Estimates Probabilities of Success for Covid-19 Vaccines Using Mathematical Models

Chenwei Wang[1,*]

[1]*Monash business school, Melbourne, 3145, Australia*
**Corresponding author. Email: Cwan0116@student.monash.edu*

ABSTRACT
To combat the COVID-19 pandemic, COVID-19 vaccine was approved for emergency use before the clinical trial phase was completed, but there has been no long-term and comprehensive review of safety data reported from vaccine trials. Therefore, this paper aims to use mathematical models to analyse resource reports of severe adverse events or deaths after vaccination in the United States. By October 2021, Vaccine side effects data reported by the Vaccine Adverse Event Reporting System were retrieved for severity or death after vaccination from Pfizer, Moderna, and Janssen. When the dependent variable is a binary variable (survival or death) and the sample size follows a normal distribution, the Probit model was used to compare the effects of gender, age, and type of vaccine on severe illness death after vaccination. Gender differences influence the frequency and severity of vaccine side effects, and it is necessary to analyze data by sex differences to ensure a specific and robust evidence base for efficacy and safety data. In addition, the safety and efficacy of COVID-19 vaccines in specific subpopulations, such as children and adolescents, pregnant women, and people with multiple underlying diseases, have not been thoroughly studied, and vaccinators should be strongly encouraged to provide more relevant data directly to drug regulatory authorities to calculate more accurate models and risk estimates.

Keywords: *Covid-19, Vaccines, Gender, Age, Probit Model.*

1. INTRODUCTION

Starting in 2019 is the period of the COVID-19 pandemic, with over 175 million cases of COVID-19 reported in 221 countries and territories as of 5 June 2021 [1]. In order to prevent and contain the global spread of the epidemic, COVID-19 vaccines were urgently authorized by drug regulators and governments around the world in the absence of sufficient long-term compelling safety data [2]. However, Unreviewed vaccines have some side effects, most of which are mild but sometimes life-threatening. In this paper, 11,732 death cases based on the VEARS database were screened, and the most valuable prognostic factors for individual assessment were explored through the binary Probit model [3]. Therefore, the purpose of this article is to analyze severe adverse reactions to COVID-19 vaccines and help people make evidence-based health decisions that are appropriate for them. This model of severe COVID-19 vaccine illness or death will support the exploration of potential influencing factors and endogenous variables, and inform policy makers evaluating global vaccination strategies.

2. ANALYSIS THE DATA OF COVID-19 VACCINATION SUCCESS RATE

2.1. Probit model

Data analyses of severe adverse reactions and deaths following vaccination from Pfizer /Moderna and Janssen were retrieved through the Vaccine Adverse Event Reporting System as of October 2021.

Probit model is a type of regression model, and the dependent variable is usually represented by 0 or 1. It is a binary model for predicting the probability classification of observation data. In this paper, after removing outliers and missing values, relevant data will be used for modeling.

