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Exploring COVID-19 Vaccine Side Effects: A Correlational Study Using Python

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Abstract

The COVID-19 pandemic had a great impact on the socio-economic stability of every country. To curb the effect and risk of transmission, governments implemented various measures including the mandatory vaccination of their citizens. However, despite these efforts, many people are still hesitant to take the vaccine because of various reasons and biases. This paper attempts to explore the perceptions of the people who have undergone vaccinations regarding the various side effects to provide inputs to vaccine manufacturers and assist people in making informed decisions in selecting the appropriate vaccine for them. The study further explored the correlation and association of age, weight category, diet category, blood type, and sleeping patterns with the severity of the selected vaccine side effects. The results revealed that vaccine side effects are associated with the vaccine type. Age, gender, weight category, diet category, blood type, and sleeping patterns have significant relationships to one or more side effects.

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Peer-review under responsibility of the Conference Program Chairs.

Keywords: COVID 19 Vaccine; Side Effects; Python; Chi-square; Spearman Correlation; Pfizer; AstraZeneca

1. Introduction

The onset of the COVID-19 brought about by the Novel Coronavirus in December 2019 led governments of every country across the globe to impose restrictions on various activities in the society [1]. Government agencies
had imposed lockdowns and temporary closures of establishments to curb the spread of the virus. This action had an adverse impact not only on the economy in general but on almost all sectors of society [2].

Governments find vaccines as the viable solution to curb the impacts of the pandemic specifically in the economy of the country. Initiatives were carefully undertaken to ensure that citizens could avail vaccination either for free or through personal initiatives. Despite these efforts, it is observed that the rate of vaccination is low as many have apprehensions about taking the vaccines for various reasons. BBC reported that people have different biases from vaccine brands and possible severe side effects, especially for older people. Although health practitioners have emphasized the risks of side effects are less significant than that of the risks of the disease itself [3].

The Supreme Council of the Sultanate of Oman, to encourage its citizens and expatriates to take the vaccine and to slow down the rate of virus transmission had issued effective September 1, 2021, a decree mandating the presentation of vaccination certificates in entering private and public premises such as schools, restaurants, shopping malls, etc[4]. Notwithstanding, the rate of vaccination is observed not to be in a full swing as people are hesitant due to the risks involved.

This paper attempted to explore the perceptions of the people who have undergone vaccinations regarding the various side effects to provide inputs to vaccine manufacturers and assist people in making informed decisions in selecting the appropriate vaccine for them. The study further explored the correlation and association of age, weight category, diet category, blood type, and sleeping patterns with the severity of the selected vaccine side effects. Ultimately, the analyzed data can be used as a training dataset for the design of prediction algorithms.

2. Review of Related Studies

There are studies conducted across different countries about the side effects of COVID 19 vaccines. Most of the studies focus on AstraZeneca and Pfizer brands, also Sinopharm and Moderna. There are few involving all vaccine types. Parameters used were the common local symptoms (arm pain, swelling, redness, etc.) and systemic symptoms (headaches, flu, etc.).

Using random forest, a study in Jordan [5] revealed that side effects significantly vary based on the vaccine type. Similarly, in Sweden [6] age and gender play roles in the severity of the side effects. In Saudi and the United Arab Emirates, side effects are common to males than females who took Pfizer or AstraZeneca [7]. Older people who have previous infections have difficulty breathing after taking Pfizer[8]. Similarly, AstraZeneca takers who had previous infections experience severe pains[9]. Females who took either Pfizer or Sinopharm were reported to experience adverse side effects[10]. The t-test and chi-square test show that Pfizer is perceived to have severe side effects as compared to the other brands[11] especially in the second dose[12] and varies depending on the BMI and health status of an individual[13]. As compared to Sinopharm, it has a shorter side effects duration[14]. The mRNA-based vaccines have been reported as the source of local side effects while viral vector-based vaccines are on the systemic ones affecting the younger age group and females[15].

3. Methodology

3.1. Respondents, Sampling, and Setting

The study is confined to the Sultanate of Oman. Respondents possessing the criteria for the study were initially selected using purposive sampling [16]. They were asked to fill out a Google Form containing the survey questions. Later, using the snowball technique, the initial respondents were asked to send the survey link to their friends who took the same vaccine. Sampling goes in the same fashion until the deadline is set. The data preparation phase eliminated the outliers in the data, thus resulting in a sample size of 362 respondents. Although currently there are eight (8) vaccines approved. Most of the respondents took the two brands (Pfizer and AstraZeneca) the government initially approved.

