A Study on Vaccination Concerns in Albania Analyzed by Machine Learning Classifiers

Ledia Qatipi[1*], Sonila Brati[2], Jonadri Bundo[2']

[1] ABC Health Center, Tirana, Albania
[2] State Health Center Nr.2, Tirana, Albania
[2'] Research and Development Department, Engineering Services, Tirana, Albania

Abstract

Background: Vaccination is one of the most successful public health interventions in the world. In our country immunization rates have shown regress in recent years from 94% in 2008-2009 to 75% in 2017-2018 according to Albania Demographic and Health Survey 2017-2018. This decline in immunization rates has led to Measles epidemics we have seen in the last decade. The "Vaccine hesitancy" phenomenon is becoming a concern in our country and is highly contributing to the decrease in the immunization rates.

Objectives: Our study intends to find out the reasons why parents Delay or Refuse vaccination of their children in the first 5 years of life. Another goal is to find similarities of concerns between parents who DO vaccinate their children and parents who Delay or Refuse vaccination.

Study design and methods: Anonymous confidential questionnaires were given to 1206 random parents in public and private health centers all over Albania. They expressed their concerns in regards of vaccines done to children 0-5 years old according to the Albanian Immunization calendar. Data was gathered and a detailed statistical analysis was done to find significant concerns parents have in both categories (1. Do vaccinate vs 2/3 Delay/Refuse vaccination). Further we used 2 Machine Learning Classification Algorithms: A. Decision Tree Classifier, B. Support Vector Machine.

Results: From the statistical analysis was concluded that 95.27 % of the parents have some type of safety concern, trust issue, side effects and source of vaccine supply concern. 10 % of all

Address for correspondence: Ledia Qatipi*, "Haxhi Sina" Street, Nr. 123, Tirana Albania. Email: qatipilediamd@gmail.com

parents and 57.7% of category 2/3 are concerned about Autism, 17% of them complain "Vaccines are not safe", while 29% believe "There are too many vaccines given at the same time". Another important new concern we found to be statistically significant is "I do not trust the effectiveness of State Vaccines" (15.38 %), Chi-Square calculated p-value= 4.42E-5(<0.05). Decision Tree Classifier and Support Vector Machine gave accuracy levels of 94.6% and 95.45% respectively.

Conclusions: This study proves there is significant evidence that parents' concerns are real and we, as health care professionals, must address these concerns and take measures. We believe that if parents are convinced that state vaccines have good quality, parents will be more prone to vaccinate their children in time and ultimately decrease Measles and other infectious diseases outbreaks. It is important to invest in giving them more information about vaccines quality and safety.

Key words: Immunizations, Vaccines, Vaccine Hesitancy, Machine Learning

INTRODUCTION

Vaccination is one of the most successful public health interventions in the world. In Albania immunization rates have shown regress in recent years from 94% in 2008-2009 to 75% in 2017-2018 according to Albania Demographic and Health Survey 2017-2018 (1). This decline in immunization rates has led to Measles epidemics we have seen in the last decade. The ISHP (Institute for Public Health) has monitored very closely the Measles epidemic situation in Albania. According to ISHP in year 2018, more than 50% of the total number of vaccines were given to children 1-5 years old, who were behind with their immunizations. In January 2019, ISHP reports 30 new confirmed cases of Measles, the majority of them to be children under 2 years old (2). Why is this happening in Albania, a country where vaccination is free and available to every child?

Interestingly, in medical journals we read more and more about "Vaccine hesitancy" phenomenon (3, 4, 5, 6). "Vaccine hesitancy" refers to a delay or refusal of vaccination even when they are readily accessible. It is becoming a concern all over the world and in Albania as well. This phenomenon is tremendously impacting the decrease in immunization rates, herd immunity and ultimately the increased occurrence of vaccine preventable diseases in children. Vaccine hesitancy is influenced by factors such as complacency, convenience, and confidence. Parents have expressed other reasons and concerns being categorized as religious reasons, personal beliefs or safety concerns. Vaccines play a vital role in preventing infectious diseases in children, but parents still are afraid to vaccinate despite the global pro-vaccination campaigns. Although there are state laws regarding vaccine administration dictating which vaccinations are required for children prior to entering schools, still parents decide to delay or refuse vaccinations and send their children to private daycare, kindergartens and schools. So, it is crucial for all healthcare professionals to understand the reasons why parents are hesitant or refuse to vaccinate their children.(3)

