#------------------------Load Necessary Libraries------------------------

library(dplyr)

library(readxl)

library(metafor)

library(openxlsx)

#------------------------Step 1: Effect Size Calculation------------------------

# Read the data

data <- read\_excel("/Users/ s.xlsx")

# Ensure that Fisher's z has been calculated. If not, add the following calculations:

data <- data %>%

mutate(

fisher\_z = atanh(correlation), # Fisher's z transformation

Variance = 1 / (n - 3) # Variance calculation formula

)

#------------------------Step 2: Overall Effect Size Estimation------------------------

# Three-level random-effects model

overall <- rma.mv(fisher\_z, Variance, random = list(~1|effetsizeID, ~1|studyID), tdist = TRUE, data = data)

summary(overall, digits = 3)

# Two-level random-effects model

overall2 <- rma.uni(fisher\_z, sei = sqrt(Variance), test = "t", data = data)

summary(overall2, digits = 3)

#------------------------Step 3: Heterogeneity Test------------------------

# Test heterogeneity for the two-level model

model\_novar2 <- rma.mv(fisher\_z, Variance, random = list(~1|effetsizeID, ~1|studyID), sigma2 = c(0, NA), tdist = TRUE, data = data)

anova(overall, model\_novar2)

# Test heterogeneity for the three-level model

model\_novar3 <- rma.mv(fisher\_z, Variance, random = list(~1|effetsizeID, ~1|studyID), sigma2 = c(NA, 0), tdist = TRUE, data = data)

anova(overall, model\_novar3)

#------------------------Step 4: Outliers Detection and Removal------------------------

# Use influence analysis

influence\_analysis <- influence(overall2)

plot(influence\_analysis) # Plot influence diagnostics

# Detect outliers

outliers <- which(abs(influence\_analysis$cooks.d) > 4 / nrow(data)) # Detect outliers based on Cook's distance

if (length(outliers) > 0) {

cat("Detected outliers:", outliers, "\n")

data <- data[-outliers, ] # Remove outliers

} else {

cat("No significant outliers detected.\n")

}

#------------------------Step 5: Moderator Analysis------------------------

# Example: Moderator effect of the variable `education\_num`

mod\_education <- rma.mv(fisher\_z, Variance, mods = ~ education\_num, random = list(~1|effetsizeID, ~1|studyID), tdist = TRUE, data = data)

summary(mod\_education, digits = 3)

# Example: Moderator effect of the variable `teaching\_modes\_num`

mod\_teaching\_modes <- rma.mv(fisher\_z, Variance, mods = ~ teaching\_modes\_num, random = list(~1|effetsizeID, ~1|studyID), tdist = TRUE, data = data)

summary(mod\_teaching\_modes, digits = 3)

#------------------------Step 6: Publication Bias Test------------------------

# Egger's regression test

egger\_test <- regtest(overall2)

print(egger\_test)

# Trim-and-fill method

trimfill\_results <- trimfill(overall2)

summary(trimfill\_results)

funnel(trimfill\_results, main = "Funnel Plot with Trim-and-Fill")

#------------------------Generate Forest Plot and Funnel Plot------------------------

# Save forest plot as a high-resolution PNG file

png("forest\_plot.png", width = 8, height = 6, units = "in", res = 300)

forest(overall2, slab = paste(data$studyID, data$effetsizeID), xlab = "Observed Outcomes", header = "Forest Plot of Effect Sizes", digits = 3)

dev.off()

# Save funnel plot as a high-resolution PNG file

png("funnel\_plot.png", width = 8, height = 6, units = "in", res = 300)

funnel(overall2, yaxis = "sei", xlab = "Effect Size (Observed Outcomes)", main = "Funnel Plot of Effect Sizes", shade = c("white", "gray"))

dev.off()

#------------------------Export Model Results to Excel------------------------

# Save model results

wb <- createWorkbook()

addWorksheet(wb, "Overall\_Effect")

writeData(wb, "Overall\_Effect", capture.output(summary(overall)))

addWorksheet(wb, "Moderator\_Effects")

writeData(wb, "Moderator\_Effects", capture.output(summary(mod\_education)))

saveWorkbook(wb, "/Users/.xlsx", overwrite = TRUE)