

Factors driving the willingness to take anti-covid-19 vaccination in urban areas: Case of Dakar

Facteurs déterminants de la disposition à prendre la vaccination anti-covid en milieu urbain : Cas de Dakar

MBAYE Edmée

Enseignante-Chercheure
Département de Géographie,
Université Cheikh Anta DIOP de Dakar
edmee.diouf@ucad.edu.sn

TANDJIGORA Amadou

Chercheur
Faculté des Sciences Economiques et de Gestion,
Université Cheikh Anta DIOP de Dakar
amadou.tandjigora@yahoo.fr

YESSOUFOU Nourou-dine

Responsable Suivi et Evaluation d'impact
The International Crops Research Institute for the Semi-Arid Tropics (ICRISAT)
yessoufounourouline@yahoo.fr

SY Thierno Bachir

Département de Géographie,
Université Cheikh Anta DIOP de Dakar
bounebaz1@gmail.com

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Summary

Since the beginning of the year 2020, the COVID-19 pandemic has dragged the whole world into a cycle of uncertainty with its share of loss of human lives and negative economic impacts. To cope this situation, several vaccines have been adopted and national vaccination campaigns organized by governments. The aim of this article is to determine the factors affecting the willingness of the population to be vaccinated in the Department of Dakar in Senegal. The data used come from the OCAD-COVID survey (Opinions, behaviors and attitudes of Dakar residents vis-à-vis COVID-19). The logistic regression model of Hosmer and Lemeshow was used for the estimations. The main results show that marital status, level of education and occupation status have no significant effect on the willingness to be vaccinated. On the other hand, variables such as: gender, knowledge of an infected person, knowledge of preventive measures and population density at the municipal level show significant effects. For example, men are 1.5 times less willing than women to take the vaccine. These results are decisive in the definition of public health policies.

Key words: Covid; Vaccination; Dakar; Urban; Multivariate binomial logistic regression

Résumé

La pandémie de COVID-19 a entraîné depuis début 2020 le monde entier dans un cycle d'incertitude avec son lot de pertes en vie humaine et d'impacts économiques négatifs. Pour faire face, plusieurs vaccins ont été promulgués ainsi que des campagnes nationales de vaccination. L'objectif de cet article est de déterminer les facteurs affectant la disposition de la population à se faire vacciner dans le Département de Dakar au Sénégal. Les données utilisées proviennent de l'enquête OCAD-COVID (Opinions comportement et Attitude des Dakarais vis-à-vis de la COVID-19). Le modèle de régression logistique de Hosmer and Lemeshow a été utilisé pour les estimations. Il ressort des principaux résultats que la situation matrimoniale, le niveau d'instruction et la situation d'occupation n'ont aucun effet significatif sur la disposition à se faire vacciner. Par contre, les variables telles que : le sexe, la connaissance d'une personne contaminée, la connaissance des mesures de prévention et la densité de la population à l'échelle communale présentent des effets significatifs. À titre illustratif, les hommes sont 1,5 fois moins disposés que les femmes à prendre le vaccin.

Mots clés : Covid ; Vaccination ; Dakar ; Urbain ; régression logistique binomial multivarié

Introduction

The COVID-19 pandemic has had a definite impact on economies around the world by affecting all areas ranging from social, health to industry and tourism (Kolahchi et al, 2021). According to the World Health Organization, as a result of the pandemic, there has been socio-economic disruption putting tens of millions of people at risk of falling into extreme poverty and worsening food insecurity (WHO, 2020). But the pandemic has above all been the cause of millions of losses of human lives. Thus, with a view to overcoming this situation, protecting populations, reviving economies, and initiating a rapid return to normal, the first anti-covid vaccines were produced in 2021. These include: Johnson & Johnson, Pfizer, Moderna, AstraZeneca, Sputnik. In this context, the World Bank already noted in its projections of the economic consequences of the COVID-19 pandemic published in March 2021, that developments in the field of vaccines would be critical to the global capacity to recover from the pandemic in a sustainable way (Guenette et al, 2021). One of the scenarios of these projections indicated in particular that effective management coupled with rapid deployment of vaccines would create the conditions for stronger economic growth.

