1) Researchers randomly selected a sample of 663 heart disease patients (male) and a control group of 772 males not suffering from heart disease. Each patient was asked to classify their degree of baldness on a 5-point scale. The results are given in the following table.

<table>
<thead>
<tr>
<th>Baldness</th>
<th>None</th>
<th>Little</th>
<th>Some</th>
<th>Much</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Heart</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Yes</td>
<td>251</td>
<td>165</td>
<td>195</td>
<td>52</td>
<td>663</td>
</tr>
<tr>
<td>No</td>
<td>35</td>
<td>221</td>
<td>185</td>
<td>30</td>
<td>772</td>
</tr>
<tr>
<td>Total</td>
<td>582</td>
<td>386</td>
<td>380</td>
<td>87</td>
<td>1435</td>
</tr>
</tbody>
</table>

\[ \hat{p}_{\text{none}} = 0.43 \quad \hat{p}_{\text{little}} = 0.43 \quad \hat{p}_{\text{some}} = 0.51 \quad \hat{p}_{\text{much}} = 0.60 \]

The observational units are the 1435 males. The explanatory variable (given in columns) is the baldness classification (a categorical variable with 4 categories in the table, “much” and “extreme” on the 5-point scale were pooled together) and the response variable is whether or not the male has heart disease (a categorical variable with 2 categories). This is considered a “case-control” study were the participants were sampled based on the response variable.

(a) (2 pts) State in words what \( \pi_{\text{none}} \) should represent in this study.

Because I used the symbol \( \pi \), this is a parameter, so the population version of \( \hat{p}_{\text{none}} \), so it represents a conditional probability. This is the probability that a man in this population with no baldness (so conditioning on not having baldness), has heart disease. In other words, of all the men in this population with no baldness, what is the long-run proportion that have heart disease. So our goal is to compare this probability to the probability of heart disease for those with little baldness to the probability of heart disease for those with some baldness etc.

(b) (2 pts) Do you consider the chi-square test valid for these data? Clearly explain how you are deciding.

Yes, because we have at least 10 successes (men with heart disease) and 10 failures (men without heart disease) in each baldness category. The smallest such count is 35.

Many of you could have been more clear on exactly, and how many, values you were looking at. Always try to put your responses in context (e.g., what is an “outcome”).

(c) (4 pts) Below is output for the chi-square test. Summarize (with brief justification) the conclusions you would draw from this study with regard to significance, causation, and generalizability.

The small p-value (.0023 < .01) gives us strong evidence against the null hypothesis. In other words, we have convincing evidence that there is an association between whether or not have heart disease and baldness classification in the population of males from which this sample we selected. In other words, we have strong evidence that the probability of heart disease differs across the baldness classifications. We cannot draw a cause and effect conclusion (your level
of baldness influences your chance of heart disease) because this was not an experiment (the
researchers didn’t determine who was going to be more or less bald). We were told that (at
least the first group) was randomly selected so we feel comfortable generalizing these
conclusions (whether significant or not) to the population from which this sample was selected.

Justify significance by evaluating whether you think the p-value is small or not. But also be
sure to state your conclusion in context (i.e., don’t stop at “reject H0). Many of you gave a
combination of “association between variables” and “differences between groups” that ended
up being incorrect (e.g., we can’t talk about association between outcomes).

Chisq Cell Contributions
<table>
<thead>
<tr>
<th></th>
<th>none</th>
<th>little</th>
<th>some</th>
<th>much</th>
</tr>
</thead>
<tbody>
<tr>
<td>yes</td>
<td>1.19</td>
<td>1.00</td>
<td>2.15</td>
<td>3.47</td>
</tr>
<tr>
<td>no</td>
<td>1.02</td>
<td>0.86</td>
<td>1.85</td>
<td>2.98</td>
</tr>
</tbody>
</table>
Sum=14.510
df=3
p-value= 0.0023

(d) (2 pts) Below is a set of simultaneous 95% confidence intervals.
none - little: (-0.0599, 0.0675)
none - some: (-0.1463, -0.0175)*
none - much: (-0.2770, -0.0558)*
little - some: (-0.1561, -0.0153)*
little - much: (-0.2845, -0.0560)*
some - much: (-0.1992, 0.0301)

Summarize what you learn from this output.

Although we don’t have compelling evidence of a difference in the probability of heart disease
between those with none and little baldness or between those with some and much baldness,
we do find evidence of higher probabilities of heart disease for those with some and much
baldness compared to someone with no baldness, and between someone with some and
much baldness compared to someone with little baldness. So individuals with some of much
baldness appear to have higher probabilities of heart disease comped to individuals with no or
little baldness. Of course age could be an obvious confounding variable here – those with
more baldness tend to be older than those with less baldness and age could be a factor in
heart disease.