000 | 1000 | 1000 |
| | income | 1000 | 1000 | 1000 | 1000 | 1000 |
| | education | 1000 | 1000 | 1000 | 1000 | 1000 |

Check multicollinearity of independent variables.
If the absolute value of Pearson correlation is greater than 0.8, collinearity is very likely to exist.
If the absolute value of Pearson correlation is close to 0.8 (such as 0.7±0.1), collinearity is likely to exist.

# Step 7 – Checking for Multicollinearity (cont.)

**Collinearity Diagnostics**[a]

| Model | Dimension | Eigenvalue | Condition Index | Variance Proportions | | | | |
|---|---|---|---|---|---|---|---|---|
| | | | | (Constant) | calorie | exercise | income | education |
| 1 | 1 | 4.778 | 1.000 | .00 | .00 | .00 | .00 | .00 |
| | 2 | .110 | 6.584 | .00 | .10 | .72 | .02 | .01 |
| | 3 | .060 | 8.924 | .00 | .41 | .03 | .56 | .00 |
| | 4 | .041 | 10.842 | .01 | .21 | .05 | .26 | .55 |
| | 5 | .011 | 21.197 | .99 | .28 | .19 | .16 | .44 |

a. Dependent Variable: BMI

A condition index greater than 15 indicates a possible problem

An index greater than 30 suggests a serious problem with collinearity.

# Step 8 – Statistics

- Goodness of fit of model

**Model Summary**[b]

| Model | R | R Square | Adjusted R Square | Std. Error of the Estimate |
|---|---|---|---|---|
| 1 | .801[a] | .642 | .641 | .77095 |

a. Predictors: (Constant), education, calorie, income, exercise

b. Dependent Variable: BMI

$R^2 = 0.642$
It means that 64.2% of variation is explained by the model.

The adjusted $R^2$ adjusts for the number of explanatory terms (independent variables) in a model and increases only if the new independent variable(s) improve(s) the model more than would be expected by chance.

# Step 8 – Statistics (cont.)

- Coefficient of each independent variable

**Coefficients[a]**

| Model | | Unstandardized Coefficients B | Unstandardized Coefficients Std. Error | Standardized Coefficients Beta | t | Sig. | 95% Confidence Interval for B Lower Bound | 95% Confidence Interval for B Upper Bound | Collinearity Statistics Tolerance | Collinearity Statistics VIF |
|---|---|---|---|---|---|---|---|---|---|---|
| 1 | (Constant) | 20.693 | .208 | | 99.404 | .000 | 20.285 | 21.102 | | |
| | calorie | .002 | .000 | .753 | 38.969 | .000 | .002 | .002 | .962 | 1.039 |
| | exercise | -.027 | .003 | -.163 | -8.434 | .000 | -.034 | -.021 | .960 | 1.042 |
| | income | 3.82E-005 | .000 | .035 | 1.837 | .067 | .000 | .000 | .994 | 1.006 |
| | education | -.001 | .006 | -.002 | -.086 | .932 | -.013 | .012 | .993 | 1.007 |

a. Dependent Variable: BMI

Unstandardized coefficients used in the prediction and interpretation

standardized coefficients used for comparing the effects of independent variables

Compared Sig. with alpha 0.05.

If Sig. <0.05 → the coefficient is statistically significant from zero.

# Step 9 Interpreting Estimated Coefficient

$$Y_{\text{BMI}} = 20.693 + 0.002x_{\text{calorie}} + (-0.027)x_{\text{exercise}} + 0.0000882x_{\text{income}} + (-0.001)x_{\text{education}}$$

- Controlling for other variables constant, if a person increase 1 calorie intake per day, the BMI of the person will increase by 0.002.
- *Please explain the estimated coefficient of exercise.*

## Steps on Model Development and Model Selection

- First, include the theoretically important variables
- Second, include variables that are strongly associated with the dependent variable (to identify independent variables that are strongly associated with the dependent variable, Pearson r test could be used for interval-ratio variables with the dependent variable).
- Third, adjusted $R^2$ need to be compared to determine if the new independent variables improve the model. At the mean time, multicollinearity needs to be checked.

# Notes on Regression Model

- **It is VERY important to have theory before starting developing any regression model.**

- If the theory tells you certain variables are too important to exclude from the model, you should include in the model even though their estimated coefficients are not significant. (Of course, it is more conservative way to develop regression model.)

# BMI data

http://courses.washington.edu/urbdp520/UDP520/BMI.sav

For exercise, you can develop your own conceptual frameworks (theories), create different OLS models, and examine different independent variables.