

QUESTION 1

Background

Melatonin is a circadian hormone transmitted via the suprachiasmatic nucleus in the hypothalamus. Melatonin secretion induces sleep and melatonin inhibition prevents the onset of sleep. While studies have shown that Light-Emitting Diode (LED) lit computer and tablet screens suppress melatonin production, patients who read books and newspapers prior to sleep from LED-lit computers, tablets, and cell phones often claim that the reading induces sleep and overcomes any melatonin inhibition caused by the LED screens. A case-control study was done to determine if there is an association between reading books or newspapers from a LED-lit tablet or cell phone and falling asleep.

Methods

Women were recruited from primary care practices in East Virginia. Cases reported falling asleep more than 1 hour after getting into bed and controls reported falling asleep within 1 hour after getting into bed. All participants completed interviewer-administered questionnaires on demographic characteristics (age, level of education) and other sleep-related measures.

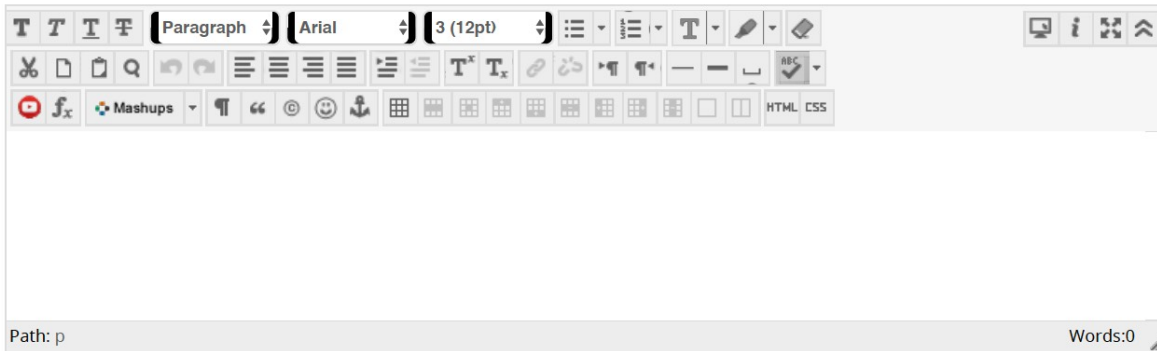
Data dictionary

age –	continuous variable
watch_tv –	0 for no, 1 for yes
E_reading –	0 for no, 1 for yes
caffeine –	0 for no, 1 for yes
alcohol_use –	0 for no, 1 for yes
BMI –	continuous variable
BMI_di	0 for BMI < 25, 1 for BMI ≥ 25
high_school_graduate --	0 for no, 1 for yes
sleep_delay --	0 for no, 1 for yes

Question 1: Given the description of the variables in the data set, describe one way you could check the data for accuracy or consistency.

QUESTION 2

Question 2: A new variable called “age_c” is created by subtracting the mean of age from each age observation. Describe one reason why the researchers may have decided to center the age variable.



A rich text editor interface with a toolbar at the top containing various icons for text formatting (bold, italic, underline, strikethrough), paragraph alignment (left, center, right, justified), list creation (bulleted, numbered), indentation, link/unlink, unlink, undo, redo, and a spell checker. Below the toolbar is a large, empty text area for the user's response. At the bottom of the editor, there is a status bar showing "Path: p" on the left and "Words:0" on the right.

QUESTION 3

Question 3: Upon examining the data, you observe that 10% of women did not report their e-reading behavior. You construct a missing indicator variable and observe that 60% of women with missing e-reading data were age 30 years or older while 35% of women who provided e-reading data were age 30 years or older. There were no other differences observed between women who did and did not report their e-reader use. Based on these findings, you could conclude that:

- ☐ a. The pattern of missing data on e-reader use is Missing Not at Random.
- ☐ b. The pattern of missing data on e-reader use is Missing at Random, conditional on age.
- ☐ c. The pattern of missing data on e-reader use is Missing at Random, conditional on age and BMI.
- ☐ d. The pattern of missing data on e-reader use is Missing Completely at Random.

QUESTION 4

Question 4: Participant characteristics are summarized separately for cases and controls in Table 1 below. Which characteristic(s) may potentially confound an observed association between e-reader use and delayed sleeping? What would have to be true about the relationship between that characteristic and e-reader use for confounding to occur (i.e. what makes a variable a confounder)? (2 points)

Table 1: Characteristics of cases and controls enrolled in a study of e-reader use and falling asleep

	No Sleep Delay (Control) n=140	Sleep Delay (Case) n=184
	Yes, n (%)	
TV watching	71 (50.7)	59 (33.1)
E-reading	79 (56.4)	134 (72.8)
Caffeine	11 (7.9)	24 (13.0)
Alcohol	17 (12.1)	30 (16.3)
High school graduate	92 (65.7)	124 (67.4)
	Mean (SD)	
Age	25.1 (4.9)	24.8 (4.0)
BMI	24.3 (3.5)	26.4 (4.5)

QUESTION 5

Question 5: What type of generalized linear model is appropriate for this study design? State the specific research question that the model will answer in terms of the exposure and outcome and the measure of association that the statistical model will produce.