Several African countries have thus benefited from the distribution of vaccines and have launched vaccination campaigns with a view to mitigating the anticipated impacts. In Senegal, vaccination campaigns started in February 2021 followed by the first doses of vaccine injections. However, the population is not unanimously willing to take these vaccines. This tends to go against the objective of the health policy to eradicate the covid-19 pandemic.

In this specific case of indecision on the part of many Senegalese and specifically Dakar citizens, what are the real factors motivating the willingness to be vaccinated against the pandemic?

In this context, the aim of this paper is to determine the factors affecting the readiness of the population to be vaccinated in the district of Dakar in Senegal. This will contribute not only to guide the decision-making of public authorities both today and in the future, but also to feed the literature on this subject rarely addressed in the African context.

The study is based on data from the survey entitled: "Opinions, attitudes and behaviors of Dakar residents vis-à-vis COVID-19 (OCAD-COVID) conducted in August 2021 in all municipalities of the department of Dakar.

This article is structured in three parts. The first part presents the documentary review on the willingness to take vaccines according to various geographical areas. The second part deals

with the methodology applied, namely an analysis of descriptive statistics and an econometric model. The last part presents the results and the discussion.

1. Literature review

Since its appearance in late 2019, the first publications have sought to address knowledge gaps about the virus, its mode of transmission, clinical treatment, etc. It was after the first quarter of 2020 that scientific documentation began to abound in several other areas. This is fundamentally due to the lack of “curative” treatment and the containment approach to stem the spread of the virus, inducing “consequences far beyond the disease itself” (Bond, 2021).

However, vaccination has always been seen as a means of warding off epidemics and preventing hospitalizations. In the case of the COVID-19 pandemic, an exceptional approach has allowed the proposal of more than 308 vaccine candidates, of which the Pfizer- BioNTec , Moderna and Janssen vaccines received emergency use authorization in May 2021 (Peiffer - Smadja *et al.* , 2021). This rapid evolution in the production of vaccines, combined with the strong dissemination of false information during this crisis, seems to have increased vaccine hesitancy in almost all countries.

The World Health Organization (WHO, 2014) defines vaccine hesitancy as “a delay in accepting or refusing vaccines despite the availability of vaccine services”. West African countries, like Senegal, must also face the challenges of vaccination. These countries certainly adopted the policy of mass vaccination in 1970s with its series of consequences. But this does not prevent, in the context of covid-19, from the hesitation or refusal noted in the country with regard to "Astrazeneca". This poses therefore for these countries the double challenge of availability and demand for the vaccine (Desclaux and Sow, 2021) .

There is a fairly extensive literature on the determinants of acceptance or refusal of vaccination. This literature focuses more on the many vaccines already available before the advent of COVID-19, in particular those which are administered to children from a very young age or those which travelers are called upon to take when they go in a country with a high risk of contagion to a certain well-known pathology. Very specific resources in this area remain limited on covid-19, especially in the African context. Doornekamp *et al* (2020) as well as Larson *et al* (2014) have made a detailed review of the papers published on this subject. These studies reveal a multitude of factors which vary in time, space and according to the vaccine. The model of determinants of vaccine hesitancy developed by the SAGE working group (Strategic Advisory Group of Experts on Immunization) considers three main categories of factors. The first is factors specific to the vaccines or the vaccination itself including: cost/benefit (proven by

science), schedule of vaccination, mode of administration, reliability of delivery, cost, role of health professionals. Then there are individual or social factors including: acceptance of the idea of immunization in society, beliefs, attitudes and motivations about preventive health, knowledge and information on why/where/what/when vaccines are needed, personal experiences and confidence in the health system, perceived risk and experience of vaccination. Finally, there are contextual factors. These include for example the influence of leaders, individuals, religions, culture, politics, gender, socio-economic groups, but also the communication, media environment, geographical barriers, etc. (Larson et al, 2014). On this last point, Dubé, Eve, et al (2013) in their review of vaccine hesitancy, note that numerous scientific studies have built evidences on the negative influence of media controversies on vaccination. A typical example is that of the controversy that arose in France over an alleged association between the vaccine against hepatitis B and multiple sclerosis. This led to the suspension of the universal vaccination program in the 1990s, even though numerous studies found no evidence of such an association. These different factors clearly show the complexity of the motives that can underlie the decision to be vaccinated.

