# Data Analysis for iGEM Trinational Survey

## Question 1: Gender

This question was designed to obtain the gender profile of the respondents, which is summarized in the following table and graph. (the total number may not tally as not all respondents revealed their gender)

Table 1. Gender of respondents

| | China | Indonesia | Singapore | Total |
|---|---|---|---|---|
| Female | 207 | 107 | 19 | 333 |
| Male | 140 | 72 | 31 | 243 |
| Total | 347 | 179 | 50 | **576** |

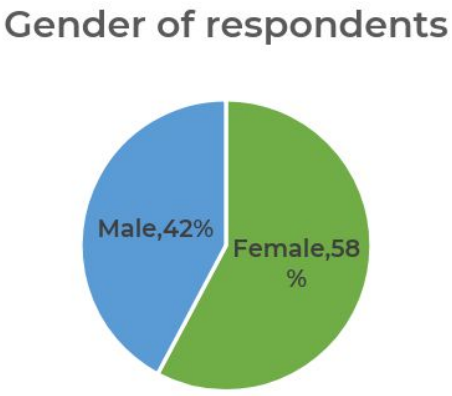


Figure 1. Gender of respondents

There are total of 576 respondents who indicated their gender, out of which, **42% are males and 58% are females.**

## Question 2: Age

This question was designed to obtain the age profile of the respondents. The following graph represent the age profile of the respondents from all three countries.

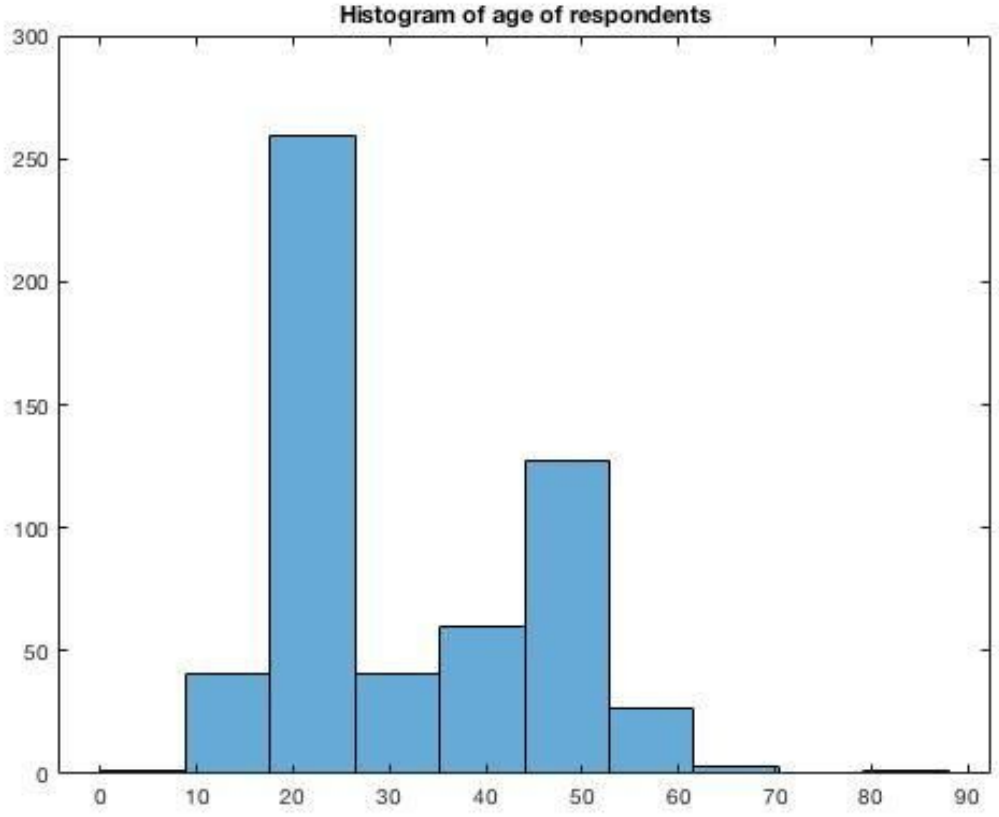


Figure 2. Histogram of age of respondents from all three countries.

There is a large proportion of respondents aging about 20 years old, possibly due to that we collected responses from the outreach activities, whose target audience are young people.

**Question 3: "I know someone with genetic disease." How confident are you in saying this? (scale of 1 to 5)**

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3.1 Aim

This question was designed to understand whether the respondents are aware of the cases of genetic diseases around them.

3.2 Result

The following table represents the average score for this question for all three countries.

Table 2. Average score for question 3 for all three countries

| | "I know someone with genetic disease" |
|---|---|
| Singapore | 2.60416667 |
| Indonesia | 3.28021978 |
| China | 3.58 |

To find out whether the difference between the mean score is significant, a T-test assuming unequal variances with null hypothesis being that there is no difference between the mean score of any two countries is carried out. The p-values for one-tail test are summarized in the table below.

Table 3. p-values for the mean score of question 3 for one-tail T-test

| | Singapore | Indonesia | China |
|---|---|---|---|
| Singapore | - | 0.00570184 | 1.9296E-05 |
| Indonesia | 0.00570184 | - | 0.00121552 |
| China | 1.9296E-05 | 0.00121552 | - |

3.3 Analysis

All of the p-values are less than 5%, the most commonly used reference, suggesting that all the differences between the mean values are significant. Therefore, it is safe to conclude that **people in China have a higher chance to know anyone with genetic disease, followed by Indonesia and Singapore**.

**Question 4: " Some diseases are caused by defects in genes." To what extent do you agree with this statement? (scale of 1 to 5)**

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4.1 Aim

This question was designed to understand whether the respondents are aware of the cause of genetic diseases.

4.2 Result

The following table represents the average score for this question for all three countries.

Table 4. Average score for question 4 for all three countries

| | "Some diseases are caused by defects in genes" |
|---|---|
| Singapore | 4.39583333 |
| Indonesia | 3.78021978 |
| China | 3.85 |

To find out whether the difference between the mean score is significant, a T-test assuming unequal variances with null hypothesis being that there is no difference between the mean score of any two countries is carried out. The p-values for one-tail test are summarized in the table below.