A screenshot of the Wondershare PDFElement software interface. The top toolbar is visible, containing various icons for text editing (bold, italic, underline, strikethrough, font color, background color), paragraph formatting (bullet points, numbered lists, indent, outdent, alignment), and drawing tools (line, rectangle, circle, arrow, eraser, highlighter, stamp). Below the toolbar, the main workspace is empty. At the bottom, a status bar shows 'Path: p' on the left and 'Words:0' on the right.

QUESTION 6

Question 6: Researchers want to use these data to determine if BMI is associated with risk of sleep delay. In particular, the investigators wanted to see if there was a dose-response between BMI and odds of sleep delay. The table below shows their results using **incremental coding** [reference group for overweight group: normal BMI ($18.5 \leq \text{BMI} < 25$)]. Would you conclude that there is a dose-response relationship between BMI and odds of sleep delay? Why or why not?

	Odds Ratio	Confidence Limits	
Normal weight ($18.5 \leq \text{BMI} < 25$)	---	---	---
Overweight ($25 \leq \text{BMI} < 30$)	1.700	1.050	2.754
Obese ($\text{BMI} \geq 30$)	5.165	2.267	11.772

The screenshot shows the top toolbar of the Wondershare PDFElement application. The toolbar is organized into several groups of icons for different functions:

- Text and Paragraph Tools:** Includes icons for bold (T), italic (T), underline (T), text color (T with a color bar), paragraph alignment (left, center, right, justified), font family (Arial), font size (3 (12pt)), bulleted list, numbered list, text box, text color, text background color, and a checkmark icon.
- Image and Annotation Tools:** Includes icons for crop, rotate, scale, and a checkmark icon.
- Form and Table Tools:** Includes icons for text box, text box with a checkmark, and a table icon.
- Other Tools:** Includes icons for redaction, signature, stamp, and a checkmark icon.

The toolbar is located at the top of the application window, which also displays the title bar with the text "Wondershare PDFElement - PDF to Word Converter".

Question 7: Researchers suspect that maternal BMI modifies the relationship between e-reader use and melatonin production. Specify an appropriate statistical test for the interaction. (If there is more than one test that is appropriate, just choose 1.) State the null hypothesis for that statistical test. Then interpret the result of that test in the SAS output below to determine whether BMI is an effect modifier. For simplicity, BMI is collapsed into 2 categories: 0 = normal weight (BMI<25) and 1 = overweight/obese (BMI≥25). (2 points)

Model Fit Statistics									
Criterion	Intercept Only	Intercept and Covariates							
AIC	445.166	429.968							
SC	448.946	445.091							
-2 Log L	443.166	421.968							
Analysis of Maximum Likelihood Estimates									
Parameter			DF	Estimate	Standard Error	Wald Chi-Square	Pr > ChiSq		
Intercept			1	-0.6690	0.2683	6.2161	0.0127		
E_reading	1		1	0.8877	0.3348	7.0307	0.0080		
bmi_di	1		1	1.0406	0.3956	6.9195	0.0085		
E_reading*bmi_di	1	1	1	-0.4292	0.4887	0.7712	0.3798		
Contrast Estimation and Testing Results by Row									
Contrast	Type	Row	Estimate	Standard Error	Alpha	Confidence Limits		Wald Chi-Square	Pr > ChiSq
OR BMI_di=0	EXP	1	2.4296	0.8134	0.05	1.2605	4.6829	7.0307	0.0080
OR BMI_di=1	EXP	1	1.5818	0.5631	0.05	0.7873	3.1780	1.6596	0.1977

Goodness of fit table for reduced model (without interaction term “E_reading*BMI_di”)

Model Fit Statistics		
Criterion	Intercept Only	Intercept and Covariates
AIC	445.166	428.742
SC	448.946	440.085
-2 Log L	443.166	422.742

Criteria For Assessing Goodness Of Fit			
Criterion	DF	Value	Value/DF
Log Likelihood		-211.3712	
Full Log Likelihood		-211.3712	
AIC (smaller is better)		428.7425	
AICC (smaller is better)		428.8175	

Questions 8-11 pertain to the **Full Model**, which is summarized in the output below.

