Your topic is a good one, as is your dataset. I think you may have included too few variables in your causal DAG. See my other comments.

Grade: 100

Causal Learning Project Proposal

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Question

Does students' workday alcohol consumption have a causal effect on their final grades?

Hypothesis

We hypothesize that workday alcohol consumption has a direct causal effect on the students' final grades. Students who drink more on weekdays would have lower final grades. In addition to the main hypothesis, we believe that workday alcohol consumption affects health because alcohol increases violence and injuries, as well as general health problems (stomach issues, headaches, etc.). Obviously, the amount of times a student spends studying will have a causal effect on their final grades. Workday alcohol consumption can lead to decreased study time because it is difficult to focus while intoxicated. We said that study time was also affected by extra-curricular activities because extra-curricular activities take up a lot of time which could otherwise be spent on studying. Studytime can also be affected by going out with friends because going out with friends means that you are not studying. Going out with friends also affects workday alcohol consumption because when someone goes out with friends, it is often to drink. A student's health can affect their absences because they may call in sick or be at the hospital. Finally, absences affect a student's grades because it could cause them to fall behind in class.

Causal Effect Measures

We plan on using the associational risk difference and the risk ratio to measure the causal effects present in our data. Each of these measures can help provide us different insights into the strength of association between a student's workday alcohol consumption and their final grade at the end of a term.

The associational risk difference tells us about the absolute difference between groups within the treatment (workday alcohol consumption). This can help tell us the absolute effect workday alcohol consumption has, or rather the excess risk it has on a student's final grade in comparison to those students who do not partake in workday alcohol consumption. The formula for calculating the risk difference of a treatment "a" can be seen below in Eq. 1.

What exactly is A? That is, how is it measured?
Does Y represent just one grade or several?

$$Pr[Y^{a=1} = 1] - Pr[Y^{a=0} = 1] = 0 \qquad (Eq. 1)$$

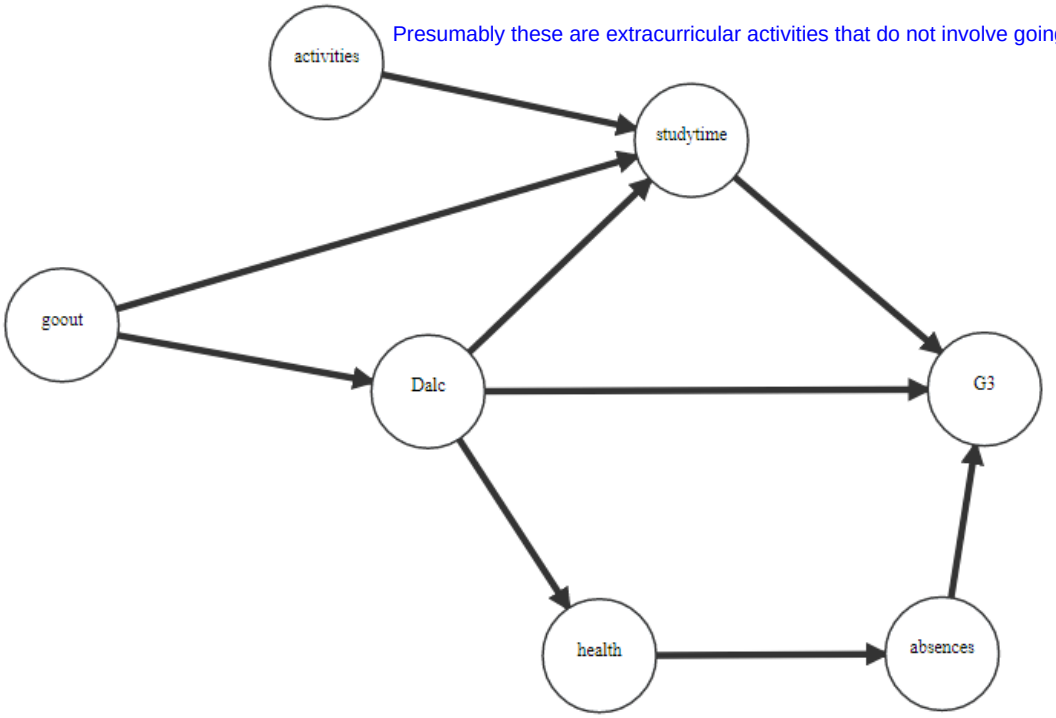
The risk ratio helps us see the association between our outcome (final grades) and the level of our exposure (workday alcohol consumption). More specifically, it tells us the ratio of the probability of experiencing an event (the final grade total) given a treatment versus not given a treatment (workday alcohol consumption vs not consuming alcohol) as seen below in Eq. 2.