From a methodological point of view, for the analysis of the determinants of the decision to get vaccinated, the researchers used a multitude of approaches, data sources and statistical models. Galle et al. (2021), carried out an online study on elderly people in southern Italy revealing that acceptance of vaccination against COVID-19 would be linked to a higher level of education and having the media social/mass as the main source of information. They also noted that the political measure of the green pass, could have played a significant role. They use a descriptive analysis coupled with a logistic model. Al-Mohaithef and B. Kumar Padhi (2021), used a somewhat similar approach in Saudi Arabia during the second wave of the epidemic, but with a snowball method for online data collection. By modeling vaccination intentions, they found that the perception of high risk and trust in the medical system are the main drivers of vaccination intention. Van D Tran et al. (2021) confirm these same results for Russia with the same approach. In the United States, using bivariate statistical analyzes coupled with logistic modeling, Malik and Al (2020) found that men, adults over 55 and Asians tend to accept the vaccine more than other groups. There also seems to be a difference in acceptance depending on whether one is from the states of New York and Chicago or not.

However, other researchers have adopted different methods. For example, Hossain et al. (2021) used multiple hierarchical linear regression in their article on vaccine hesitancy in Bangladesh. This modeling was based on descriptive analysis and analysis of variance (ANOVA). Another

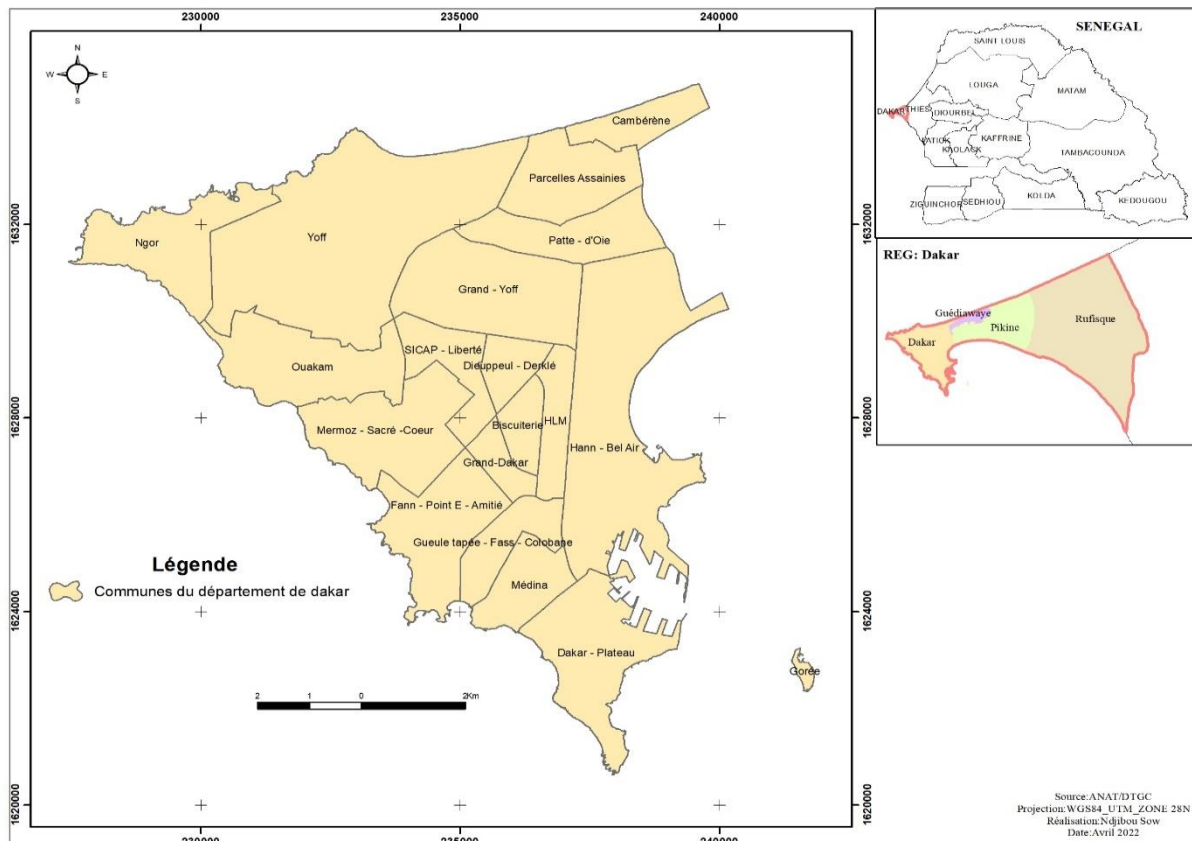
document that caught our attention is that of Mariam et al. (2021) on the psychological determinants of COVID-19 vaccine acceptance in Kuwait. The chi-square test was used to test associations between qualitative variables. Mann Whitney's non-parametric test, Kruskal-Wallis (KW) test and one-way analysis of variance (ANOVA) were used to test possible associations between scale variables. The linear-by-linear association test (LBL) was used to estimate changes in preference over time. It turned out to be a higher rate of hesitation among women.