3.2. Statistical Variables, Hypotheses, Statistical Tools and Processing

Using a 5% level of significance, the Chi-square test of independence/association and Spearman test of correlation (Fig. 1) determined if there is a significant relationship between the group of variables used in the study: the independent variables (Table 1) and dependent variables (Table 2) [17] [18].

Statistical analyses (both descriptive and inferential) were performed using Python in the Anaconda Spider and
libraries such as Pandas for loading and data preparation, NumPy for arrays and matrices, Matplotlib for data visualization, Seaborn for heatmaps and data summarization, SciPy for statistical analysis, and Sklearn for clustering. Instead of the actual count, the frequency of the responses in each category was expressed in percentage for better understanding.

The level of severity [19] was interpreted by mapping the mean values to the verbal interpretations (4.20 – 5.00, Worst; 3.40 – 4.19, Very Severe; 2.60 – 3.39, Severe; 1.80 – 2.59, Moderate; 1.00 – 1.79, Mild; and 0.00 – 0.99, Not experiences at all). The interpretation of the Spearman test was taken from the study of Schobert et al [20].

Table 1. Independent Variables.

| Variable          | Scale      | Code                      | Values                                     |
|-------------------|------------|---------------------------|--------------------------------------------|
| Gender            | Nominal    | gender                    | 0(Female), 1(Male)                         |
| Age               | Ratio      | age                       | 0 … n                                      |
| Blood Type        | Nominal    | blood_type                | 0+……AB−/1….8                              |
| Weight Category   | Interval   | weight_category           | 1(underweight)….5(overweight)             |
| Average Hours of Sleep | Ratio  | average_sleep          | 0 … n                                      |
| Diet Category     | Interval   | diet_category             | 1(Meat-base)…. 5(Vegetable-Based)          |
| Vaccine Type      | Nominal    | vaccine_type              | 0(AstraZeneca), 1(Pfizer)                   |

Table 2. Dependent Variables.

| Variable                      | Scale      | Code                       | Values                                      |
|-------------------------------|------------|----------------------------|---------------------------------------------|
| Arm Pain                      | Ratio      | d1_arm_pain, d2_arm_pain  | 0(Not Experienced), 5(Extreme)             |
| Redness in the Arm (shot location) | Ratio  | d1_arm_redness, d2_arm_redness | 0(Not Experienced), 5(Extreme)             |
| Arm Swelling                  | Ratio      | d1_arm_swelling, d2_arm_swelling | 0(Not Experienced), 5(Extreme)             |
| Tiredness                     | Ratio      | d1_tiredness, d2_tiredness | 0(Not Experienced), 5(Extreme)             |
| Headache                      | Ratio      | d1_headache, d2_headache  | 0(Not Experienced), 5(Extreme)             |
| Muscle Pain                   | Ratio      | d1_muscle_pain, d2_muscle_pain | 0(Not Experienced), 5(Extreme)             |
| Chills                         | Ratio      | d1_chills, d2_chills      | 0(Not Experienced), 5(Extreme)             |
| Fever                          | Ratio      | d1_fever, d2_fever        | 0(Not Experienced), 5(Extreme)             |
| Nausea/Vomiting               | Ratio      | d1_nausea_vomitting, d2_nausea_vomitting | 0(Not Experienced), 5(Extreme)             |
| Duration of Side Effect(s)    | Ratio      | duration,d2_duration      | 0 … n                                      |

### 3.3. Data Preprocessing

Respondents were segmented into two based on the vaccine type taken. The normal distribution, test of skewness, interquartile range, and box plotting (Fig. 2) helped to identify the data outliers that will potentially affect the inferential statistics [21]. Extreme outliers were removed, and the minor ones were replaced with the median value as it is not affected by the outliers [22].
4. Results and Discussion

4.1. Vaccine Brands and Side Effects

The Chi-square tests (Table 3) show the association between local and systemic side effects and vaccine brands. Pfizer has moderate to worst side effects during the second dose. The Spearman correlation shows that vaccine brand has a negative weak correlation (p=0.001, r=0.253) to the duration of the side effects. AstraZeneca tends to have a longer duration of side effects as compared to Pfizer.