Table 5. p-values for question 3 for one-tail T-test (>5%, yellow)

| | Singapore | Indonesia | China |
|---|---|---|---|
| Singapore | - | 3.1219E-06 | 9.4125E-05 |
| Indonesia | 3.1219E-06 | - | 0.07865498 |
| China | 9.4125E-05 | 0.07865398 | - |

4.3 Analysis

The p-values between Singapore and the other two countries less than 5%, the most commonly used reference, suggesting that **Singaporeans are more aware of the cause of genetic diseases than China and Indonesia.** China, though having a higher sample mean than Indonesia, may still hold the same population mean as the p-value (0.0786) is higher than 0.05, suggesting that the difference may be caused by random sampling.

**Question 5: If you agree with the previous statement, can you name some of the diseases that are caused by genetic defects?**

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5.1 Aim

This question was designed to understand what are the most common genetic diseases to the respondents.

5.2 Result

For easier visualization, the responses from respective countries are summarized in the form of word cloud shown below.

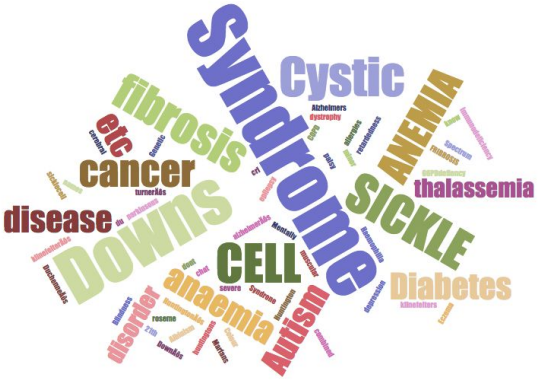


Figure 3. Word cloud for responses from Singapore for question 5.

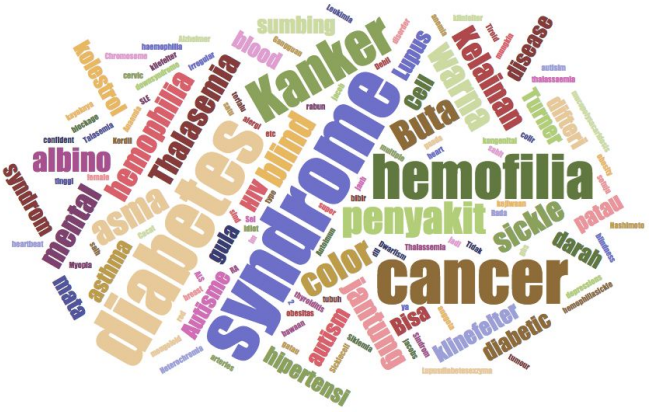


Figure 4. Word cloud for responses from Indonesia for question 5.


Figure 5. Word cloud for responses from China for question 5.

5.3 Analysis

According to responses from Singapore, the diseases that occur with the highest frequency is **down's syndrome**, followed by cystic fibrosis, diabetes, Huntington's disease and sickle cell anemia.

According to responses from Indonesia, the diseases that occur with the highest frequency is **down's syndrome**, followed by hemophilia, diabetes and cancer.

According to responses from China, the disease that occur with the highest frequency is **color blindness**, followed by down's syndrome, mental disorders, diabetes, hemophilia, albino, hypertension.

Over 50% of the respondents are able to identify at least one genetic disease correctly, with diabetes and down's syndrome being the most frequently mentioned diseases for all three countries. This suggests that most respondents have some degree of awareness of the genetic diseases around us.

However, cancer, being one of the most common genetic disorders, is surprisingly not among the most commonly mentioned diseases in the responses. It only ranks 4$^{th}$ most frequently identified genetic diseases for

Indonesia and the rank is even lower in the other two countries, indicating that cancer is not classified as a genetic disease according to most of the respondents. Therefore, we can conclude **that though most respondents are able to name one or a few genetic disorders, they are less familiar with what exactly constitutes a genetic disease.**

**Question 6: To what extent do you agree with the following applications of gene editing on humans? [Cure lethal disease, cure non-lethal diseases, improve intelligence, improve physical features] (scale of 1 to 5)**

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6.1 Aim

This question was designed to understand what the acceptance level for gene editing on humans is in these countries. To further understand how the acceptance changes under different circumstances, the question was further divided into four different hypothetical situations.

6.2 Result

6.2.1 Result from individual countries.

The responses are represented by the column graphs as shown below.