2. Data Source and Methodology

2.1.Data source

The data used in this study come from the OCAD-COVID survey (Opinions behavior and attitude of Dakar residents vis-à-vis COVID-19). This survey conducted in August 2021 in the department of Dakar (see figure 1) covers a sample of 773 individuals aged 15 and over and is representative of the population down to the municipal level. The survey came at a time when access to the vaccine was proven and vaccination campaigns underway.

Figure 1: Location of the study area



Source : Agence Nationale pour l'Aménagement du Territoire/Direction des Travaux Géographiques et Cartographiques. Avril 2022.

2.2.Methodology

After a descriptive analysis of the variables of interest and the socio-demographic characteristics of the population studied, we use the multivariate binomial logistic regression model. We denote by *DV*, the dichotomous variable “Willingness to take vaccine” taking the value 1 if the unit is vaccinated or willing to be vaccinated and 0 otherwise. Based on the literature review, a set of variables were selected for modeling. After the selection process based on the information criteria (AIC, BIC and the prediction quality of the model), the final list of variables is summarized in the table below

Table 1: List of variables

Variables	Descriptions
DV	Willingness to get vaccinated
Gender	Sex of respondent
Age	Respondent's age
Sit Mat	Marital status
InstLevel	Educational level
StatusOcc	Occupation status
KnowPerson	Knowledge of a person who has been infected
SymptIndex	Symptom awareness index
Self-medication	practice of self-medication
IndexPrevention	Index of the level of knowledge of prevention means
DensPop	Density of the population per Km2 in the respondent municipality

By grouping all of these explanatory variables in *X* and denoting by β the vector of parameters, the model can be materialized by the equation:

$$\begin{aligned} \text{Logit}(P(DV = 1)) &= \ln\left(\frac{P(DV = 1)}{1 - P(DV = 1)}\right) = X\beta + \epsilon \\ &= \beta_0 + \beta_1 \text{Gender} + \beta_2 \text{Age} + \beta_3 \text{SitMat} + \beta_4 \text{NivInst} + \beta_5 \text{StatOcc} \\ &\quad + \beta_6 \text{ConnaisPerson} \\ &\quad + \beta_7 \text{IndexSympt} + \beta_8 \text{Automedication} + \beta_9 \text{IndexPrevention} + \beta_{10} \text{Denspop} + \epsilon \end{aligned}$$

To determine the probability *P* based on the linear predictor $X\beta$, we use the expression:

$$P(DV = 1) = \frac{\exp(X\beta)}{1 + \exp(X\beta)}$$

The coefficients are estimated by the Maximum Likelihood method. The quality of the model is assessed by McKelvey's R-squared coefficient. the Hosmer-Lemeshow test (quality of fit of

the data to the model), the good classification rate, link test (specification test). The significance of the relationships is given by the p-values of the individual significance tests.

2.3. Interpretation of model coefficients

The coefficients of the logistic model are often interpreted in terms of odds ratio. The odds below give the chances of being willing to take the vaccine compared to the opposite event.

$$Odds(X) = \frac{P(DV = 1|X)}{P(DV = 0|X)}$$

To see the effect of X on this ratio, the odds ratio is given (for a move from category A to category B) by the expression:

$$OR(X) = \frac{Odds(A)}{Odds(B)} = \exp(X\beta)$$

- If $OR(X) < 1$, this means that the event is less likely to occur in group A than in group B;
- Yes $OR(X) = 1$ means that the event has equal chance of occurring in both groups;
- If $OR(X) > 1$ means that the event is more likely to occur in group A than in group B.