Analysis of Maximum Likelihood Estimates						
Parameter		DF	Estimate	Standard Error	Wald Chi-Square	Pr > ChiSq
Intercept		1	-0.3737	0.3035	1.5161	0.2182
E_reading	1	1	0.6457	0.2490	6.7240	0.0095
age_c		1	0.0138	0.0272	0.2587	0.6110
bmi_di	1	1	0.7963	0.2384	11.1539	0.0008
watch_tv	1	1	-0.7780	0.2436	10.1952	0.0014
high_school_graduate	1	1	0.2459	0.2526	0.9473	0.3304

Question 8: Exponentiate (i.e. e^{β}) the parameter estimate for e-reader use (e_reading) from the output above and interpret it in words.

QUESTION 9

Question 9. Which independent variable has the strongest association with the odds of sleep delay? Justify your answer.

A screenshot of the Wondershare PDFElement software interface. The top toolbar is visible, containing various icons for editing, formatting, and navigation. The 'Paragraph' style is selected, and the font is set to 'Arial' with a size of '3 (12pt)'. The 'ABC' icon is highlighted, indicating the 'Spell Check' feature. The 'HTML' and 'CSS' options are also visible in the bottom right of the toolbar. The main workspace is empty, and the status bar at the bottom shows 'Path: p' and 'Words:0'.

Question 10: Imagine your colleague who typically works with prediction models rather than etiologic models sees the table above for the full model. Which covariate is the colleague likely to recommend removing first from the model? (1/2 point)

A screenshot of the Wondershare PDFElement software's toolbar. The toolbar is organized into several groups of icons. The first group includes text formatting tools like bold, italic, underline, and font color. The second group shows paragraph alignment and indentation options. The third group contains text box and text frame tools. The fourth group includes drawing tools like lines, rectangles, and ovals. The fifth group shows annotation tools like comments and stamps. The sixth group includes table and form field tools. The seventh group shows navigation and search tools. The eighth group includes window and view management tools. The ninth group shows the 'HTML' and 'CSS' options. The tenth group includes the 'PDF' icon and the 'Wondershare PDFElement' logo. The toolbar is located at the top of the application window, which also displays the file path 'Path: p' and the word count 'Words:0'.

QUESTION 11

Question 11: Below is the output for the crude model of the association between maternal e-reader use and odds of delayed falling asleep. Is the crude effect estimate biased due to not controlling for confounding? Explain your answer.

Analysis of Maximum Likelihood Estimates						
Parameter		DF	Estimate	Standard Error	Wald Chi-Square	Pr > ChiSq
Intercept		1	-0.1988	0.1908	1.0865	0.2973
E_reading	1	1	0.7992	0.2377	9.3582	0.0022

[illegible]

QUESTION 13

Question 13: Based on your results from Question 12, would you remove TV watching from the final statistical model? Would you remove obesity from the final statistical model? Why or why not?

QUESTION 14

Part 3 – Interpreting the Final Model

Below is the SAS output for the final model for your analysis. Use this output to answer questions 14 and 15.

Analysis of Maximum Likelihood Estimates						
Parameter		DF	Estimate	Standard Error	Wald Chi-Square	Pr > ChiSq
Intercept		1	-0.0177	0.2796	0.0040	0.9494
E_reading	1	1	0.6783	0.2445	7.6979	0.0055
watch_tv	1	1	-0.7449	0.2386	9.7477	0.0018
high_school_graduate	1	1	0.2361	0.2482	0.9045	0.3416
age_c		1	0.00287	0.0266	0.0117	0.9140

Question 14: Write out the logistic model represented by the output above.

A screenshot of the Wondershare PDFElement software interface, specifically the top toolbar. The toolbar is organized into several groups of icons. On the left, there are icons for basic editing like copy, paste, and delete, as well as a 'Mashups' dropdown menu. The central part of the toolbar contains a large set of icons for text and layout formatting, including bold, italic, underline, font color, background color, text alignment, bullet points, numbered lists, and text orientation. To the right of these are icons for linking, commenting, and a 'HTML CSS' dropdown. On the far right, there are icons for window management (minimize, maximize, close) and a help icon. The status bar at the bottom of the window shows 'Path: n' on the left and 'Words:0' on the right.