### Table 3. Association Between Vaccine Brands and Side Effects

| Variable                  | First Dose  | Vaccine (moderate to worst) | Second Dose  | Vaccine (moderate to worst) |
|---------------------------|-------------|-----------------------------|--------------|-----------------------------|
| Arm Pain                  |             |                             | p<0.05       | Pfizer(47.5%), AstraZeneca (0%) |
| Redness in the Arm (shot location) | p<0.05     | Pfizer(32.5%)               | p<0.05       | Pfizer(17.5%), AstraZeneca (0%) |
| Arm Swelling              | p<0.05      | Pfizer(26.5%)               | p<0.05       | Pfizer(22.5%)               |
| Tiredness                 |             |                             |              |                             |
| Headache                  | p=0.03      | AstraZeneca(35%)            | p<0.05       | Pfizer(40%), AstraZeneca(20%) |
| Muscle Pain               |             |                             | p<0.05       | Pfizer(18.75%), AstraZeneca (0%) |
| Chills                    |             |                             | p<0.05       | Pfizer(20%), AstraZeneca(0%) |
| Fever                     | p=0.02      | AstraZeneca(40%)            | p<0.05       | AstraZeneca(0%)             |
| Nausea/Vomiting           |             |                             | p<0.05       | AstraZeneca(0%)             |

4.2. Chi-Square Test and Spearman Correlation for Pfizer Vaccine

The tests show that females(F) have greater chances to experience moderate to worst side effects, both for the first (Table 4a) and second (Table 4b) doses as compared to the males(M). Similarly, blood types B-, AB+, O-, underweight(UW), overweight(OV), and people with an unbalanced diet were found to experience the same.

### Table 4a. Association Between Gender, Blood Type, Weight Category, Diet Category and Vaccine Side Effects - Pfizer

| Variable                  | Gender | First Dose (Moderate to Worst) | Blood Type | Weight | Diet |
|---------------------------|--------|--------------------------------|------------|--------|------|
| Arm Pain                  | p=0.020,F(63%),M(47%) | -                            | -          | -      | -    |
| Redness in the Arm (shot location) | p=0.017, F(47%),M(40%) | p=0.029, B-(40%),AB+(67%) | -          | -      | -    |
| Arm Swelling              | -      | -                            | -          | -      | -    |
| Tiredness                 | p=0.017, F(47%),M(40%) | p=0.011, AB+(98%),O-(57%)   | -          | -      | -    |
| Headache                  | p=0.003,F(34%),M(23%)  | -                            | -          | -      | p=0.038,meat,veggie |
| Muscle Pain               | p=0.028,F(49%),M(37%)  | -                            | -          | p=0.026, UW | -    |
| Chills                    | p=0.017,F(30%),M(17%)  | -                            | p=0.012,AB+(68%),O-(29%) | p=0.012, UW | p=0.019,veggie |
| Nausea/Vomiting           | -      | -                            | -          | p=0.002, UW | -    |
Table 4b. Association Between Gender, Blood Type, Weight Category, Diet Category and Vaccine Side Effects - Pfizer

| Variable                        | Gender       | Second Dose (Moderate to Worst) |
|---------------------------------|--------------|---------------------------------|
|                                 |              | Blood Type | Weight      | Diet          |
| Arm Pain                        | p=0.011,F(53%),M (40%) | -          | -           | -            |
| Redness in the Arm (shot location) | p=0.028,F(19%),M (17%) | p=0.044,0-(29%),AB+(67%) | p=0.017,UW | -            |
| Arm Swelling                    | -            | -          | p=0.007,UW | -            |
| Tiredness                       | p=0.028,F(41%),M(30%) | -          | p=0.040,UW | -            |
| Headache                        | -            | -          | p=0.000,AB+(98%),B-(40%) | p=0.000,UW | -            |
| Muscle Pain                     | -            | -          | p=0.007,UW | -            |
| Chills                          | p=0.036,F(21%),M(10%) | p=0.000,AB+(98%),B-(40%) | p=0.003,UW,OV | p=0.014,meat,veggie |
| Fever                           | -            | -          | p=0.000,UW | -            |
| Nausea/Vomiting                 | -            | -          | p=0.040,OV | -            |

Table 5 shows that age has a negative weak (WN) to moderate (MN) correlation to the side effects’ level of severity. The severity affects the younger respondents during the first and second doses. Average sleep per day has no significant relationship with the vaccine side effects except for a very weak negative correlation (r=-0.230, p=0.005) with nausea or vomiting during the second dose. Table 5 shows the result of the test, emphasizing the significant variables. Duration of the side effects has nothing to do with age and sleeping pattern.