3. Descriptive analysis

The population targeted by the OCAD-COVID survey is within people aged 15 and over. It turns out that 47.5% are women. According to age, 38% of respondents are in the age group of 15 to 29 years and those over 60 represent 17.1%. It is also observed that one person out of 10 has no education, 17% have had a Franco-Arabic or Koranic education, a quarter have reached at least the university level. It should also be noted that more than 7 out of 10 people have an occupation (active), whether formal or informal. Among the non-active there are more women (64%) and among those active, men are majority (60%).

In addition, it should be noted that one respondent over three knows someone who has contracted the disease and 9% claim to have contracted COVID-19. Regarding the perception of the seriousness of the disease, 93% think that the disease is serious or even very serious.

When it comes to means of prevention that respondents themselves used or of which they are aware, the most cited means of prevention are wearing a mask and regular hand disinfection with soapy water or other dedicated solutions, respectively mentioned spontaneously by 92% and 89% of the population. Compliance with social distancing was mentioned by nearly two-thirds of respondents. As for the vaccine, it is mentioned by just over a third of respondents.

Table 2: Means of prevention known by the population

Means of prevention	Yes	No
Regular hand washing with soap and water, or with a hydro alcoholic solution	89%	11%
Wearing a mask	92%	8%
Respect for social distancing	64%	36%
Vaccine	34%	66%
Others	5%	95%

Source: Authors' calculation, OCAD-COVID data

It is known, moreover, that vaccination is in principle the most effective means of protecting against a contagious disease. However, several rumors have been spread about its effectiveness; which has developed an aversion of the populations vis-à-vis vaccination. However, it appears that 3 out of 10 people surveyed have been vaccinated. Note that the OCAD-COVID survey took place in the context of a vaccination campaign. Of the 70% unvaccinated, half are ready to be vaccinated if offered. Breaking down by gender, it appears that women seem more willing to take the vaccine than men.

Table 3: Willingness to be vaccinated of unvaccinated by sex

	Yes	No	Total
Male	48%	52%	100%
Female	53%	47%	100%

Source: Authors' calculation, OCAD-COVID data

It should also be noted that 56% of respondents believe that the vaccine can really prevent against COVID-19 against 29% who do not believe in the potential of the latter. It is also among those who believe in the potential of vaccine that we find the highest proportions of people willing to be vaccinated. This shows the decisive role of trust in the decision to get vaccinated or not.

4. Model results

After the model selection process based on the information criteria: AIC and BIC, we obtain the model which quality information is summarized in the table below.

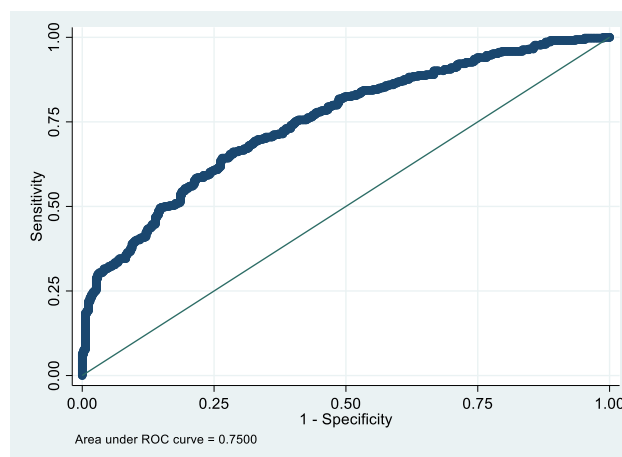
Table 4: General information on the model

<i>Information diagnostics</i>	<i>Values</i>
<i>Number of observations</i>	773
<i>McFadden's R2</i>	0.152
<i>McKelvey and Zavoina's R2</i>	0.256
<i>Hosmer-Lemeshow p -value test</i>	0.4841
<i>AIC</i>	1.231
<i>BIC</i>	-4068.47
<i>Maximum Likelihood R2</i>	0.188
<i>Count R2</i>	0.679
<i>LR chi2(18)</i>	160.61
<i>Prob > chi2</i>	0.0000
<i>Linktest (hatsq p-value)</i>	0.16