[illegible]

Question 15: Use the output above to calculate the odds ratio for delayed sleeping comparing women who watch TV at night and were 10 years older than the mean age in the sample to women who did not watch TV and were the mean age. Interpret the result in a sentence. (2 points)

A screenshot of the Wondershare PDFElement software's toolbar. The toolbar is organized into several groups of icons. The first group includes text formatting tools like bold, italic, underline, and font color. The second group shows paragraph alignment and indentation options. The third group contains text alignment and bullet point tools. The fourth group includes text color, background color, and text box tools. The fifth group shows link, image, and annotation tools. The sixth group includes table, form, and signature tools. The seventh group contains drawing tools like line, rectangle, and circle. The eighth group includes text box, text area, and text frame tools. The ninth group shows text box, text area, and text frame tools. The tenth group includes text box, text area, and text frame tools. The eleventh group shows text box, text area, and text frame tools. The twelfth group includes text box, text area, and text frame tools. 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The fifty-second group includes text box, text area, and text frame tools. The fifty-third group shows text box, text area, and text frame tools. The fifty-fourth group includes text box, text area, and text frame tools. The fifty-fifth group shows text box, text area, and text frame tools. The fifty-sixth group includes text box, text area, and text frame tools. The fifty-seventh group shows text box, text area, and text frame tools. The fifty-eighth group includes text box, text area, and text frame tools. The fifty-ninth group shows text box, text area, and text frame tools. The sixtieth group includes text box, text area, and text frame tools. The sixty-first group shows text box, text area, and text frame tools. The sixty-second group includes text box, text area, and text frame tools. The sixty-third group shows text box, text area, and text frame tools. The sixty-fourth group includes text box, text area, and text frame tools. The sixty-fifth group shows text box, text area, and text frame tools. The sixty-sixth group includes text box, text area, and text frame tools. The sixty-seventh group shows text box, text area, and text frame tools. The sixty-eighth group includes text box, text area, and text frame tools. The sixty-ninth group shows text box, text area, and text frame tools. The seventieth group includes text box, text area, and text frame tools. The seventy-first group shows text box, text area, and text frame tools. The seventy-second group includes text box, text area, and text frame tools. The seventy-third group shows text box, text area, and text frame tools. The seventy-fourth group includes text box, text area, and text frame tools. The seventy-fifth group shows text box, text area, and text frame tools. The seventy-sixth group includes text box, text area, and text frame tools. The seventy-seventh group shows text box, text area, and text frame tools. The seventy-eighth group includes text box, text area, and text frame tools. The seventy-ninth group shows text box, text area, and text frame tools. The eightieth group includes text box, text area, and text frame tools. The eighty-first group shows text box, text area, and text frame tools. The eighty-second group includes text box, text area, and text frame tools. The eighty-third group shows text box, text area, and text frame tools. The eighty-fourth group includes text box, text area, and text frame tools. The eighty-fifth group shows text box, text area, and text frame tools. The eighty-sixth group includes text box, text area, and text frame tools. The eighty-seventh group shows text box, text area, and text frame tools. The eighty-eighth group includes text box, text area, and text frame tools. The eighty-ninth group shows text box, text area, and text frame tools. The ninetieth group includes text box, text area, and text frame tools. The ninety-first group shows text box, text area, and text frame tools. The ninety-second group includes text box, text area, and text frame tools. The ninety-third group shows text box, text area, and text frame tools. The ninety-fourth group includes text box, text area, and text frame tools. The ninety-fifth group shows text box, text area, and text frame tools. The ninety-sixth group includes text box, text area, and text frame tools. The ninety-seventh group shows text box, text area, and text frame tools. The ninety-eighth group includes text box, text area, and text frame tools. The ninety-ninth group shows text box, text area, and text frame tools. The hundredth group includes text box, text area, and text frame tools.

QUESTION 16

Part 4 – Model building for a slightly different question

A new researcher joins your group who is interested in the relationship between duration of e-reader use and developing a sleep problem. She examines these data again, this time modeling the time to event (i.e., incident sleep disorder) using an additional variable recording the time from start of e-reader use to developing a sleep disorder.

Question 16: What effect estimate will you calculate in the new study described above?

- ☐ a. Odds ratio
- ☐ b. Hazard ratio
- ☐ c. Incidence rate ratio
- ☐ d. Risk ratio

QUESTION 17

Question 17: What is the primary assumption you will need to check before proceeding with the statistical analysis described in the excerpt above? How can you check this assumption?

QUESTION 18

Question 18: The table below corresponds to the analysis proposed in Question 16. Interpret in words the effect estimate (measure of association) for e-reader use in the table below.

Analysis of Maximum Likelihood Estimates								
Parameter		DF	Parameter Estimate	Standard Error	Chi-Square	Pr > ChiSq	Hazard Ratio	Label
E_reading	1	1	0.39028	0.16845	5.3681	0.0205	1.477	E_reading 1
bmi_di	1	1	0.48673	0.15320	10.0941	0.0015	1.627	bmi_di 1
watch_tv	1	1	-0.48131	0.16131	8.9028	0.0028	0.618	watch_tv 1
high_school_graduate	1	1	0.12188	0.15878	0.5892	0.4427	1.130	high_school_graduate 1
age_c		1	0.01408	0.01751	0.6461	0.4215	1.014	