The Centers for Disease Control and Prevention (CDC) is clear about the fact that "No Vaccine" is completely safe or 100% effective (7). Vaccines have their benefits and risks. The majority of parents understand vaccine benefits, but have a hard time understanding the concept of "Vaccine herd immunity" (8). Herd immunity is a form of indirect protection from infectious disease when a large percentage of a population has become immune to an infection. This provides protection for individuals who are not immune in that community, like children under 12 months of age. Parents have a hard time understanding how their personal decision of Delay/Refuse vaccination can potentially harm other children who are not yet vaccinated due to their age. Subsequently measles, pertussis and other infectious diseases can spread in their community and potentially cause epidemics (9).

According to the World Health Organization, attitudes towards vaccine safety are more negative in Europe, with 41 percent of respondents in France, 36 percent in Bosnia and Herzegovina disagreeing that vaccines are safe (10). UNICEF has reported significant drop in immunization coverage in North Macedonia, registering the lowest coverage in the country for the MMR vaccine, standing at only 67% (11).

According to an analysis of the World Health Organization/UNICEF Joint Report Form as of June 2017 was confirmed that "vaccine hesitancy" is present in the majority of countries and increasing annually (12). Unfortunately, no one knows exactly why. With current large Measles outbreaks across the Balkan Region, including in nearby Italy, France, Romania, Serbia and North Macedonia, our region is on high alert for outbreaks (9).

OBJECTIVES

Our study intends to find out the reasons why parents/ legal guardians Delay or Refuse vaccination of their children in the first 5 years of life. Another goal is to find similarities of concerns between parents who DO vaccinate their children and parents who Delay vaccination /Refuse vaccination of their children.

MATERIALS AND METHODS

Anonymous confidential questionnaires were given to 1206 random parents in 14 Public and 1 Private Health Centers (HC) all over Albania during a 3 months period (October 1, 2018-

December 31, 2018). These Public Health Centers cover a significant number of children from different backgrounds in Tirana (Health Center 1,2,4,8,9), Burrel, Lushnje, Fier, Kastriot and Zerqan in Diber, Pogradec, Elbasan, Aranitas Mallakaster and Polis Librazhd. The only private primary health center was ABC Health Center in Tirana. Survey templates were created on Google docs and printout questionnaires were sent to all Health Centers. Family doctors or nurses gave these questionnaires to parents who were vaccinating their children from 0-5 years old according to the Albanian Immunization calendar. Parents were informed in advance about the scope of the survey and the confidentiality of their information. They voluntarily agreed to answer 3 multiple choices questions regarding the reasons why they Do or Delay/Refuse to vaccinate their children and if they have any concerns regarding vaccines. All vaccines were categorized in 5 groups 1.MMR, 2.PENTA (DTP-Hep-B-HIB), 3.PCV, 4.IPV/OPV, 5.ALL vaccines.

The possible alternative questions were selected based on the most common concerns parents expressed during our daily pediatric visits in Private and Public Health Centers. In the private Health Center we noticed that many parents were purchasing vaccines privately due to "Not trusting the effectiveness of the State Vaccine". Other parents were refusing to do vaccines due to "Not trusting vaccines overall"; "Vaccines are not safe"; "Do not believe vaccines prevent infectious diseases"; and/or "There are too many vaccines given in the first 2 years of life".

In Public Health Centers parents were delaying vaccines due to "Vaccines have many side effects"; "There are too many given at the same time; and/or "Vaccines cause high fever".

Afterwards, we created a questionnaire with 10 possible alternative questions for three groups of parents, Group 1 "Do vaccinate ", Group 2 "Delay Vaccination" and Group 3 Refuse vaccination.

Data gathered was entered in Google files for each Health Center. All data entered was analyzed by using 2 Machine Learning Classification Algorithms to find out the most important concerns and study model accuracy.

