Name: Myra Rust
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Title: Predicting Success Rates of In Vitro Fertilization (IVF)

- **Introduction**
  Many women have difficulty becoming pregnant and look to assisted reproductive procedures to help with conceiving a child. In vitro fertilization (IVF) is one of the procedures available. During the IVF procedure, an egg is retrieved from the woman, fertilized in a laboratory, then the fertilized embryo is transferred to the woman's uterus. The IVF process is a very expensive process and therefore, someone looking to undergo the procedure would be interested in knowing success rates and factors that can affect success rates. An individual should be able to review the information provided by the models and use it to help decide whether in vitro fertilization is a good choice for them.

- **Research questions**
1. What is the success rate of in vitro fertilization compared to other assisted reproductive procedures?
2. What is the success rate of in vitro fertilization by age?
3. What factors have the largest positive and negative effects on the in vitro fertilization process?
4. Does using multiple embryos increase your chances of success?
5. How much does using multiple embryos increase the likelihood of having twins or multiples?

- **Addressing the problem**
  The data set used for this research project was provided by the Human Fertilization and Embryology Authority (HFEA) in the United Kingdom. The data set included extensive fertility information on patients for the years of 2015 – 2016. Descriptive and inferential statistics along with visualizations were used to answer the research questions and draw conclusions about the success rate of the procedure based on the effects of a variety of variables. It is important to note that in this research, success of the IVF process is defined as a pregnancy being achieved.

  Reference Data Set: **https://www.hfea.gov.uk/media/2667/ar-2015-2016-xlsb.xlsb**

- **Insights from Analysis**

Q1: My first research question focused on success rates of IVF compared to other assisted reproductive procedures, but it is difficult to compare the different fertility treatments because the treatment chosen is usually based on the circumstances surrounding the individual(s) involved in the process. For example: a woman having difficulty becoming pregnant because of her age might choose IVF, whereas a woman without a partner, wishing to become pregnant may choose Generic Donor Insemination (DI).

**Number of Pregnancies by Treatment Cycles & Treatment Type**
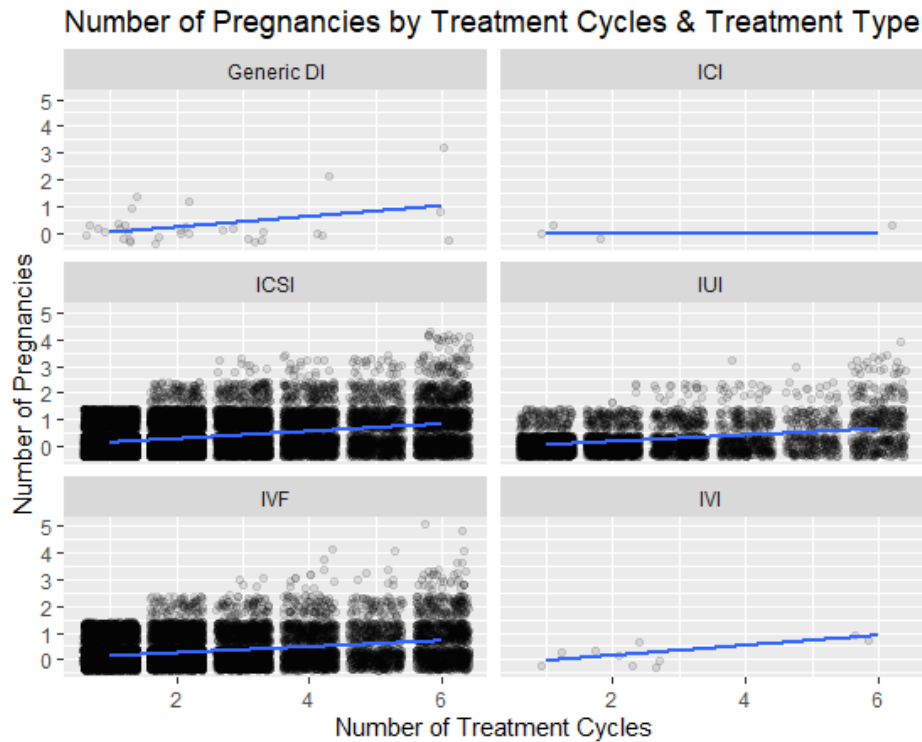
Above is a scatterplot showing the relationship between the number of pregnancies and the number of treatment cycles for each type of fertility procedure. Even though these procedures cannot be compared 1 for 1, I used a multiple regression model and a significant regression equation was found, $(F(7, 70817)) = 99.14$, $p < .001$, with an R^2 of 0.126. Participants total pregnancies increased 13% with each additional cycle of treatment.

