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Research Article

An Analysis Study in OECD Countries on Pediatric Vaccines and Their Effects with Cluster Analysis and Multiple Regression Technique

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Abstract – In the study, Turkey's position in this field was examined children vaccination rates between the years 2000-2017 in the OECD countries by taking clustering technique. Data were tested by non-hierarchical clustering method. Then it was analyzed by multi-dimensional scaling. According to the results of clustering, countries are grouped into 3 groups. The relationship between the results obtained and the development level of the countries are analyzed. As a result, clustering occurred between countries with distant values. In a multidimensional scaling analysis, child mortality data in Turkey in 2017 are used as the dependent variable. Health spending, Gdp, diphtheria, measles and hepatitis-b vaccination rates have been determined as impact factors. Purpose in the second analysis is to see to what extent these vaccines and a few variables affect and to put it numerically to the infant mortality rate in Turkey by looking at the obtained stress values.

Keywords – Clustering, Multidimensional Scaling Analysis, Child Vaccination Rates, OECD Countries, Multiple Linear Regression Analysis

I. INTRODUCTION

Vaccine is one of the effective and economical methods known for the protection of people and public health today. It is the introduction of pathogenic organisms into the body, either weakened or dead. Thus, it is aimed to activate the protective system in the body. The vaccination of many important diseases such as whooping cough, polio, diphtheria, hepatitis A, hepatitis B, mumps, measles, rubella, chicken pox, tetanus, tuberculosis has been implemented in many countries with the policies set by the World Health Organization [1].

Vaccination is seen as a safe and economical method of minimizing childhood mortality rates for health protection [2]. One of the most important public health practices carried out about sustaining health and preventing infectious diseases is vaccination studies [3].

Concerning vaccination practices, hesitations due to different reasons have been emphasized by parents. To eliminate these hesitations; Achieving GBP targets is important to protect the society from diseases that are at risk of death and serious complications. Although there is an increase in vaccination rates in our country, as in many countries, discussions about vaccines are on the agenda. Therefore, the need to reconsider the factors affecting vaccine applications has arisen [4].

WHO created a commission in 2012 to investigate vaccine rejection. Depending on the report prepared

as a result of the work of this commission, vaccine hesitation and vaccine rejection were named as different concepts. This element, which has emerged with the combination of many social, cultural and individual factors, can ensure the continuity and successful implementation of vaccine applications [4]. Measles, which has an important place in vaccination; high fever, encephalitis, pneumonia, otitis media, mumps; pancreatitis, infertility, rubella; Hereditary heart diseases can lead to important health problems such as cataracts and deafness. Adverse effects such as fever, rash, joint pain, restlessness, anorexia, muscle pain, cough, thrombocytopenia and aseptic meningitis have been reported as side effects of the vaccine [1].

In this case, hepatitis B vaccine is administered as two doses with an interval of one month and as a third dose six months after the first dose [5]. It is reported that hepatitis B vaccine should be administered in premature babies when the baby is 2000 grams, the vaccine and hepatitis B immune globulin (HBIG) should be administered together if the baby is below 2000 grams and the mother is a hepatitis B carrier [6].

Non-responsiveness to hepatitis B virus vaccines is not uncommon in hemato-oncological sicks due to disease-related or created with treatment immune trap. Hepatitis B virus infection, the most common chronic viral infection in the world, can have grave clinical complications ranging from abruptly hepatitis to cirrhosis and hepatocellular carcinoma [7]. Chronic hepatitis C and hepatitis B infections are important health problems all of the world. Whence, suppression of the contamination of the viral infections gets advanced primacy [8]. Vaccination against hepatitis B is the most influential tip to control HBV infection [9].

Scientific and clinical understanding of vaccines and vaccination is remaining dramatically and holds huge potential to detract the human and pecuniary charge of disease. Recombinant science is reforming vaccination technic, making new and preferable vaccines feasible [10]. An extension size of vaccines targeting several of the significant causes of mortality and morbidity are reaching the world's children [11]. Also the implications for identification of private patients, understanding measles vaccine defeat is crucial to assigning the defiance of attaining and nourishing regional measles sifting and the applicability of global measles disposal [12].