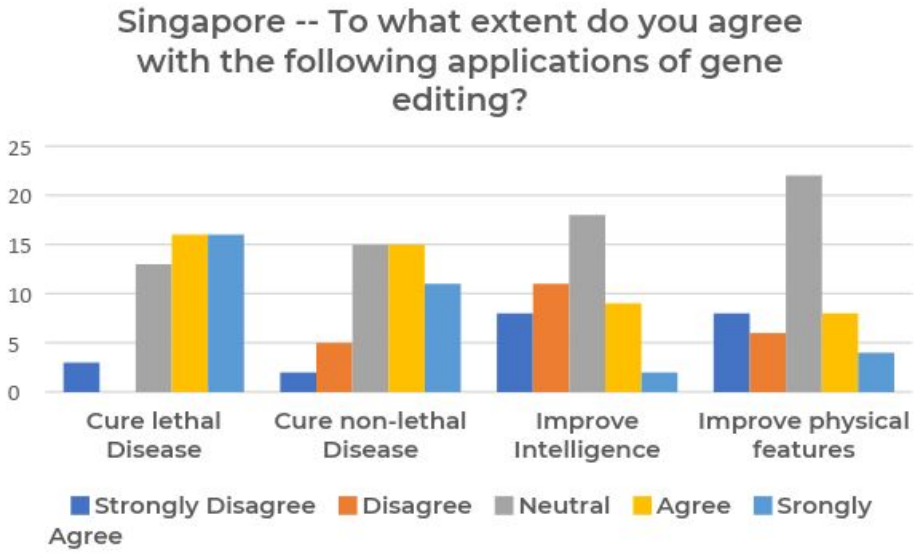


Figure 6. Graph of the responses from Singapore for question 6

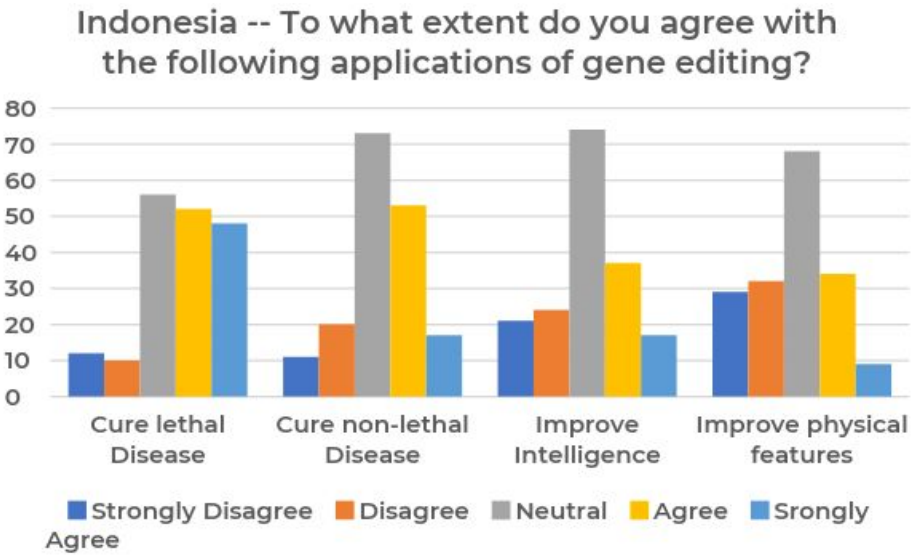


Figure 7. Graph of the responses from Indonesia for question 6

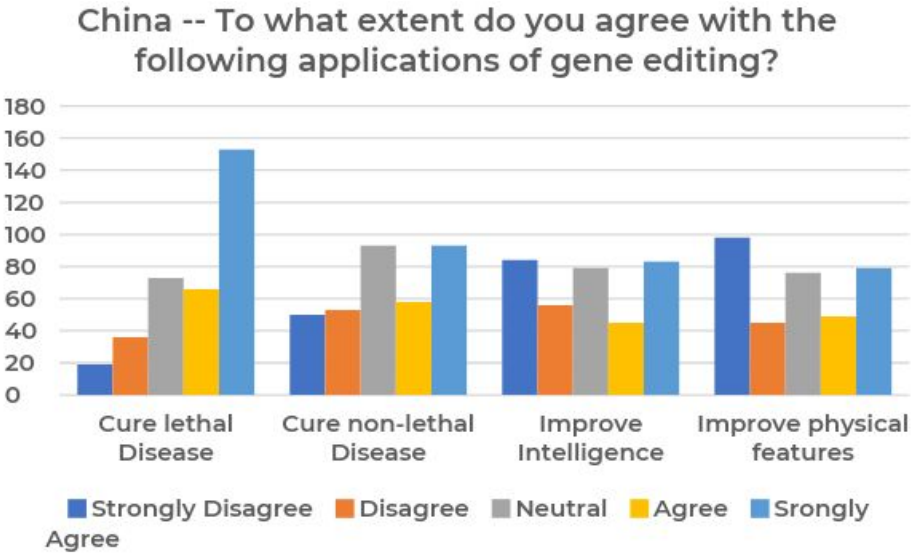


Figure 8. Graph of the responses from China for question 6

6.2.2 Comparison across countries

To compare across the countries, a graph of mean score for all four applications of gene editing and all three countries is plotted and shown below.

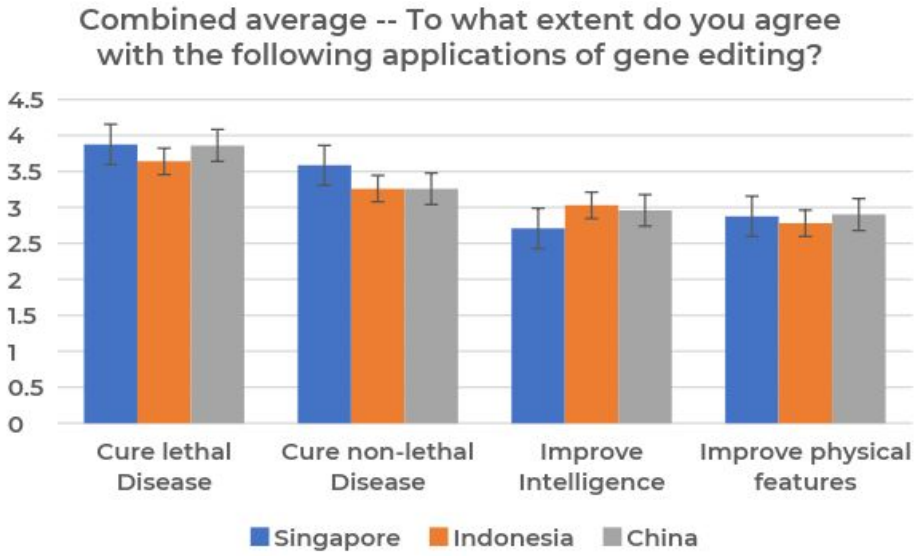


Figure 9. Graph of the mean score for question 6 for all three countries

As the difference between the mean score is relatively small, for more direct comparison, the mean scores for the countries for question 6 are tabulated below.

Table 6. mean scores of all three countries for question 6 (highest, yellow)

| | Lethal Disease | Non-lethal Disease | Intelligence | Physical features |
|---|---|---|---|---|
| Singapore | 3.875 | 3.58333333 | 2.70833333 | 2.875 |
| Indonesia | 3.64044944 | 3.25862069 | 3.02890173 | 2.77906977 |
| China | 3.86 | 3.26 | 2.96 | 2.9 |

To find out whether the difference between the mean score is significant, a T-test assuming unequal variances with null hypothesis being that there is no difference between the mean score of any two countries is carried out. The p-values for one-tail test are summarized in the table below.

