SCENARIO BASED VACCINE STATUS MONITORING AND RECOMMENDATION SYSTEM FOR COVID-19 VACCINATION

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ABSTRACT

The entire world is eagerly waiting for COVID-19 vaccination. The scientist has successfully created the vaccination but it is a great challenge for the governments all over the world to provide the vaccination without any defect from the originated efficiency vaccine to end users. Originated efficiency vaccine is the most important parameter that needs to be checked before providing to the consumers. There are number of choices with at least few vaccines proven to be more effective than 90 percentages. The proposed work makes use of IoT devices to capture the status of storage of the vaccine at all the scenarios. The entire flow of vaccine supply chain is tracked constantly at all instances right from the manufacturers to consumers. It also concentrates on recommending physicians whether the vaccine can be injected to the patient or not based on the VSMR model. The VSMR model also provides a preventive mechanism based on the recommendation to the physician and also has an effective monitoring mechanism to find out the origin of the defect created in the vaccine.

Keywords: COVID-19, Vaccination, Supply Chain Management, Vaccine storage

INTRODUCTION

Corona virus pandemic is one of the most severe pandemic the world has ever faced in this decade. This not only as affected the health of the people around the world but also it has created an excessive fear among all the people who are living in this planet. Due to this the entire world face serious economy shutdown and the world is excepting a speedy recovery from all the negative impact created by this pandemic. The engineers and scientist around the world work towards the various methods and solutions to help the human kind. The scientists have worked tremendously to find the vaccine for this COVID-19 in a short period of time. Now it is the work of the engineers to see that there is no defect created in the vaccine by the constant monitoring of the vaccine and proper supply chain management from the origin of the vaccine to the end user.

The World Health Organisation (WHO) as given some of the COVID-19 vaccines comparison. They have given four major companies and type of vaccination and the number of doses and, how effective vaccine will be effective on the patient. It also talks about the prescribed storage condition. The storage condition goes to even -70^{o}C. The first vaccine company name is Oxford Uni-AstraZeneca and the type of vaccine is viral vector (genetically modified virus) which needs to be given two doses and it will be 60%-90% effective on the vaccinated person. It is easy to store this even with regular fridge temperature. Secondly the next vaccine company name is

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Moderna which is of type using RNA (part of virus genetic code) which needs to be given two doses and its very effective with 95% but in case of storage it should be kept at -20ºC and the life time is upto 6 months. Thirdly the Pfizer-BioNTech company as given the vaccine of the type RNA with two doses and high efficiency of 95% on the vaccinated person but the storage vaccine is very challenging since it has to be maintain at -70ºC this makes more challenging while it is transported. The fourth and final vaccine that has been discussed is Gamaleya (Sputnik V) this is of the type viral vector this also involved two doses but gives more efficiency on the vaccinated person of 92% which could be easily store the regular. In this article we have also applied our VSMR model in the above mentioned vaccine to find out the efficiency of the proposed method.

The proposed VSMR model uses the parameters like brand reliability, vaccine effectiveness and storage efficiency. It can be observed from the Table.1 that the parameter brand reliability is depicted with three different values which is found to be static at least for nine scenarios. This means that brand reliability will remain mostly constant with the weightage ranging from 0.2, 0.1 and 0.05, the main reason why the value starting from 0.2 and ending to 0.05 as a low weightage because in most of the causes the government agency will prepare a very good reliable brand. Similarly, vaccine effectiveness depends upon the brand reliability which may vary from 0.4 to 0.15. This is because of the said above reason and more weightage has to be given to the vaccine effectiveness even at the case of static value which has the more influence on vaccine acceptance. The major factor that various constantly and which can be influence by the external factor is the storage efficiency. We can observe that the value ranges from 0.4 to 0.05. This kind of major variance because this as a greater influence on the vaccine acceptance.

RELATED WORK

Medication quality is defenseless against dread, distress, and disinformation. While trusting that the endeavors of WHO furthermore, worldwide alliances to quicken COVID-19 exploration will give the way to battle this pandemic, we should guarantee that admittance to moderate quality clinical items, especially in low-asset settings, doesn't become another setback (Newton, 2020)
This author from South Africa concentrates (Singh, 2020) on global regulation and efficiency of vaccine trails and also it is focus on Personal Protective Equipment and Occupational Health and Safety (OHS) regulations followed locally in South Africa. He provides more information that trails are done in the urgent basis but also it concentrates on sensitive navigation.