STATISTICAL ANALYSIS / RESULTS

Statistical analysis of studying the population's behavior towards vaccines first went through preprocessing step. Non numeric data was encoded to numeric data.

During this analysis we will consider as independent Boolean variables 10 questions, which represent the possible concerns of a parent who is about to make a decision to vaccinate his child. As dependent variable will consider the decision on vaccinating his child or not. This way, we would have a result if a parent decides to Do the vaccine, Refuse or Delay the vaccine.

Due to the fact that we are working with categorical data, we will assign to each category a numerical value as shown below:

- Category indicated by Value 1- DO vaccination on time

- Category indicated by Value 2- Refuse vaccination
- Category indicated by Value 3- Delay vaccination

During our analysis we are merging "Delay Vaccination" category with "Refuse Vaccination" category.

As the first step we are going to find what is the percentage of parents who Delay / Refuse vaccination. This is shown in the following graph.
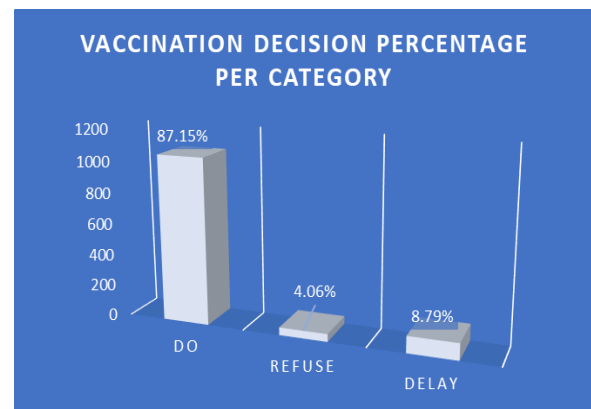
Figure 1. Vaccination Decision Percentage

We note that 12.85% of all parents in our dataset Delay / Refuse vaccination.

Our main concern is to find out the reasons that probably would make a parent decide to Delay or Refuse vaccination to his child. This is better shown in the following graph.
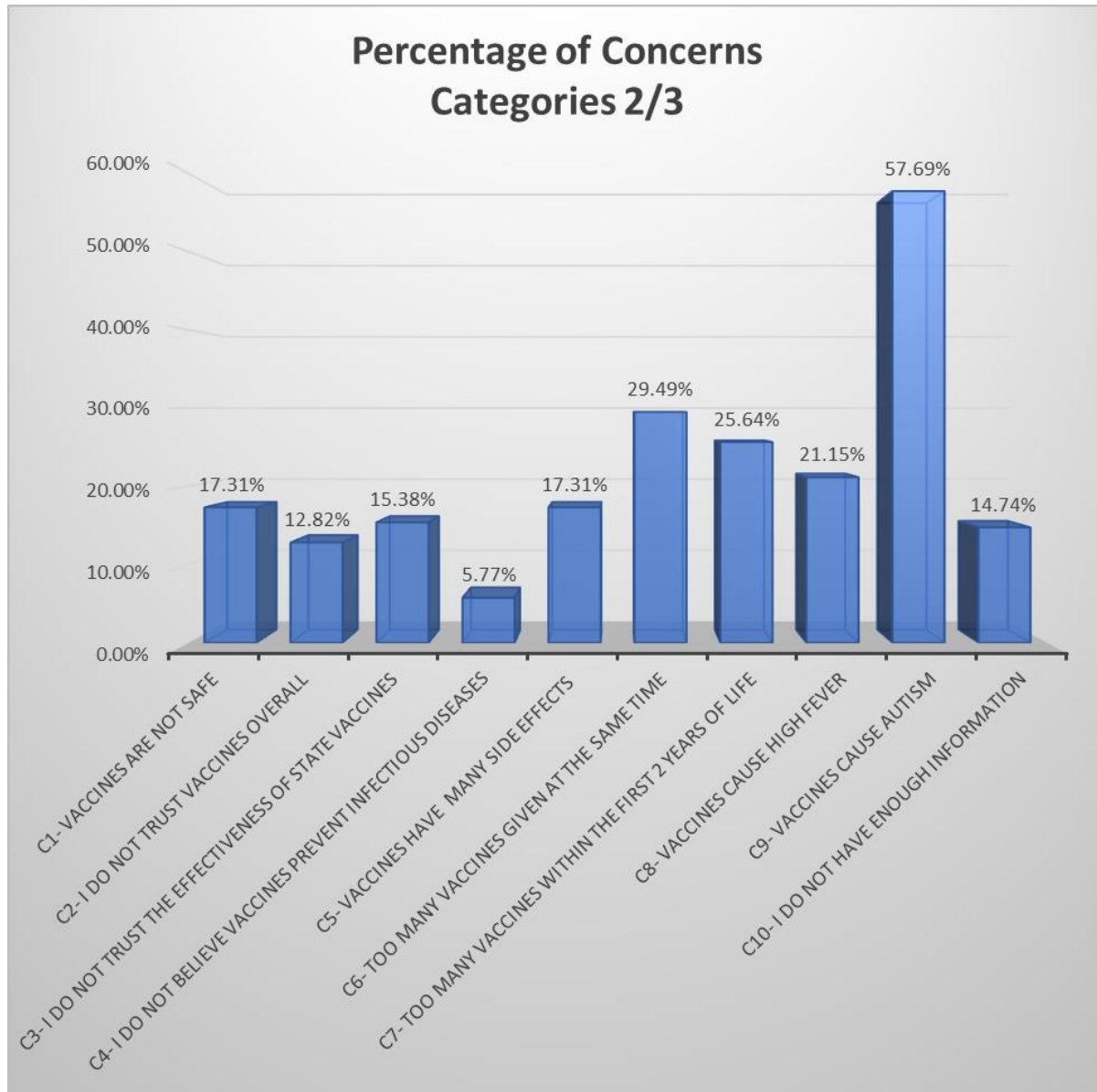
Figure 2. Percentage of concerns, Categories 2/3