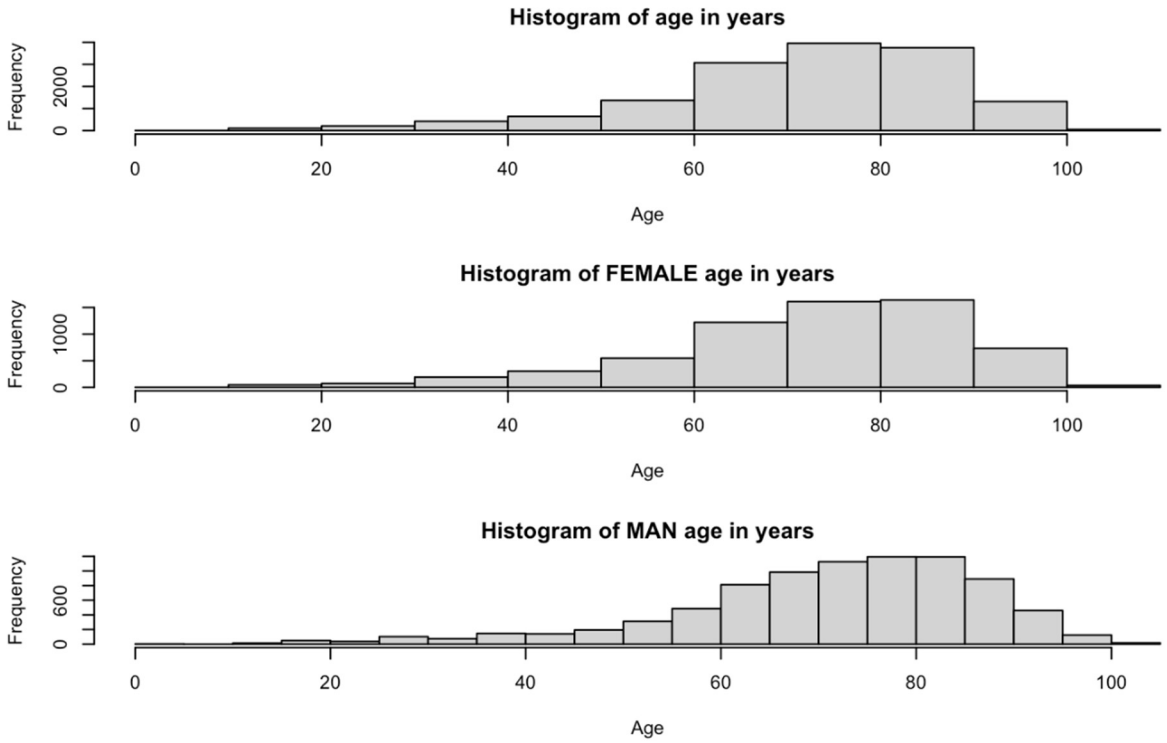

Figure 1 Age distribution of vaccine deaths

2.2. The data analysis based on Probit model

It is clear from the bar chart that people aged 60-90 had the highest frequency of severe adverse reactions and deaths after vaccination and that people older than 65 years of age were more likely to develop severe cases in the COVID-19 medical record system. Because autoantibodies and inflammatory cytokines or chemokines are associated with immune aging, resulting in an interaction between aging factors and mRNA vaccines in older adults. Although the effect of immunosenescence on vaccine safety is more uncertain and the theoretical risk of serious adverse events mediated by overactivation of the immune system is lower, from the above data, the risk reduction would be offset by an increase in the overall propensity for adverse events, which is a sign of frailness [4].

Men experienced adverse reactions after vaccination significantly less frequently than women, but GH5050's COVID-19 tracking report showed that men were less likely to be vaccinated and tested for COVID-19 but more likely to be hospitalized for the disease and more likely to die from COVID-19 than women [5], three times as many men as women were seriously ill or died. Known biological differences in fitness and innate immune responses between the sexes explain the observed differences. Gender structure at the social level also contributes to differences, such as the risk of severe disease (men smoke and drink more frequently than women) and the low number of men participating in health care services [6]. As of March 2021, only five available vaccine policies mentioned gender, and only 24% of the data from 75 COVID-19 vaccine clinical trials included provided sex-disaggregated results [7]. However, these observations are part of much broader and more complex biological, behavioral, and social aspects. Therefore, it is reasonable to assume that sex is a significant part of the vaccine response, and based on a variety of different data, the unique phenotypic expression of the cell system is critical for the interaction between SARS-COV-2 and the bisexual target tissue. In particular, the entry of COVID-19 into host cells begins with the interaction between Spike proteins exposed to the viral capsid and the host protein angiotensin-converting enzyme (ACE2), whose expression and activity are gender-specific [8]. Therefore, age, gender and vaccine type were used as explanatory variables for modeling.

Table 1. Binary probity model

Variable	Coefficient	Std.Error	Prob.
C	-3.6468	0.080682	0.000
Age_YRS	0.032531	0.000255	0.000
Female	-0411791	0.038822	0.000

Male	0.053046	0.038840	0.1720
Janssen	-0.027022	0.070297	0.7007
Moderna	-0.300832	0.069377	0.000
Pfizer	-0.136537	0.069356	0.069356

In this paper, the Probit model was established to observe the explanatory variables that could significantly affect death, and in this binary Probit model, we set sex variables and vaccine manufacturer variables as dummy variables. In order to avoid dummy variable traps, we drop two rarely explanatory variables, which are Unisex and Unknown manufacturer, out from the model.