The author provides resilience analytics in vaccine supply chain network models plan (Golan, 2020), absorb, recover, adapt using the four phase temporal approach. He also insists on critical infrastructure supply chains, such as the Information and Communications Technology (ICT) and biopharmaceutical finished goods to ensure immunization targets are met regardless of disruptions to the supply chain. Rizou, M., 2020 provides the safety of food and food supply chain in the given scenario COVID-19 pandemic and also insists on virally inactivation when its goes above 70º C but transmission of virus is possible in most of the frozen food (Rizou, M., 2020). The author concludes that the last stage of supply chain is more critical and needs more safety measures and more number of people is involved in the process. This methodology may concern screening of populaces as well as observing of nourishments, surfaces, and general conditions.

Here it works on recommendation technology using accurate and fast working on recommendation system. Time correlation coefficient and an improved K-means with cuckoo search (CSK-means) an it also provides It can provide a higher quality recommendation by analyzing the user's behaviors. The personalized recommendation model based on preference pattern model, in view of the time entropy strategy, can just break down the client's example.

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Notwithstanding, the client personal conduct standard additionally complies with more exact models, such as the Gauss model, the cosine model (Cui, Z. 2020)

VACCINE STATUS MONITORING AND RECOMMENDATION (VSMR) MODEL

In this VSMR proposed work COVID 19 Vaccination is analysed. Four different vaccines are analysed and the parameters like manufacture reliability, and how effective the vaccine is, and storage effective of the vaccine are used to find out whether the vaccine can be accepted or rejected or the vaccine can be physician decision.

Manufacture Reliability

The important parameter analysed is manufacture reliability. Since the brand represents the quality of their product. The quality depends upon the standard procedure followed in the organization, their success rate, reduced failure by the increased number of trails. Even though the manufacture reliability is the important parameter VSMR model is provided with value ranging from 0.2 to 0.05 since the value of the manufacture is contact without much variation.

Vaccine Effectiveness

The most crucial parameter to be analysed is the Vaccine Effectiveness. The Vaccine Effectiveness represents the percentage of effectiveness it has proved in the trails. The Vaccine Effectiveness proves to be the sole parameter of the VSMR model which is to be given the higher priority in weightage over the previous parameter which ranges 0.4 to 0.15 even though this also remains to be the constant parameter.

Storage Efficiency

The parameter Storage Efficiency sets the real reason in decision making either to accept or reject the vaccine to be given to the patient. Storage Efficiency means the duration up to which the vaccine will be effective, under what temperature it will be effective and how effectively it is transported and maintained before reaching the patient. This parameter of the VSMR model is the most dynamic parameter so it is given the highest range 0.4 to 0.05 of weightage. The IOT devices is helping VSMR model to get constant information about the storage duration and also the storage temperature. It also tracks the information about any anomaly that has happen in the storage space and while it is transported. The anomaly generally happen due to any kind of failure in standards like the duration, fluctuation in temperature due to electricity failure or any disaster like flood, earth quake, physical security failure, etc., and also while transporting the vaccine.

The value of manufactures reliability various from 0.2 to 0.05 where the weightage of α_1=0.2, α_2=0.1 and α_3=0.05. The α_1=0.2 since it is assumed that it is more reliable manufacture and the value of α_2=0.1 since it is in the mid-range of manufacture reliability and the value of α_3 is 0.05 since it is a less reliable. Secondly the vaccine efficiency is analysed and the value of the efficiency for the weightage various from 0.4 to 0.15. Where the value of weightage given to β_1=0.4, β_2 is 0.25 and β_3 is 0.15. The value of β_1 is 0.4 since it is observed that it is most efficient on the patient, β_2=0.2 value since it is efficient on the patient and the value of β_3 is given as 0.15 because it is observed that it is less effective on the patient. Finally the storage effectiveness is being given the weightage which various from 0.4 to 0.05. The value of γ_1 is 0.4, γ_2 is 0.2 and γ_3 is 0.05. It is observed that γ_1 is 0.4 because it has a high effective storage and the value of γ_2 is 0.2 since the storage effectiveness is on the mid-range and γ_3 value is 0.05 since storage effectiveness is very low. All the three above parameters it is observed that maximum weightage of the

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parameter given as 0.4 and minimum weightage is 0.05. For the first parameter the value starts from 0.2 it is the mid-range as compared to the parameter2 and parameter3. This is done for the reason the effectiveness and the storage efficiency is the key parameters to be looked on while to be provided to the patient.