The abbreviations for each concern are as follows:

C1 "Vaccines are not safe"

C2 "I do not trust vaccines overall

C3 "I do not trust the effectiveness of the State vaccines"

C4 "I do not believe vaccines prevent infectious diseases"

C5 "Vaccines have many side effects"

C6 "There are too many vaccines given at the same time"

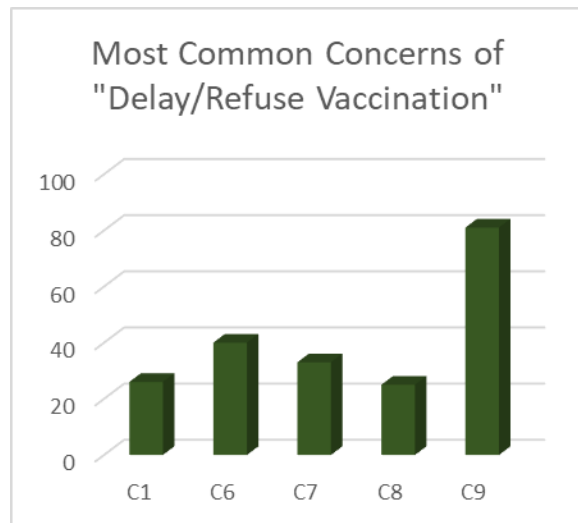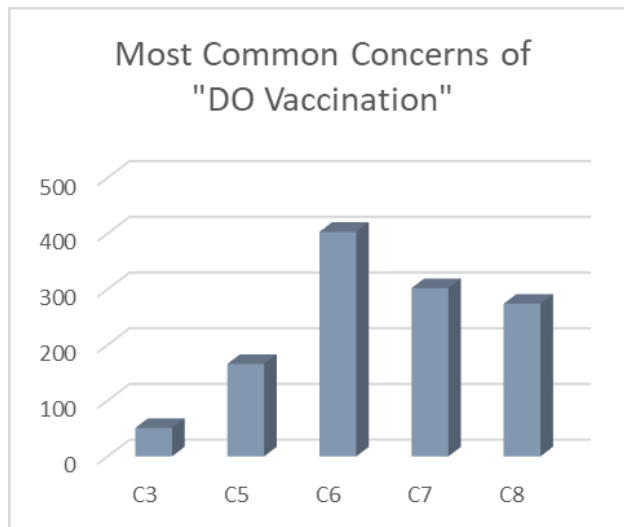C7 "There are too many vaccines given within the first two years of life"

C8 "Vaccines cause high fever"

C9 "Vaccines cause Autism"

C10 "I do not have enough information"

We see that the major concern is C9 Autism (57.69%) and the minor concern is C4 "I do not believe vaccines prevent infectious diseases" (5.77%). The second most important concern is C6 "Too many vaccines are given at the same time" (29.49%).