Q2: Focusing now on IVF, I calculated the mean IVF success rate variable by using only observations that had at least 1 cycle of IVF and dividing the number of IVF pregnancies by the number of IVF treatment cycles. The results indicate that the 35-37 age group has the highest success rate for IVF at nearly 18% per cycle, with a gradual decline after that, and then drastically dropping to approximately 13% per cycle for the 43-44 age group.
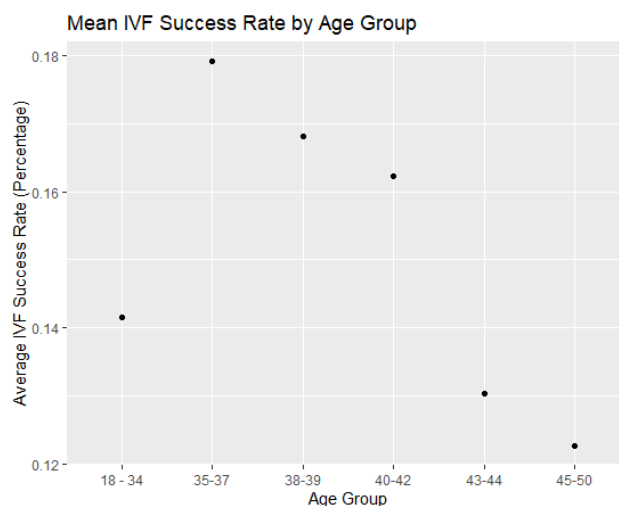
Q3: In attempt to identify what factors have the largest positive/negative effects on the IVF process, I created two heat maps. The first to view if there was correlation between IVF success rate and any of the infertility reason variables. No obvious correlations were viewed and I decided not to further investigate those variables.
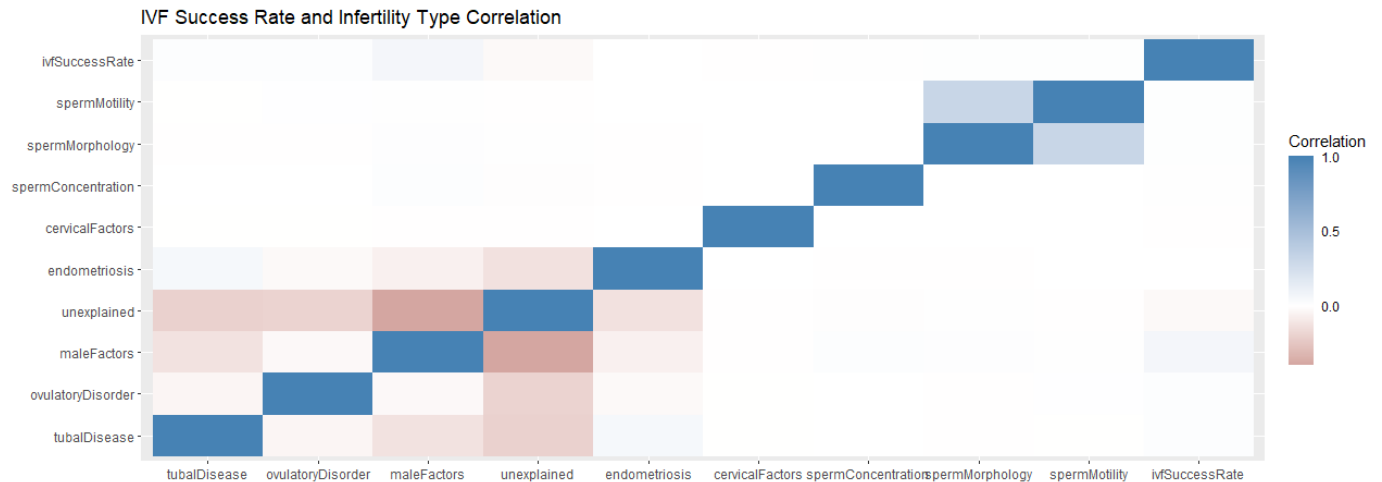

The second heat map was created to display any correlation between IVF success rate and the type of embryo used for the procedure. The heat map did indicate that there was a slight positive correlation between IVF success rate and using a frozen embryo, a slight negative correlation between IVF success rate and using a fresh embryo, and no correlation between IVF success rate and using a donor embryo, which was not what I had expected.
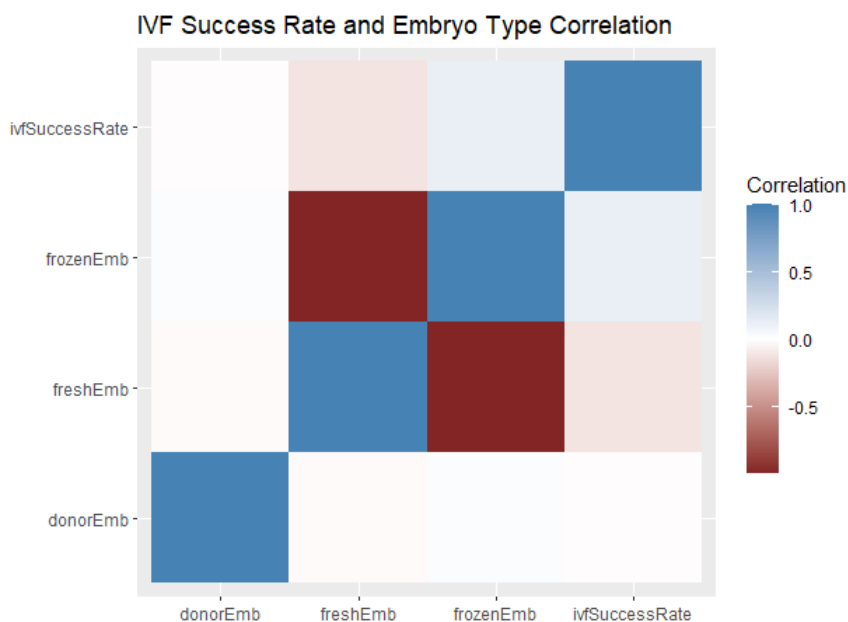
Q4: While researching if using multiple embryos increased the chance of IVF success, I was again surprised by the results. It appears that transferring one embryo had the highest average success rate at 20%, then dropping to 13% when transferring two or three embryos.