$$\frac{Pr[Y^{a=1}=1]}{Pr[Y^{a=0}=1]} = 1 \qquad \textit{(Eq. 2)}$$

We think it is important to use both of these measures because while the risk ratio allows us to measure the association between treatment versus not treatment for a specific outcome on a multiplicative scale, the risk difference allows us to quantify this difference on an additive scale. More specifically, the risk difference can tell us how many more students' grades would improve given the treatment.

You should precisely define the variables. What values do they have?

Causal DAG



Presumably these are extracurricular activities that do not involve going out.

Dataset

We used the Student Alcohol Consumption Dataset from Kaggle[1]. The data was collected in a survey of students in mathematics and Portuguese language courses from two secondary schools in Portugal. There are survey responses from 649 students in the Portuguese language courses and from 395 students in the mathematics courses. Originally, we were planning to simply merge these two datasets. However, the link to the data states that there are 382 students that belong to both datasets, meaning that the vast majority of the survey responses in the mathematics dataset are already represented in the Portuguese dataset.

[1] https://www.kaggle.com/uciml/student-alcohol-consumption

Therefore, we use only the dataset containing survey responses from students in the Portuguese language courses.

The dataset contains 33 total attributes, which for the sake of completeness are listed in the Appendix of this document. However, for our project we chose what we believe to be the seven most insightful and interesting attributes: the student's final grade (the outcome); workday alcohol consumption (the treatment); and extra-curricular activities, study time, going out with friends, health, and number of absences, which we believe will be directly or indirectly related to either or both of the outcome and the treatment (as explained in the "Hypothesis" section of this document).

There were a few other attributes that we considered including in our hypothesis but ultimately decided against. For example, while the quality of the student's relationships with their family members could be hypothesized to have a causal effect on alcohol consumption, we decided not to explore this attribute because it was a self-reported value from 1 to 5. As such, different students may have different perspectives on what constitutes an "excellent" versus "very bad" family relationship, and thus this attribute is not well-defined. Another attribute that we ultimately decided against using was the effect that the number of past failures may have on the student's final grade. While we believe that these two attributes would certainly be associated with each other, this does not warrant a causal relationship. Why not?

You could repeat the analysis with and without either of these attributes.

Study Design

We want to estimate the average causal effect of workday alcohol consumption in the entire population on received grades. As can be seen in the DAG, we surmise that Dalc has 2 different flows of association to G3; the first being directly, and the second being through the covariate "studytime." Within levels of studytime, we expect conditional exchangeability to hold between the treated and the untreated. Thus, we will stratify our analysis by studytime. Since the effect of goout on G3 is likely almost entirely due to associational flow through studytime (in theory, as long as you study sufficiently well, your frequency of going out should not affect grades), we will not adjust by goout. We also need to worry about the flow of association along the path Dalc → health → absences → G3. Under the assumption that the primary reason that students miss class is due to illness (that may or may not be caused by alcohol consumption), we also stratify by absences. All together, within levels of school absence and time spent studying, we expect the association between workday alcohol consumption and final grades to also be causation.

An issue that needs to be accounted for in our proposed plan is the structure of the data that we are stratifying by. The range of study time is relatively small as there are only so many free hours in the week, so this is not an issue. However, the scale for absences is from 0 to 93. To remedy this, we propose further discretizing the data into a fewer number of values. Otherwise, having a small number of students in every stratum would make our model more susceptible to random fluctuations in the data.