Next, we analyze the 5 major common concerns of parents per categories and detect the most common concerns in both categories.

"Bartlett's Test" tests the "significance" of the study and gives the p-value. We will consider that this data set is significant if p-value < 0.05. After applying the Bartlett's test to this data set and concluded that p-value = 2.49E-265 (significant), we continued with KMO (Kaise-Meyer-Olkin) test.

Data obtained from KMO test will be found in [0, 1] interval, where values > 0.6 will be considered positive for applying the factor analysis. Values

Figure 3. Most Common Concerns for Each Category

Clearly, we see that C6, C7 and C8 are similar concerns in both categories.

This survey, in statistical aspect, it will be worth applying the Factor Analysis to understand the group of factors that have the major weight on the final result. Before we go to the factor analysis, let's see if "Bartlett's Test" and "Kaiser-Meyer-Olkin Test" tell us that this data set is adequate for applying factor analysis.

< 0.6 will indicate that the factor analysis is not applicable to this data set. The KMO test result for our study is:

- KMO for Model = 0.49
- KMO per each variable

This test concludes that the Factor Analysis is not applicable to this data set, due to KMO value < 0.6.

Table 1. KMO Test Results

Res	C1	C2	C3	C4	C5	C6	C7	C8	C9	C10
0.49	0.55	0.61	0.68	0.74	0.33	0.37	0.33	0.35	0.47	0.35

Legend: Res- Result; C- Concern

Table 2. Chi2 Calculated P Value

C1	C2	C3	C4	C5	C6	C7	C8	C9	C10
8.47e-20	1.98e-15	4.42e-05	0.15	0.69	0.003	0.06	0.009	5.94e-79	1.51e-07

To test each variable's weight we are going to apply Chi Square and get the P-Value for each concern. After we applied Chi Square to all data set the results we received are as follows:

By evaluating the above results we concluded that concerns C4, C5 and C7 can be considered not significant.

Since we want to test further the significance of these data, will apply the statistical analysis based on 2 algorithms of Machine Learning as follows:

- Decision Tree
- Support Vector Machine

A. Decision Tree

After the training process, it results that the model is 94.6 % accurate. Using 10 variables in this model makes the tree having a complex structure that makes interpretation difficult. However, the assessed value of the model accuracy confirms that the data set is significant.
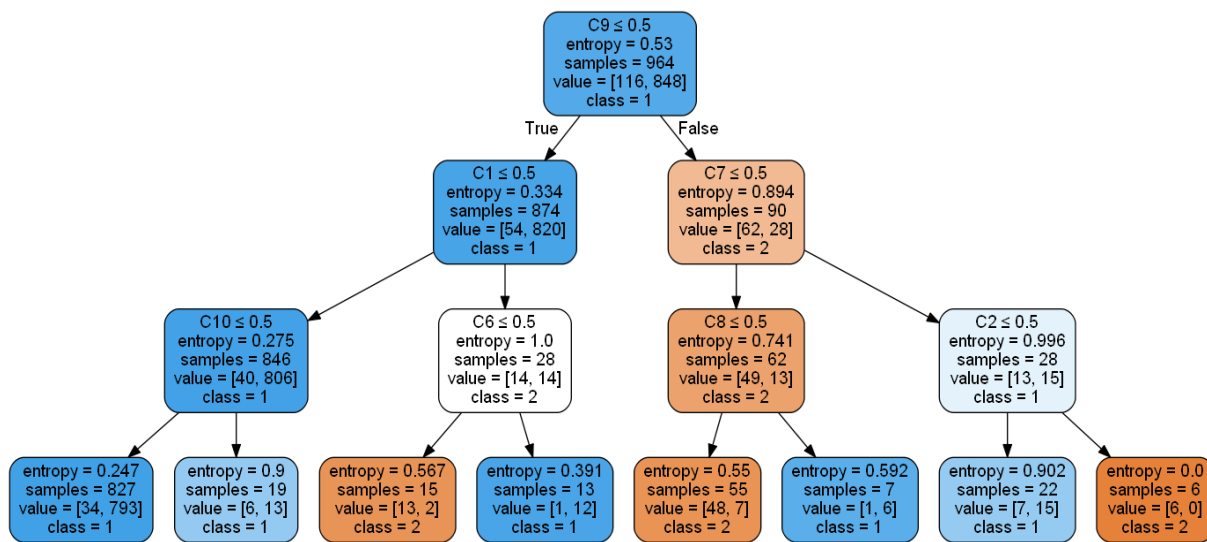
Figure 4. Decision Tree Simplified Model