Table 7. p-values of the mean scores for question 6 for one-tail T-test (>5%, yellow)

| | Lethal disease | Non-lethal disease | Intelligence | Physical feature |
|---|---|---|---|---|
| Singapore - China | 0.09601312 | 0.03344968 | 0.03841623 | 0.30294852 |
| Singapore - Indonesia | 0.46218823 | 0.03436124 | 0.0771206 | 0.44179092 |
| China - Indonesia | 0.02218655 | 0.48636697 | 0.28447038 | 0.14773829 |

## 6.3 Analysis

### 6.3.1 General trend for individual countries

Generally, people are receptive of gene editing on the purpose of curing lethal diseases, as it holds the highest proportion of “agree” and “strongly agree”. As of the other three applications of gene editing, the trend differs.

- In Singapore, people support **more on curing minor diseases, followed by improving physical trait, and lastly intelligence.**
- In Indonesia, people support **slightly more on curing non-lethal diseases, followed by improving intelligence and physical features.**
- In China, the graphs hold the same shape for all three other applications of gene editing. **There is no obvious difference in the support level.**

### 6.3.2 Comparative analysis between countries

From the mean score only

- Singapore ranks first in accepting gene editing to cure lethal and non-lethal diseases.
- Indonesia ranks first in accepting to improve intelligence;
- China ranks first in improving physical features.

From the p-values

- In curing lethal disease, the acceptance level of China is significantly higher than that of Indonesia.
- In curing non-lethal disease, the acceptance level of Singapore is significantly higher than China and Indonesia.
- In improving intelligence, the acceptance level of Singapore is significantly higher than China.
- In improving physical features, all the p-values are above 0.05, suggesting any difference between the mean score could be attributed to random sampling.

**Question 7: Should you ever be diagnosed with genetic disease, how confident are you in making an informed choice to do gene therapy? (scale of 1 to 5)**

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7.1 Aim

This question was designed to understand how much the respondents perceive themselves to know about gene therapy. It also leads to the next question of the different factors to consider when making a choice about gene therapy.

7.2 Result

To understand the difference between the perceived knowledge on gene therapy among the countries, a graph of the confidence level of all countries is plotted in the graph below.

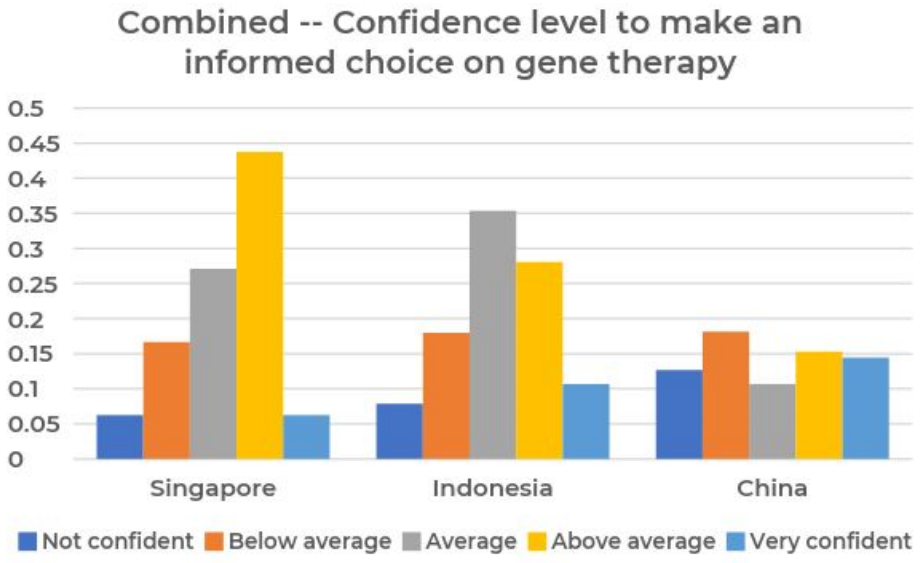


Figure 10. Graph of the responses from all countries for question 7

The average scores for Singapore, Indonesia and China are 3.27, 3.15 and 3.01 respectively.

To find out whether the difference between the mean score is significant, a T-test assuming unequal variances with null hypothesis being that there is no difference between the mean score of any two countries is carried out. The p-values for one-tail test are summarized in the table below.

Table 8. p-values for the mean score of question 6 for one-tail T-test

| | Singapore | Indonesia | China |
|---|---|---|---|
| Singapore | - | 0.25194456 | 0.05257547 |
| Indonesia | 0.25194456 | - | 0.07233733 |
| China | 0.05257547 | 0.07233733 | - |

7.3 Analysis

From the graph, Singapore and Indonesia show similar trends where there is a bulk in the middle. Most of the people in these two countries perceive themselves to have some degree of confidence when they need to make a decision on gene therapy. Whereas for people in China, there is no obvious peak or valley, suggesting that the degree of confidence is random.

From the mean score, Singapore is the country to have the highest perceived knowledge on gene therapy, followed by Indonesia and China. However, all the p-values are above 0.05, indicating that the difference may not be significant enough. Therefore, it is not sufficient to conclude that people in Singapore are more aware of gene therapy.

**Question 8: Please rate the importance of the following factors in affecting your decision to do gene therapy. [Cost, safety, ethics] (scale of 1 to 5)**

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8.1 Aim

This question was designed to understand what the most important concerns for the respondents are when considering gene therapy. The most common factors that we have identified are cost, safety and ethics. This question was followed by an open-ended question where respondents could share about other concerns that we have not identified.

8.2 Result

8.2.1 Results from individual countries

To understand which factor is the most important for each country, graphs of the responses for each factor are plotted below.