Source: Authors' calculation, OCAD-COVID data

The model is globally significant at 1% level. McFadden's R2 values of 15.2% and McKelvey and Zavoina's R2 of 25.6% indicate good quality of fit. This is also confirmed by the Hosmer-Lemeshow test which concludes at the 5% threshold that the hypothesis of equal frequencies is not rejected. The correct prediction rate of the model is 67.9%. Furthermore, the area under the ROC curve is 75% indicating that the underlying model successfully predicts 3 out of 4 individuals unwilling to take the anti-covid vaccine (see Figure 2).

Figure 2: ROC Curve



Source: Authors' calculation, OCAD-COVID data

In order to detect a possible specification error, we carried out the link-test which null hypothesis is the nullity of the “hatsq” coefficient, that is the correct specification of the model.

It appears that at the 5% threshold, the current specification cannot be rejected. Finally, collinearity is absent from the model with VIF values all below 10.

Table 5 summarizes the main results. Firstly, it emerges that marital status, level of education and employment status have no significant effect on willingness to be vaccinated. As for the variables that show significant effects, we first note gender. Indeed, men are 1.5 times less willing than women to take the vaccine. Being in the age group of 60 years and over makes it twice as likely to be ready to be vaccinated compared to young people aged 15 to 29. The results also highlight the influence of the direct or indirect environment on the willingness to take the vaccine. In this case, the fact of knowing a person who has been infected with the disease doubles the propensity of the population to accept the vaccine compared to those who have never known a person who has been infected. In the same vein, knowledge of preventive measures, measured by the index constructed for this purpose, significantly increases people's propensity to take the vaccine. Finally, the community factor measured by the population density in the municipality of residence indicates a positive but weak effect (significant at the 7% threshold) on the willingness to be vaccinated. In other words, populations living in high-density municipalities tend to accept the vaccine more than others.

Table 5: Odds ratio of the model

DV	odds ratio	Standard. Err	z	P> z	[95% Conf. Range]
<i>Gender</i>	(ref : Woman)					
<i>Male</i>	0.68	0.12	-	0.03**	0.48	0.96
<i>Age</i>	(ref : 15-29 years old)					
<i>30-44 years old</i>	1.27	0.31	0.98	0.33	0.79	2.04
<i>45-59 years old</i>	1.46	0.46	1.22	0.22	0.79	2.70
<i>60 and over</i>	2.01	0.66	2.14	0.03**	1.06	3.82
<i>Sit Mat</i>	(ref : Single)					
<i>Divorced/widowed</i>	0.74	0.29	-	0.44	0.34	1.59
<i>Bride)</i>	1.30	0.31	1.09	0.27	0.81	2.07
<i>InstLevel</i>	(ref : None)					
<i>Others</i>	1.66	1.24	0.68	0.50	0.38	7.18
<i>Middle School</i>	1.02	0.31	0.07	0.94	0.56	1.86
<i>Franco-Arab/Koranic School</i>	1.15	0.36	0.44	0.66	0.63	2.10
<i>High school</i>	0.93	0.30	-	0.82	0.50	1.73
<i>Primary</i>	1.25	0.40	0.72	0.47	0.67	2.34
<i>Superior</i>	1.40	0.44	1.07	0.28	0.76	2.59
<i>StatusOcc</i>	(ref : Not occupied/Not working)					
<i>Busy</i>	1.06	0.21	0.32	0.75	0.72	1.57
<i>KnowPerson</i>	(ref : No)					
<i>Yes</i>	1.85	0.35	3.27	0.00**	1.28	2.67
<i>SymptIndex</i>	1.84	0.86	1.31	0.19	0.74	4.61
<i>Selfmedication</i>	(ref : No)					
<i>Yes</i>	0.47	0.09	-	0.00**	0.33	0.67
<i>IndexPrevention</i>	55.25	30.36	7.30	0.00**	18.82	162.24
<i>DensPop</i>	1.00	0.00	1.87	0.06*	1.00	1.00
<i>_cons</i>	0.07	0.03	-	0.00**	0.03	0.16

Source: Authors' calculation, OCAD-COVID data

5. Discussion

As underlined in the results section, five variables turned out to be significant. These are gender, knowledge of an infected person, knowledge of preventive measures, age and finally the density of the population. Thus, the results of this article were compared with other studies on the same theme in different countries.