Going further, we trained a new model by determining the maximum number of tree levels to 3 (three). Although the accuracy decreased by approximately 2%, the graph readability increased significantly.

Decision Tree Interpretation

Each box evaluates a specific concern (Cx). If the concern is present (>0.5) step down to the right side (False) of the tree. If the concern is not present (<0.5) step down to the left side (True). Repeat this process until the final tree level is reached to conclude if this parent will vaccinate (blue color) or delay/refuse vaccination (brown color). The color intensity represents the decision-making confidence level.

Legend:

- Blue Box represents category 1 (Do Vaccination)
- Brown Box represents category 2 (Delay/Refuse Vaccination)

According to tree structure we see that training process automatically eliminated variables C3, C4, and C5. Sitting at the bottom of the tree, we see that 3 concerns determine if the vaccination will occur or not. These variables are C2, C6, C8:

- I do not trust vaccines overall

- There are too many vaccines given at the same time
- Vaccines cause high fever

It's easily noticeable that the autism concern (C9) is a very common concern in the majority of population who delays or refuses vaccination.

B. Support Vector Machine

A support vector machine (SVM) is machine learning algorithm that analyzes data for classification and regression analysis. SVM is a supervised learning method that looks at data and sorts it into one of two categories. To train the SVM model, we chose a polynomial Kernel of the 5th order. After training SVM model by using 80% of data, we obtained an accuracy level 95.45% which shows a very good level of confidence.

Let's test these 2 Machine Learning Models, by taking 1 random sample from the test data set which we know that "Refused Vaccination".

Giving the following data to SVM model results that this person will Refuse Vaccination. By applying the same data to the Decision tree, the tree steps to be evaluated are C9, C1 and C6 that will take us to the final tree step determining the sample's vaccination refusal.

Table 1. One Random Sample from the Test Data Set

Res	C1	C2	C3	C4	C5	C6	C7	C8	C9	C10
2	1	1	1	0	0	0	1	1	0	0

Legend: Res 2- Refuse vaccination
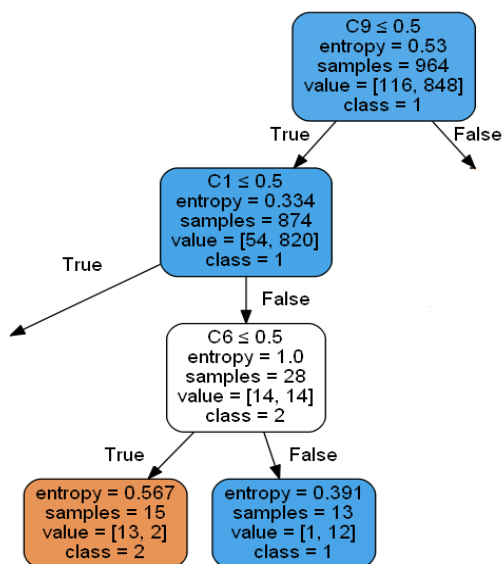
Figure 5. Decision Tree Steps on Vaccination Decision Making

Statistical Analysis finds Autism (57.7%) as the major concern and "Too many vaccines are given at the same time and/or in the first 2 years of life." (29 %) as the second most important concerns. Approximately 21% of parents believe "Vaccines cause high fever", while 17% of them are worried about "Vaccines are not safe". Chi Square calculated p-value results not significant for concerns C4, C5 and C7.