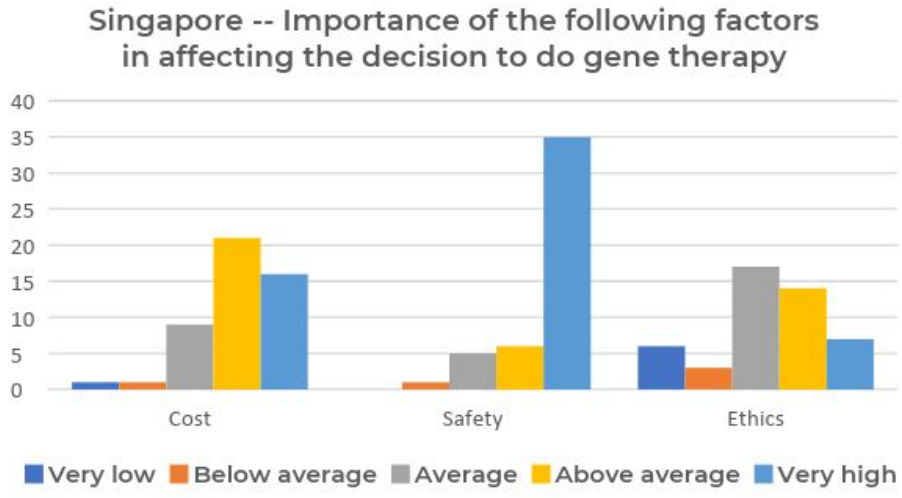


Figure 11. Graph of the responses from Singapore for question 8

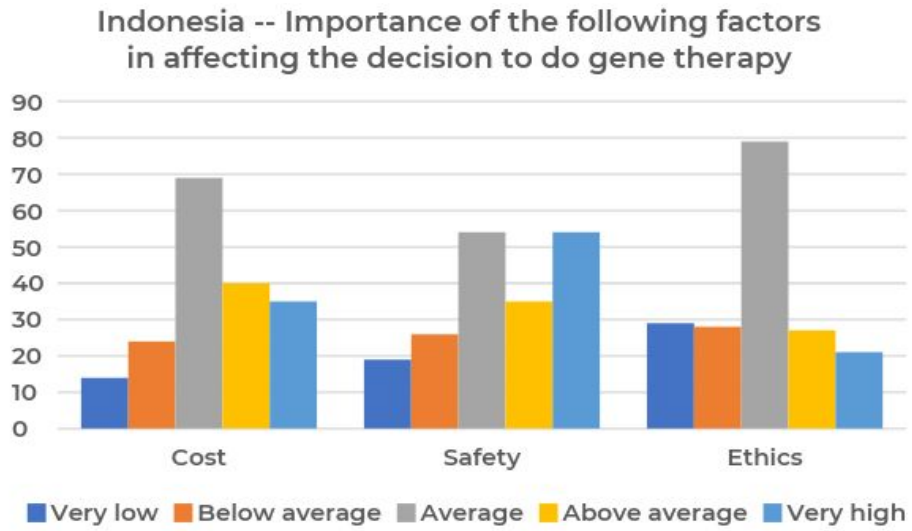


Figure 12. Graph of the responses from Indonesia for question 8

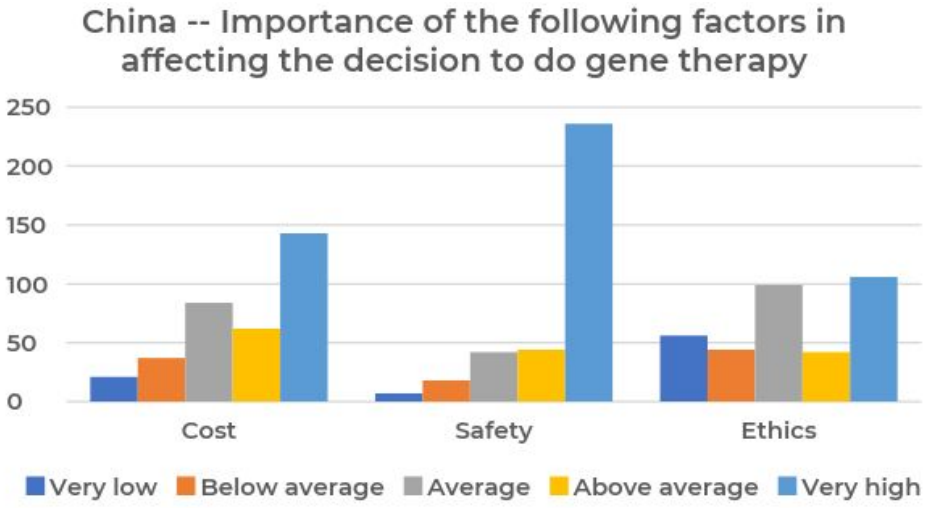


Figure 13. Graph of the responses from China for question 8

8.2.2 Comparison across countries

The average score for each factor for each country is computed and tabulated below.

Table 9. Mean scores for all three countries for question 8

| | Cost | Safety | Ethics |
|---|---|---|---|
| Singapore | 4.04166667 | 4.59574468 | 3.27659574 |
| Indonesia | 3.31868132 | 3.42021277 | 2.9076087 |
| China | 3.77521614 | 4.39481268 | 3.28242075 |

The mean scores for each factor for each country are plotted in the graph shown below

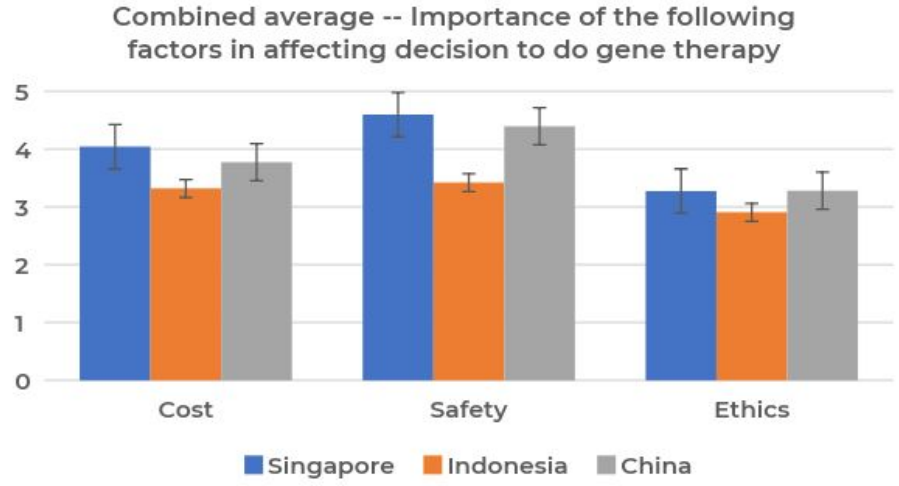


Figure 14. Graph of the mean scores from all three countries for question 8

To find out whether the difference between the mean score is significant, a T-test assuming unequal variances with null hypothesis being that there is no difference between the mean score of any two countries is carried out. The p-values for one-tail test are summarized in the table below.