5.1. Gender

Regarding gender, the results showed that men are 1.5 times less willing than women to take the vaccine. This result corroborates that of Gallè et al. (2021). These authors found significantly higher rates of reported vaccination and willingness to vaccinate among women

compared to men. However, for other authors like Hossain *et al.* (2021), the average hesitation was higher among city women. Their study revealed that women were more reluctant than men to be vaccinated against Covid-19, which they explained by various reasons such as their low economic capacity, their concerns about the potentially harmful effect of Covid-19 vaccines on the development of the baby in the womb and of young children, conspiratorial beliefs concerning subfertility imposed by the Covid-19 vaccine, infertility, miscarriages. The fact that the anti-covid vaccine is more likely to be taken by men than by women is also the result found by Malik *et al.* (2020). In their study looking at the determinants of Covid-19 vaccine acceptance in the United States, 67% said they would accept a Covid-19 vaccine if recommended. Of these, 72% were men.

5.2. Knowledge of a person infected with Covid-19

The results of this article showed that knowing someone who had been infected with the disease greatly increased the propensity of the population to accept the vaccine compared to those who had never known someone who had been infected. Sandu and Rajka (2021) also showed in their research on the factors that can influence in Romania the decision of parents regarding the anti-covid-19 vaccination of children and adolescents aged 12 to 15, a similar result. In the group of respondents whose family members have risk factors, the proportion of those who intend to have their children vaccinated is about 1.4 times higher (40.7%) than in the group of respondents without family members with risk factors (27.7%). This knowledge would thus induce in individuals a greater awareness based on lived facts and not on speculation.

5.3. Knowledge of prevention measures

Knowledge of preventive measures increases the propensity of people to take the vaccine. The observation is the same for Houssain *et al.* (2021). For the latter, the average level of vaccine hesitancy varied significantly depending on the behavioral practices of the participants to prevent Covid-19. Respondents who never wore the mask were more hesitant than the others. Similarly, those who never avoided crowds were also more hesitant. This means that the more people know about the consequences of Covid, the more they tend to move away from it by respecting barrier measures and vaccination and the more they ignore the consequences, the less inclined they are to take steps to avoid it.

5.4. Population density

The density of the population also plays, according to the results of this article, an important role in up-take of the anti-covid-19 vaccination. The more populated the locality, the more the population tends to be vaccinated. However, other authors like Malik *et al.* (2020) showed for

three large cities in the United States (Denver, New York and Chicago), the existence of notable geographical differences in the acceptance of the COVID-19 vaccine. Denver is the least populated city but has a vaccine acceptance rate of over 75%. The other two most populated cities – New York and Chicago – have an acceptance rate for the anti-covid vaccine of less than 50%. This situation is the same as for the other influenza vaccines previously offered to the populations of these different cities.

Conclusion and recommendations

This article, devoted to the study of the factors driving the willingness of the population to be vaccinated against COVID-19 in the department of Dakar in Senegal, has made it possible to know the main variables presenting significant effects. These include sex, knowledge of an infected person, knowledge of preventive measures and population density at the municipal level. It thus emerged that women, the elderly, people who know an infected person and then those living in high-density areas are the groups most likely to accept vaccination against covid-19 compared to other groups. Knowledge of preventive measures also plays a very important role in this decision as a driver for informed decision-making.

Moreover, marital status, level of education and employment status appeared to have no significant effect on the willingness to be vaccinated.

The results obtained seem decisive for the definition of national public health policies and even at the territorial level to a lesser extent. To do this, it would be wise to:

- Focus on raising women's awareness as a vector for reaching more men (target population);
- Focus on raising awareness among young people who seem to feel less concerned;
- Make every effort to increase the level of knowledge and understanding of the population in relation to the health situation since it appears that this level of knowledge can be a major incentive;
- Also direct sensitization towards non-populous municipalities.

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