TABLE 1
ESTIMATED STATUS VALUE OF VACCINE

Scenario	Brand Reliable	Vaccine Effectiveness	Storage Efficiency	Estimated Status Value
S1	0.2	0.4	0.4	1
S2	0.2	0.4	0.2	0.8
S3	0.2	0.4	0.05	0.65
S4	0.2	0.25	0.4	0.85
S5	0.2	0.25	0.2	0.65
S6	0.2	0.25	0.05	0.5
S7	0.2	0.15	0.4	0.75
S8	0.2	0.15	0.2	0.55
S9	0.2	0.15	0.05	0.4
S10	0.1	0.4	0.4	0.9
S11	0.1	0.4	0.2	0.7
S12	0.1	0.4	0.05	0.55
S13	0.1	0.25	0.4	0.75
S14	0.1	0.25	0.2	0.55
S15	0.1	0.25	0.05	0.4
S16	0.1	0.15	0.4	0.65
S17	0.1	0.15	0.2	0.45
S18	0.1	0.15	0.05	0.3
S19	0.05	0.4	0.4	0.85
S20	0.05	0.4	0.2	0.65
S21	0.05	0.4	0.05	0.5
S22	0.05	0.25	0.4	0.7
S23	0.05	0.25	0.2	0.5
S24	0.05	0.25	0.05	0.35
S25	0.05	0.15	0.4	0.6
S26	0.05	0.15	0.2	0.4
S27	0.05	0.15	0.05	0.25

From the Table 1 it could be clearly understood that the estimated status value close to 1 will be accepted as the good status vaccine and the when it move close to 0 it would be rejected as the vaccine is not good condition to be given to the patient. It is over served that the highest value is 1 and the lowest value observed is 0.25.

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The value of the estimated vaccine status value is computed using the formula
$\Sigma\ \alpha\ (1 \ldots n)\ \beta\ (1 \ldots n)\ \gamma\ (1 \ldots n)\ \geq \Delta(\Phi)$ ……. (1)

$\Delta_{(\Phi)}$ is in between 1 to 0.75 the vaccine most suitable to be given to the patient
$\Sigma\ \alpha_{(1\ldots n)}\ \beta_{(1\ldots n)}\ \gamma_{(1\ldots n)} \geq \Delta_{(\eta)}$ …… (2)
$\Delta_{(\eta)}$ is in between 0.74 to 0.65 the vaccine is suitable to be provided to the patient only with the final decision of the physician
$\Sigma\ \alpha_{(1\ldots n)}\ \beta_{(1\ldots n)}\ \gamma_{(1\ldots n)} \geq \Delta_{(\chi)}$ .....(3)
$\Delta_{(\chi)}$ is less than 0.55 to 0 the vaccine should not be provide to the patient since it is not suitable for vaccination If the vaccine is of Reliable Brand and greater Vaccine Effectiveness and good Storage Effectiveness then the Estimated Vaccine Status Value is accepted.

The four different vaccine are studied here,
$V1 = \{\alpha 1=0.2, \beta_2 = 0.25, \gamma_1 = (0.4, 0.2, 0.05)\}$ …. (4)
We have 3 different cases in this let us see the find out it lies in $\Delta_{(\Phi)}$ or $\Delta_{(\eta)}$ or $\Delta_{(\chi)}$
Case 1
$V1 = \{\alpha 1=0.2, \beta_2 = 0.25, \gamma_1 = 0.4\} = 0.85$
The Δ value is between 1 to 0.75 so the vaccine 1 is accepted in the case1=$\Delta_{(\Phi)}$
Case 2
$V1 = \{\alpha 1=0.2, \beta_2 = 0.25, \gamma_1 = 0.2\} = 0.65$
The Δ value is between 0.74 to 0.65 so the vaccine 1 is final decision of the physician in the case2 = $\Delta_{(\eta)}$
Case 3
$V1 = \{\alpha 1=0.2, \beta_2 = 0.25, \gamma_1 = 0.05\} = 0.5$
The Δ value is less than 0.55 so the vaccine 1 is not suitable for vaccination in the case3 = $\Delta_{(\chi)}$
$V2 = \{\alpha 1=0.2, \beta_2 = 0.4, \gamma_1 = (0.4, 0.2, 0.05)\}$ ……. (5)
Secondly, for vaccine 2 the 3 different cases are computed to find out it lies in $\Delta_{(\Phi)}$ or $\Delta_{(\eta)}$ or $\Delta_{(\chi)}$
Case 1
$V1 = \{\alpha 1=0.2, \beta_2 = 0.4, \gamma_1 = 0.4\} = 1$
The Δ value is between 1 to 0.75 so the vaccine 1 is accepted in the case1 = $\Delta_{(\Phi)}$
Case 2
$V1 = \{\alpha 1=0.2, \beta_2 = 0.4, \gamma_1 = 0.2\} = 0.8$
The Δ value is between 1 to 0.75 so the vaccine 1 is accepted in the case1 = $\Delta_{(\Phi)}$
Case 3
$V1 = \{\alpha 1=0.2, \beta_2 = 0.4, \gamma_1 = 0.05\} = 0.65$
The Δ value between 0.74 to 0.65 so the vaccine 1 is final decision of the physician in the case2 = $\Delta_{(\eta)}$
The vaccine 3 and vaccine 4 are found to be having the cases similar to the above vaccine 2
$V3 = \{\alpha 1=0.2, \beta_2 = 0.4, \gamma_1 = (0.4, 0.2, 0.05)\}$ …….(6)
$V4 = \{\alpha 1=0.2, \beta_2 = 0.4, \gamma_1 = (0.4, 0.2, 0.05)\}$……..(7)