Table 10. p-values for the mean score of question 8 for one-tail T-test (>5%, yellow)

| | Cost | Safety | Ethics |
|---|---|---|---|
| Singapore - China | 0.03613017 | 0.05623045 | 0.487824 |
| Singapore - Indonesia | 3.4005E-11 | 2.409E-05 | 0.10209114 |
| China - Indonesia | 0.0001433 | 3.2966E-14 | 0.01326133 |

8.3 Analysis

8.3.1 General trend for individual countries

- Safety is the most important as it is ranked highest factor for all three countries.
- Cost is the second most important factor as it is ranked second highest for all three countries.
- Ethics is the least important factor, and the difference between ethics and cost is larger than the difference between cost and safety.

8.3.2 Comparative analysis between countries

From the mean score only

- Singaporean are most concerned about the safety of the technology and the price as Singapore ranks first in these two categories, followed by China and Indonesia.
- China and Singapore are more concerned with ethics than Indonesia.
- Indonesia ranks lowest for all three factors of cost, safety and ethics.

From the p-values

- In the aspect of ethics, only China is more concerned with this factor than Indonesia. The difference between Singapore and China or Indonesia could be due to random sampling.
- In the aspect of cost, China and Singapore possibly have the same mean.

**Question 9: Apart from aforementioned factors, is there any other factor that may affect your decision to do gene therapy??**

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9.1 Aim

This question was designed to understand what could be the other concerns that the respondents may have regarding gene therapy apart from the three factors that we have identified.

9.2 Result

This question was designed to understand what could be the other concerns that the respondents may have regarding gene therapy apart from the three factors that we have identified.

This question was designed to understand what could be the other concerns that the respondents may have regarding gene therapy apart from the three factors that we have identified.

Pertaining to the technology itself:

- What is the success rate?
- How long does it take to cure?
- Is it a permanent cure?
- What could be the possible side effects? Does it interfere with non-targeting genes?
- Does it induce pain?
- Is it going to affect my children?

Pertaining to the society:

- What is the public acceptance level for gene therapy?
- Would it change how other people see me?
- Will my data be protected?
- Will this change the bio environment of the earth?
- Does it make crime more difficult to detect?

9.3 Analysis

There are many responses from the respondents, most of which could be classified into pertaining to the technology itself and the long-term effect it could induce on the society. About the technology, people are most concerned about the safety level of this new mode of treatment. From the social aspect, people are concerned about what others think of it and whether the information would be protected or not.

**Question 10: If you were to take genetic therapy, which of the following treatment would you prefer? [one-off treatment with permanent changes and irreversible effects (DNA editing), multiple treatments with temporary changes and reversible effects (RNA editing)]**

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10.1 Aim

This question was designed to understand whether the respondents would be more willing to receive DNA gene therapy or RNA gene therapy.