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> successByNumEmb
  numEmbXfer meanIVFSuccessRate
1          1          0.2010181
2          2          0.1305738
3          3          0.1320928
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IVF Success Rate by Number Embryos Transferred
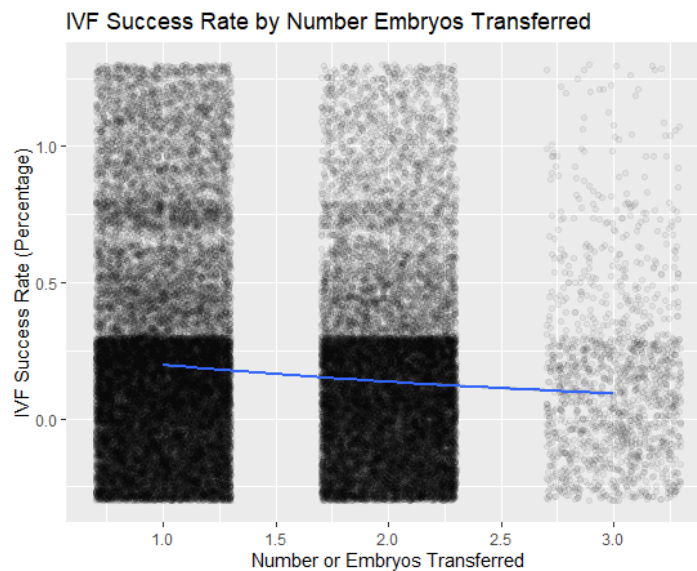
Q5: When plotting number of live births by number of embryos transferred, it was visually obvious that transferring two embryos increases likelihood that a woman will have multiples. I decided to drill down manually and calculate the likelihood of having multiples by the number of embryos transferred, the results are provided in the table below.

Live Births by Embryos Transferred
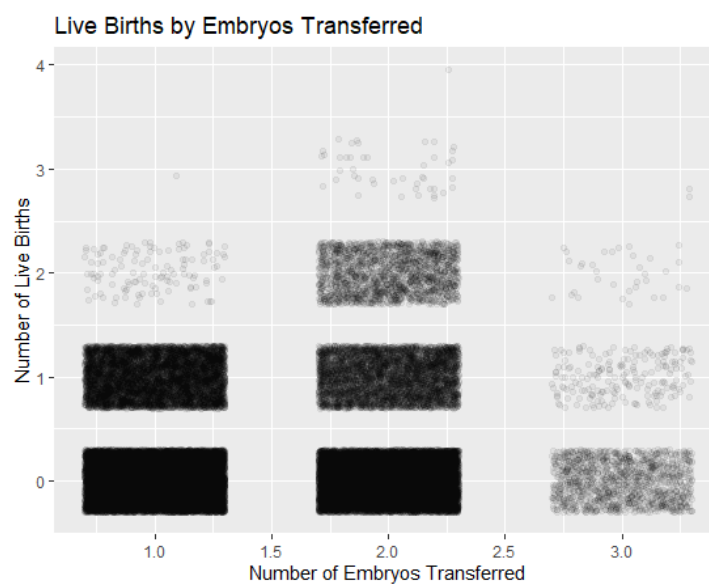
Number of Embryos Transferred	Likelihood of having multiples
1	1%
2	22%
3	13%

- **Summary of Implications**

  Implications to consider with the IVF process are:
  - IVF on average has a low success rate, maxing out at 18% per cycle.
  - That rate does increase with the number of cycles performed. A woman considering the IVF process, should be aware that more than likely several cycles will be required.
  - The 35-37 age group has the highest average success rate at 18% success per cycle, with the likeliness of success decreasing thereafter.
  - Transferring one embryo has the highest rate of success.
  - Transferring two or more embryos significantly increases your chances of having multiples.

- **Limitations**

  I was limited by my lack of scientific knowledge on the topic and could only provide the numbers, but there were findings that would be interesting to follow up on, learn more about, and also conduct more research. Unfortunately, due to time constraints with this project, I had to keep it limited to my original research questions. Additional research could be conducted on:
  - What percentage of IVF pregnancies end in live births, by age group?
  - Further investigate the correlation discovered between type of embryo used and IVF success rate.
  - Research any scientific reasons behind the transferring of more embryos decreasing the chance of success.