4.3 Chi-Square Test and Spearman Correlation for AstraZeneca Vaccine

AstraZeneca has a lesser number of perceived side effects as compared to Pfizer. Mostly, underweight (UW), overweight (OW), and people with unbalanced diets tend to experience moderate to worst side effects. Gender and blood type were not associated with any side effects. For brevity, Table 5 shows the variables having significant associations.

Table 6. Association Between Weight, Diet and Side Effects

| Variable          | Weight     | First Dose Diet | Second Dose Diet |
|-------------------|------------|-----------------|------------------|
| Arm Swelling      | p=0.020,UW | -               | -                |
| Headache          | -          | -               | p=0.038,meat-based |
| Muscle Pain       | -          | p=0.007,meat-based | -               |
| Chills            | p=0.016,UW&OW | p=0.000,meat-based | -               |
| Fever             | -          | p=0.013,meat-based | -               |
| Nausea/Vomiting   | -          | p=0.043,meat-based | -               |

Although age has a negative weak correlation (r=-0.362, p=0.030) to fever during the first dose, together with average sleeping hours per day, has no significant relationship with the rest of the side effects.

5. Conclusion

The study revealed that vaccine side effects are associated with the vaccine type. It was identified that Pfizer has many known side effects. Age, gender, weight category, diet category, and blood type have significant relationships
to one or more side effects. On the contrary, the sleeping pattern variable has no significant relationship to the other variables.

To draw more reliable conclusions, it is highly recommended to involve more respondents and vaccine brands.

References

[1] UNESCO, "UNESCO COVID-19 education response: how many students are at risk of not returning to school? Advocacy paper," unesco.org, 30 July 2020. [Online]. Available: https://unesdoc.unesco.org/ark:/48223/pf0000373992. [Accessed 10 October 2020].

[2] World Health Organization [WHO], "Coronavirus disease 2019 (COVID-19) Situation Report – 94," who.int, 23 April 2020. [Online]. Available: https://www.who.int/docs/default-source/coronaviruse/situation-reports/20200423-sitrep-94-covid-19.pdf. [Accessed 10 October 2020].

[3] D. Robson, "Why some people don't want a Covid-19 vaccine," 23 July 2021. [Online]. Available: https://www.bbc.com/future/20210720-the-complexities-of-vaccine-hesitancy. [Accessed 12 October 2021].

[4] Times of Oman, "Vaccination mandatory to enter malls, restaurants in Oman: Supreme Committee," 19 August 2021. [Online]. Available: https://timesofoman.com/article/105644-vaccination-mandatory-to-enter-malls-restaurants-in-oman-supreme-committee. [Accessed 12 October 2021].

[5] M. M. Hatmal, M. A. I. Al-Hatamleh, A. N. Olaimat, M. Hatmal, D. M. Alhaj-Qasem, T. M. Olaimat and R. Mohamud, "Side Effects and Perceptions Following COVID-19 Vaccination in Jordan: A Randomized, Cross-Sectional Study Implementing Machine Learning for Predicting Severity of Side Effects," MDPI, vol. IX, no. 6, p. 556, 2021.

[6] F. Nyberg, M. Lindh, L. E. Vanfleteren, N. Hammari, B. Wettermark, J. Sundström, A. Santosa, B. K. Kirui and M. Gisslén, "Adverse events of special interest for COVID-19 vaccines - background incidences vary by sex, age and time period and are affected by the pandemic," MedRxiv, 2021.

[7] M. Adam, M. Gameraadinn, M. Alelyani, M. Y. Alshahrani, A. Gareeballah, I. Ahmad, A. Azzawi, B. Komit and A. Musa, "Evaluation of Post-Vaccination Symptoms of Two Common COVID-19 Vaccines Used in Abha, Aseer Region, Kingdom of Saudi Arabia," Patient Prefer Adherence, vol. 15, pp. 1963-1970, 2021.