The coefficient of age is a positive number 0.0325, which means as an individual grows 1 year older, he/she will increase the chance of death due to the injection of Covid-19 vaccine by 3.25%, holding other variables constant. It is the same as expectation since the body's immunity ability decreases as age increases. The p-value is less than 0.005.

As a coefficient of a dummy variable, it indicates that the probability of a female individual who could die from covid-19 vaccine injection is 41.17% less than other genders, male and unisex), holding the other variables constant. The p-value is $0.004 < 0.05$, it indicates the strong significance. However, the model illustrates that a male individual who would die by injection is 5.30% more likely than other genders while other variables stay constant. It is noticed that the p-value of the dummy variable, male gender, is 0.1720 which is obviously higher than 0.005. Hence, it is controversial to say the effect is significant at 5% significance level.

2.3. The vaccination data from different companies

According to the estimated model, considering the biotech used and chemical composition in vaccines are distinguished by a different company, the possibility of covid-19 vaccine lethality can be varied from manufacturer to manufacturer.

JANSSEN: the possibility of death is 2.70% lower than the person who gets vaccination produced by other manufacturers, which includes MODERNA, Pfizer and other unknown manufacturers, holding other variables constant. Nonetheless, the p-value is 0.7007 which far exceeds the value at 5% significance level. the significance of the Janssen variable cannot be proved.

MODERNA: the possibility of death is 30.08% lower than the person who gets vaccination produced by other manufacturers, which includes Janssen, Pfizer and other unknown manufacturers, holding other variables constant. The p-value is 0.00 which is statistically significant at 5% significance level.

PFIZER: the possibility of death is 2.70% lower than the person who gets vaccination produced by other manufacturers, which includes MODERNA, Janssen and other unknown manufacturers, holding other variables constant. The p-value is 0.49 which is statistically significant at 5% significance level.

In addition, essential on the lack of information collection, it is likely to be neglected in the model of a large number of endogenous variables and other interpretations, for example, pregnant women and nursing mothers, immunocompromised patients, suffering from complications of weak patients and patients with autoimmune diseases or inflammatory disease vaccine more data.

3. DISCUSSION

Part of the crowd to the vaccine potential side effects of uncertainty and controlled to a vaccine-hesitant, and the analysis of vaccine of severe adverse reactions to help guide about the good personal decision and help people for their health to make a wise decision, especially those (high-risk) older people, it is important to note that although women's response to vaccines has more side effects, But the death rate is higher for men. Current estimates suggest that for every 100,000 vaccinations, four fatal side effects and 16 serious side effects must be accepted [9], and the accurate figure is likely to be much higher, as only a tiny fraction of side effects are reported to the adverse event pool, with a median of 95% underreporting [10]. Therefore, the gender factor is a part that cannot be ignored. Furthermore, the safety and effectiveness of COVID-19 vaccines in specific subpopulations, such as children and adolescents, pregnant women, and people with multiple underlying conditions, have not been thoroughly studied. This will require the cooperation of national drug regulatory authorities, and vaccinators should be strongly encouraged to provide more relevant data directly to drug regulatory authorities or doctors [11] (GP) to calculate more accurate risk estimates. It may be September 2023 before there is enough vaccine for worldwide use. It is unclear whether these early vaccines will be enough to end the COVID-19 crisis effectively. The vast majority of experts predict that the first-generation vaccine alone will not be enough to end the pandemic effectively and that it will take much longer to develop a vaccine that fully protects against infection [12]. This means that the world must be prepared to commit to other public health measures to contain the spread of the virus for many years

and should invest in a broader and more diverse vaccine portfolio focusing on diagnosis and treatment through better international cooperation and market incentives [13].

4. CONCLUSION

Modeling based on gender differences is necessary for events that impact product reporting when not readily available, currently available statistical data do not support sufficient analysis of gender differences. Endogenous variables such as sub-healthy populations (children and surveillance, government and government studies, and people with these underlying diseases) need further research, this will require local government cooperation with the national drug regulatory authorities, encourage the vaccination to the medical staff to provide more information, to establish a more accurate model. So far, multiple mutated viruses have emerged (such as Omicron and Delta), first-generation vaccines alone cannot effectively end the COVID-19 pandemic, and it will take longer to develop a vaccine that fully protects against infection. The significance of the study reminds the local governments should provide more detailed data to help vaccine developers create safer and more comprehensive COVID-19 vaccines.

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