Finally, it is observed that the vaccination status and the recommendation about the vaccine is given by the doctor based on the $\Delta_{(\Phi)}$, $\Delta_{(\eta)}$, $\Delta_{(\chi)}$ which is computed using the formula $\Sigma\ \alpha_{(1\ldots n)}\ \beta_{(1\ldots n)}\ \gamma_{(1\ldots n)}$. The table 2 represents all the twenty-seven states and the possible computed output of recommendation of the vaccine.

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TABLE2 VACCINE RECOMMENDATION			
S. No	**Accepted**	**Physician decision**	**Rejected**
1	S1	S3	S6
2	S2	S5	S9
3	S4	S8	S15
4	S7	S11	S17
5	S10	S12	S18
6	S13	S14	S21
7	S19	S16	S23
8	-	S20	S24
9	-	S22	S26
10	-	S25	S27

1. Vaccine Estimated Status of VSMR Model

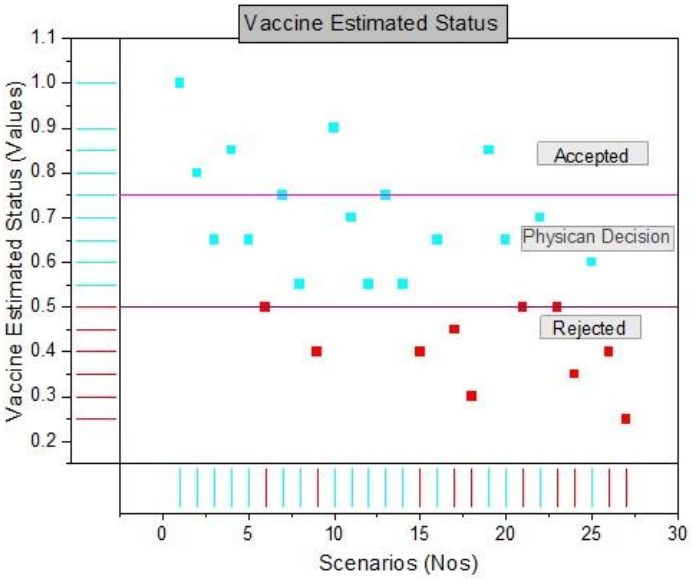

FIGURE 1
VACCINE ESTIMATED STATUS

Figure 1 clearly depicts the vaccine estimated status for 27 different scenarios that could probably happen with respect to vaccine preserved in a storage and while it is transported and when it reaches the patients. Scenario 1,2,4,7, 10, 13, 19 these are the different scenarios where it has crossed the threshold and they are recommended for the patients' vaccination. On the other hand scenarios like 3,5, 8,11, 12, 14,16, 20, 22, 25 are given for the physician decision. The physician shall decide whether to give it to the patients or not. On the contrast the scenarios like 6, 9, 15,17,18,21,23,2426,27 are reject and they should not be given to the patients at any cause.

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CONCLUSION

The proposed VSMR model uses gives the clear recommendation on vaccine status based on monitoring the status of vaccine. VSMR also provides various range of recommendation whether to accept, reject or the physician shall take to final decision either to accept or reject the vaccine which is very vital, which is done based on not only the static information like brand reliability, vaccine effectiveness but also storage efficiency which may varying based on physical condition and changes in environment. All these parameters are put together and based on the weightage given to both static and varying dynamic parameters the final vaccine estimated status is arrived. Based on this VSMR model we are able to arrive at clear recommendation for the physician who provides the vaccine.

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