10.2 Result

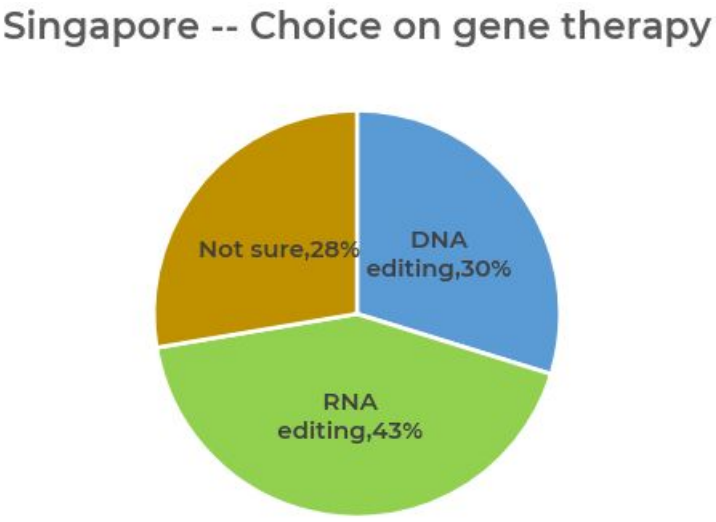


Figure 15. Responses from Singapore for question 10

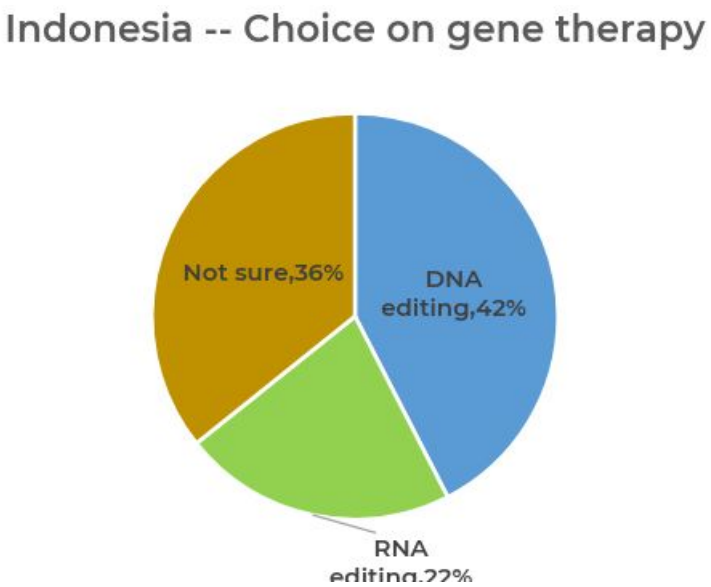


Figure 16. Responses from Indonesia for question 10

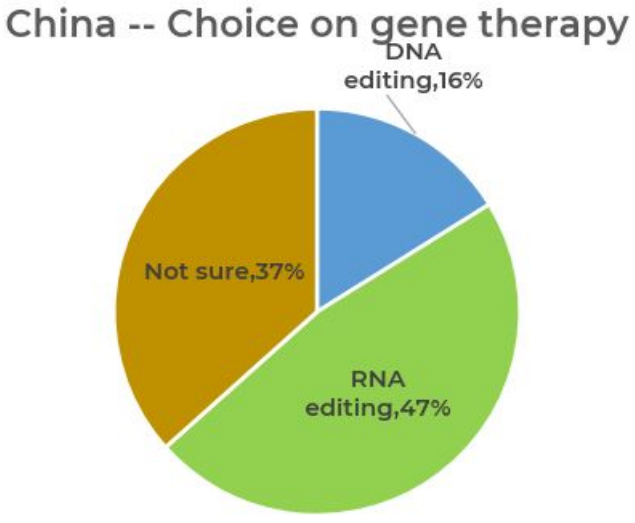


Figure 17. Responses from China for question 10

10.3 Analysis

- Singaporeans prefer RNA editing (42%) over DNA editing (30%), with a difference of **12%.**
- Indonesians prefer DNA editing (42%) over RNA editing (22%), with a difference of **20%.**
- Chinese prefer RNA editing (47%) over DNA editing (16%), with a difference of **31%.**

**Question 11: If you were to take genetic therapy, would you prefer your children to inherit your genetic changes as well?**

11.1 Aim

This question was designed to understand whether the respondents would be willing to genetically modify their children before they were born.

11.2 Result

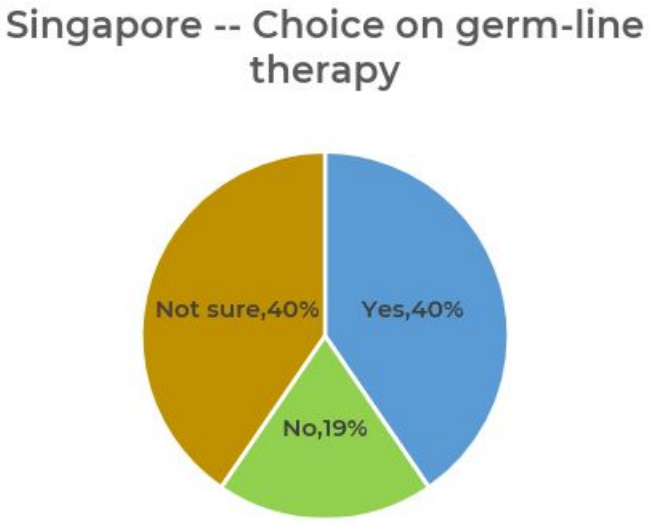


Figure 18. Responses from Singapore for question 11


Figure 19. Responses from Indonesia for question 11

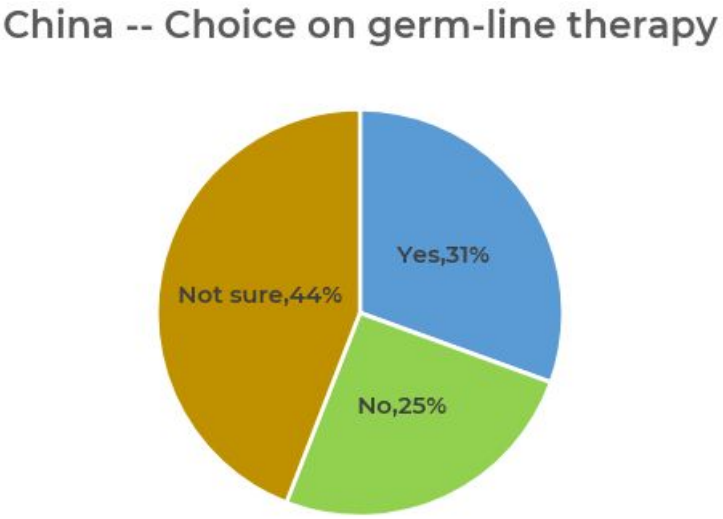


Figure 20. Responses from China for question 11

11.3 Analysis

- The largest proportion of the respondents chose “I am not sure”, indicating that most of them are not particularly sure if they want their children to have the same genetic changes or not.
- Of the respondents who made a choice, all countries show a preference on germ-line gene editing.

- Singapore is the country with the highest proportion supporting germ-line gene editing (41%), followed by Indonesia (36%) and China (31%).

## Question 12: Educational background

12.1 Aim

This question was aimed to obtain the educational background of the respondents and investigate if there is any relationship between educational background and their choice on gene therapy.

12.2 Result

Educational background itself is not of great value to the analysis. We seek to relate education with the decision people make regarding gene therapy as described in question 10 and question 11, and it is represented in the following graph.