We believe that selection bias exists to some degree in the form of censoring. We reason that students who are out drinking are less likely to regularly attend class, increasing the odds that they would not be a part of this survey. Unfortunately, we do not believe that we can adequately correct for this without a better understanding of the body of students who the survey was made available to.

Why not consider the effect of Walc on grades?

A number of other variables listed in the appendix look like potential confounders, e.g., sex, famsup, paid, and internet, among others.

Analysis Method

We hope to discuss various techniques involving continuous outcome values with Professor Podgurski as our next steps for this project. As such, the analysis methods to be used for our project are currently undecided.

Appendix

The following is a complete list of all attributes included in our chosen dataset:

(1) "school": a binary attribute representing the student's school, since the survey collected data from students of two Portuguese secondary schools
(2) "sex": a binary attribute representing the student's sex
(3) "age": a numeric attribute representing the student's age, ranging from 15 to 22
(4) "address": a binary attribute representing the student's home address type, either urban or rural
(5) "famsize": a binary attribute representing the student's family size, either less than or equal to 3 people or greater than 3 people
(6) "Pstatus": a binary attribute representing the student's parent's cohabitation status, either living together or apart
(7) "Medu": an ordinal attribute representing the student's mother's highest level of education; the values are none, primary education, secondary education, or higher education
(8) "Fedu": an ordinal attribute representing the student's mother's highest level of education; the values are none, primary education, secondary education, or higher education
(9) "Mjob": a nominal attribute representing the student's mother's job; the values are teacher, health, services, at_home, and other
(10) "Fjob": a nominal attribute representing the student's father's job; the values are teacher, health, services, at_home, and other
(11) "reason": a nominal attribute representing the reason the student chose to go to their school; the reasons include being close to home, the school reputation, course preferences, and other
(12) "guardian": a nominal attribute representing the student's guardian; the values are mother, father, or other
(13) "traveltime": a numeric attribute representing the time it takes the student to travel from home to school in hours
(14) "studytime": a numeric attribute representing the number of hours a student spends studying on a weekly basis
(15) "failures": a numeric attribute representing the number of classes the student has failed in the past
(16) "schoolsup": a binary attribute representing whether or not the student receives extra educational support
(17) "famsup": a binary attribute representing whether or not the student receives family educational support
(18) "paid": a binary attribute representing whether or not the student has taken extra paid classes within the course subject

(19) “activities”: a binary attribute representing whether or not the student is involved in extra-curricular activities
(20) “nursery”: a binary attribute representing whether or not the student attended nursery school
(21) “higher”: a binary attribute representing whether or not the student wants to take higher education
(22) “internet”: a binary attribute representing whether or not the student has Internet access at home
(23) “romantic”: a binary attribute representing whether or not the student is in a romantic relationship
(24) “famrel”: an ordinal attribute representing the quality of the student’s family relationships, ranging from 1 (very bad) to 5 (excellent)
(25) “freetime”: an ordinal attribute representing the student’s amount of free time after school, ranging from 1 (very low) to 5 (very high)
(26) “goout”: an ordinal attribute representing the student’s amount of time spent going out with friends, ranging from 1 (very low) to 5 (very high)
(27) “Dalc”: an ordinal attribute representing the student’s workday alcohol consumption, ranging from 1 (very low) to 5 (very high)
(28) “Walc”: an ordinal attribute representing the student’s weekend alcohol consumption, ranging from 1 (very low) to 5 (very high)
(29) “health”: an ordinal attribute representing the student’s current health status, ranging from 1 (very bad) to 5 (very good)
(30) “absences”: a numeric attribute representing the student’s number of school absences
(31) “G1”: a numeric attribute representing the student’s first period grade
(32) “G2”: a numeric attribute representing the student’s second period grade
(33) “G3”: a numeric attribute representing the student’s final grade