[8] N. A. El-Shitany, S. Harakeh, S. M. Badr-Eldin, A. M. Bagher and B. Eid, "Minor to Moderate Side Effects of Pfizer-BioNTech COVID-19 Vaccine Among Saudi Residents: A Retrospective Cross-Sectional Study," International Journal of General Medicine, vol. 14, pp. 389-1401, 2021.

[9] M. Azimi, W. M. Dehzad, M. A. Atiq, B. Bahain and A. Asady, "Adverse Effects of the COVID-19 Vaccine Reported by Lecturers and Staff of Kabul University of Medical Sciences, Kabul, Afghanistan," Infect Drug Resist, vol. 14, pp. 4077-4083, 2021.

[10] B. Q. Saeed, R. Al-Shahribi, S. S. Alhaj and Z. M. Alkkhardi, "Side effects and perceptions following Sinopharm COVID-19 vaccination," International Journal of Infectious Disease, vol. 111, pp. 219-226, 2021.

[11] R. A. Kadali, R. Janagama, S. Peruru and S. V. Malayala, "Side effects of BNT162b2 mRNA COVID-19 vaccine: A randomized, cross-sectional study with detailed self-reported symptoms from healthcare workers," Internation Journal of Infectious Diseases, vol. 106, pp. 376-381, 2021.

[12] J. C. Bardales, J. Gee and T. Myers, "Reactogenicity Following Receipt of mRNA-Based COVID-19 Vaccines," JAMA, vol. 325, no. 21, pp. 2201-2202, 2021.

[13] C. Menni, K. Klaser, A. May, L. Polidori, J. Capdevila and P. Louca, "Vaccine side-effects and SARS-CoV-2 infection after vaccination in users of the COVID Symptom App in the UK: a prospective observational study," The Lancet Infectious Diseases, vol. 21, 2021.

[14] S. Abu-Halaweh, R. Alqassieh, A. Suleiman, M. Q. Al-Sabbagh and M. Abu-Halaweh, "Qualitative Assessment of Early Adverse Effects of Pfizer-BioNTech and Sinopharm COVID-19 Vaccines by Telephone Interviews," Vaccines, vol. 9, no. 9, 2021.

[15] M. Kluger, A. Riad, M. Mekhemar, J. Conrad, M. Buchbender, H. P. Howaldt and S. Attia, "Side Effects of mRNA-Based and Viral Vector-Based COVID-19," Biology, vol. 10, no. 752, 2021.

[16] H. Ames, C. Glenston and S. Lewin, "Purposive sampling in a qualitative evidence synthesis: a worked example from a synthesis on parental perceptions of vaccination communication," BMC Med Res Methodol, vol. 19, no. 26, 2019.

[17] Center for Disease Control and Prevention, "Possible Side Effects After Getting a COVID-19 Vaccine," CDC, 30 September 2021. [Online]. Available: https://www.cdc.gov/coronavirus/2019-ncov/vaccines/expect/after.html. [Accessed 4 October 2021].

[18] World Health Organization, "Coronavirus disease (COVID-19): Vaccines safety," WHO, 19 February 2021. [Online]. Available: https://www.who.int/news-room/q-a-detail/coronavirus-disease-(covid-19)-vaccines-safety. [Accessed 4 October 2021].

[19] D. Weatherspoon, "What is a pain scale, and how is it used?," HealthLine, 18 September 2018. [Online]. Available: https://www.healthline.com/health/pain-scale. [Accessed 4 October 2021].

[20] P. Schober, C. Boer and L. Schwarte, "Correlation Coefficients: Appropriate Use and Interpretation," Anesthesia & Analgesia, vol. 126, no. 5, pp. 1763-1768, 2018.

[21] J. Kostanje, "6 ways to test for a Normal Distribution — which one to use?," Towards Data Science, 13 December 2019. [Online]. Available: https://towardsdatascience.com/6-ways-to-test-for-a-normal-distribution-which-one-to-use-9dcf47d8fa93.

[22] S. Kumar, "7 Ways to Handle Missing Values in Machine Learning," Towards Data Science, 24 July 2020. [Online]. Available: https://towardsdatascience.com/7-ways-to-handle-missing-values-in-machine-learning-1a6326adf79e. [Accessed 7 September 2021].