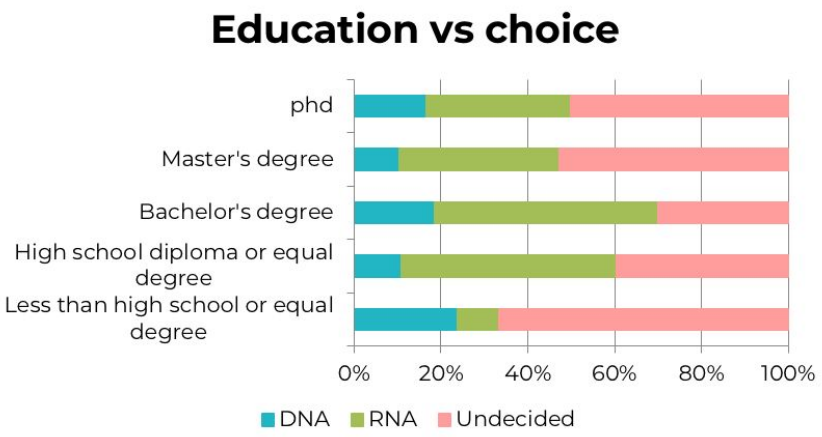

Figure 21. Cross relation between question 12 and question 10

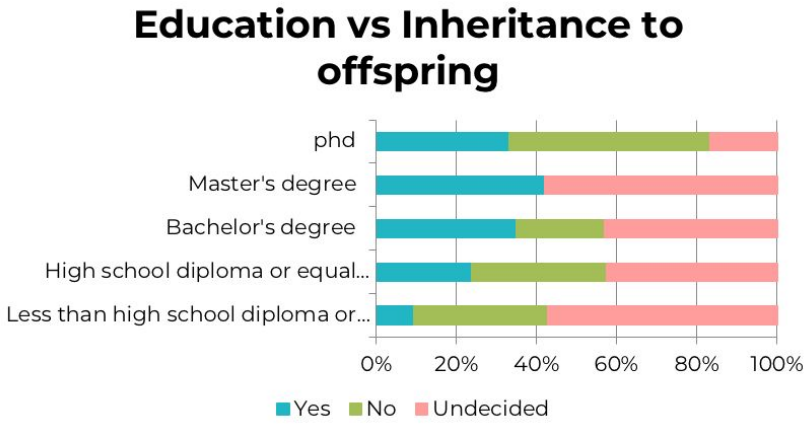


Figure 22. Cross relation between question 12 and question 11

12.3 Analysis

- The vast majority of the respondents hold either Bachelor's degree or high school diploma, therefore trends in these two categories are more representative than the other three.
- For both cases, people with less than high school diploma show the highest percentage choosing "I am not sure".
- For question 10, there are less people with Bachelor's degree who are undecided for choosing between RNA editing and DNA editing compared to high school diploma.
- There is a slight increase in the percentage of people choosing RNA editing and a slightly larger increase in the percentage of people choosing DNA editing from high school diploma to Bachelor's degree.
- Comparing between these two groups and the other three groups at the end, there is a higher percentage of people favoring RNA editing with a high school diploma or a Bachelor's degree.

- For question 11, there are more people willing to pass down the genetic changes to their children in Bachelor's degree as compared to high school diploma.

## Conclusions

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1. **Awareness of gene editing and gene therapy**

   Question 3, 4 and 5 test the respondents of their awareness of genetic disease, including awareness of cases of genetic disease around them, awareness of cause of genetic disease and if they could correctly identify some common genetic diseases.

   Chinese are more aware of the cases of genetic disease around them; Singaporeans are more aware of the cause of genetic disease; and all of them are able to identify some common genetic diseases.

   In order to minimize bias from the falsified perception of the respondents, question 5 was set to test the real understanding of the respondents on genetic diseases. The country with the highest

percentage of responses is Singapore (80%), followed by Indonesia (74%) and China (69%). This is further supported by the responses from question 7, where Singapore ranks highest for the confidence level to make an informed choice for themselves on gene therapy.

Therefore, we can conclude that **Singaporeans have the highest awareness level** of the genetic disease.

2. **Acceptance of gene editing and gene therapy**

Question 6 tests the acceptance level of the public on different applications of gene editing and gene therapy on humans, namely curing lethal diseases, curing non-lethal diseases, improving intelligence and improving physical features.

All the countries show the strongest support for curing lethal diseases. Singapore ranks highest for curing lethal disease and non-lethal disease, while Indonesia ranks highest for improving intelligence. As of improving physical features, there is no significant difference between countries as suggested by a higher than 0.05 p-value. Singapore ranks lowest for this section. All the countries have similar values of improving physical features.

Therefore, we can conclude that **Singaporeans support most for curing diseases and least for improving intelligence.**

3. Concerns on gene editing and gene therapy

Question 8 asks about the important factors to consider when deciding on gene therapy. The three factors that we hypothesized to be the most important are safety, cost and ethics. To avoid limiting our scope only to these three factors, question 9 was designed to

elicit more responses from the public and we indeed found a fourth important factor that many people consider important -- social stigma.

**The most important factor for Singaporeans is safety, followed by cost**. The mean scores for two factors for Singaporeans are significantly higher than the other two countries. As for ethics, though Singapore's score is the lowest, p-value analysis shows that it could be due to random sampling. Nevertheless, it is still sufficient to show that as compared to cost and safety, **ethics is relatively unimportant.**

Through the open-ended question 9, we identified that the concerns of the public can be divided into two large groups, one related to the details and effectiveness of gene editing, the other related to social issues – whether they will be treated differently by the society if they receive genetic treatment or if their privacy would be protected.

From the open responses, we can reaffirm that the **most important factor for the public is indeed safety**, as concerns regarding the safety of the technology appear at the highest frequency. Furthermore, we are able to identify a **fourth factor that the public worry about – social issue**, or the fear to be viewed as a social outlier.

4. **Choice between DNA editing and RNA editing**

Question 10 asks about the preference for gene editing -- whether the public prefers DNA editing or RNA editing.

From the responses with a choice made, all countries show a higher percentage of people choosing RNA editing over DNA editing. In

Singapore, there are 42% of the respondents choosing RNA editing, relatively higher than those choosing DNA editing, which is 30%. **Therefore, the public in Singapore favor towards RNA editing.**

5. **Choice between germline editing and somatic editing**

Question 11 asks about the preference for germline editing – whether the public want to pass the genetic changes to their children.

From the responses, Singapore is the country with the highest percentage of agreement (41%) on passing down genetic changes, while the percentage saying no is only 19%, about half of the population saying yes.

**Therefore, the public in Singapore support germline editing.**

6. **Relationship between educational background and choice**

Question 12 asks about the educational background of the respondent. To find out whether the level of education would have an effect on the choice that people make, the responses from questions 10 and 12 are divided according to the respondent's educational level.

The study is limited by the relatively huge proportion of respondents with a high school diploma and Bachelor's degree (more than 80%), and low proportion of respondents with a degree higher than a Bachelor's degree and a degree lower than that of high school diploma.

By comparing two largest groups with the others, we can observe that **people with a high school diploma and Bachelor's degree**

**show a stronger preference for RNA editing (about 50%) as compared to the other three groups at the end (about 40%).**

By comparing between the two largest groups, we can observe that **people with a Bachelor's degree are more willing to pass down their genetic changes to their offspring.**