Table 4. Chi2 Calculated P Value

C1	C2	C3	C4	C5	C6	C7	C8	C9	C10
8.47e-20	1.98e-15	4.42e-05	0.15	0.69	0.003	0.06	0.009	5.94e-79	1.51e-07

By applying the Machine Learning Decision Tree classifier we were able to find 3 important concerns, besides Autism, that may determine the parents "decision making" if vaccination will occur or not. These concerns are: "I do not trust vaccines overall" (C2), "There are too many vaccines given at the same time" (C6) and "Vaccines cause high fever "(C8).

Similarities we noticed between two groups are "Too many vaccines are given at the same time" (C6), "Too many vaccines are given within 2 years of life" (C7) and "Vaccines cause high fever" (C8).

A new concern we find to be statistically significant is "I do not trust the effectiveness of the State Vaccines "(15.4%) , Chi-Square calculated p-value= 4.42E-5(<0.05) .

DISCUSSION

We as healthcare professionals should know parents' concerns and make all the efforts to address them. That is our main goal, and in this study we were able to find the most important concerns that will make parents Delay/Refuse vaccination to their children. Are we as healthcare professionals seriously considering their concerns? Interestingly enough approximately 15% of parents claim they don't have enough information about vaccines. This is a major problem concerning doctors and nurses who apply the vaccines and inform parents about vaccines

benefits and side effects. When parents do not get the information they need from their doctors, they seek information from other sources that can potentially mislead and misinform them, causing them to make poor choices for their children (5). We need to stay up to date on recommended vaccines. Then, we need to inform parents with up to date information we can get from trustable sources such as ISHP (Institute of Public Health), WHO (World Health Organization), UNICEF, CDC (Centers for Disease Control and Prevention) and FDA (Food and Drug Administration) (1, 7, 9, 11, 13). Subsequently, parents will be informed, ask more questions and ultimately make rational decisions on vaccinating their children.

We find trust and safety concerns to be the major determining factors on each parent "decision making". Why some parents don't trust vaccines overall? Does this opinion have anything to do with the vaccine ingredients or pharmaceutical companies (14)? Media constantly quotes problems with components of vaccines, such as thimerosal in MMR vaccine, and reports that vaccines can cause autism, brain damage, or behavioral problems. On the other hand, researchers in the last 20 years have shown no connections between MMR and Autism (15, 16, 17). In this study, Autism was the major concern 57.7% of Albanian parents who delay or refuse vaccination have. Possible solution to this concern would be to give more evidence-based information to parents (18, 19, 20). In addition, pharmaceutical companies can do more research to show the safety of each vaccine ingredient and publicly inform parents. This approach will improve the education barrier, raise awareness, and probably result in higher immunization rates.

The common concerns between two groups arise due to parents fear that administering multiple vaccines at the same time may overburden their child's immune system. They think that by spreading vaccinations in time, not according to the actual Albanian immunization schedule, will protect their children against vaccine side effects (18). In this case, we as health care providers should take more time in explaining how vaccines work and why spreading vaccination in time will lead to infectious disease outbreaks.

Finding "Source of vaccine supply" concern statistically significant makes us question if there is any evidence that proves it to be true or misleading information. In both cases, if parents are convinced that state vaccines have good quality, they will be more prone to vaccinate their children in time.

CONCLUSIONS

This study demonstrates there's significant evidence that parents' concerns are real and we, as health care professionals, must address these concerns and take measures. We believe that if parents are convinced that state vaccines have good quality, they will be more prone to vaccinate their children in time and ultimately decrease Measles, and other infectious diseases outbreaks. It is important to invest in giving them more

evidenced-based information about vaccines quality and safety. This study opens a door to another study with socioeconomic data and checking further the importance of improving the quality of vaccines that children get in Albania.

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Conflict of Interest Disclosure: None declared.

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