Compared to the WHO European region countries, the high vaccination rates achieved in recent years seem to have outstripped many countries. In addition, while the vaccination rate in the third dose of mixed vaccines of the countries in which we are in the same income level group (middle upper income group) is 92%, this rate has reached 96% in our country. This rate is higher than the rate of upper income group countries (95%) [1]. As this data supports, our country has achieved vaccination rates equivalent to developed countries with its vaccination policies [13].

People should be careful about the side effects of vaccines. Because no vaccine is 100% safe. Vaccine-related reactions may occur [14]. Due to these side effects, the increase in the prevalence of autism in the world over the years causes the vaccine discussions to intensify. For example, in a study conducted in the United States between 2000-2012 and in all states, it was reported that the prevalence of autism in 8-year-old children in the period 2000-2006 was 1 in 150 children, it increased to 1 in 68 children in the period after 2006 [15]. Accordingly, in the report published by the World Health Organization in 2004, it is recommended that the mercury-containing thiomersal substances found in vaccines for protective purposes are not found at a toxic level and their use should be continued [16]. However, the United States removed mercury-containing vaccines in 2001 due to concerns that vaccination rates would drop due to negative rumors [17].

The aim of this study is to examine the vaccination rates of OECD countries between 2000-2017 by performing numerical analysis Turkey's position in this field with clustering technique. Second aim is to see the effects of this vaccine on child mortality and the identified variables in Turkey and to be able to reveal numerically.

Many studies are carried out in the field of health, taking into consideration the conflicts about vaccination between countries. In current studies, it was observed that general vaccination percentages and specific analyzes for diseases were also performed. In the light of these studies, it is aimed to contribute to the literature with a different perspective by using numerical analysis techniques related to the subject of vaccination regardless of

any specific area. Current studies in the literature are compiled below.

Gülcü and Arslan (2018) discussed the significance of immunization and anti-vaccination voyages in their study. Vaccination rates and vaccination policies should be carried out successfully. As a result, she argued that education of health personnel and current approaches of health workers in vaccines are very important [1]. Yüksel and Topuzoğlu (2019) studied about vaccinations. The World Health Organization created a brokerage in 2012 to investigate vaccine rejection. According to the report prepared as a conclusion of the study of this commission, immune hesitation and immune rejection were defined as different concepts. This concept, which is formed by the compound of many clubby, agrarian, diplomatic and personal agents, contacts the persistence and successful application of vaccine applications. In many studies, the behaviors and reasons of parents' refusal, delay or hesitation to vaccinate their children were examined. As a result, about the childhood vaccination of parents, especially the effectiveness of vaccines and vaccine components; Sufficient information on risks such as possible side effects and benefits of vaccination can help them make an informed choice about vaccinating their children [4]. Argüt et al. (2016) examined the factors that may affect vaccine acceptance in their studies. The aim is to contribute to strengthening vaccine practices and reducing shyness. In this article, it is aimed to synthesize the publications about the factors affecting vaccine acceptance [3]. Poyraz and Özdoğan (2016) presented a study examining the developments in hepatitis B and C vaccines in their studies. Zhao et al. (2020) in their study, they examined the development and administration of hepatitis B vaccine. Improving of two-dose vaccine feasible in childs with comparable efficacy will be more proper to enforce global hepatitis B immunization [9]. Giffin et al. (2004) in their study, they examined childhood vaccine Finance and safety issues. In addition, tensions within the state and federal partnership in public health in general and immunization in particular still require attention [10]. Higgins et al. (2016) in their study, they examined Society of BCG, DTP, and measles having vaccines with childhood death rate: systematic comment. Their comment was conducted at the demand of WHO following a suggestion of the Strategic Advisory Group of Experts (SAGE) on the need to assess whether the evidence respecting non-specific effects is sufficient to warrant adjusting the ordinary immunization time further research planned to support future argument based adjustments in vaccination policies [11]. Moss (2018) in the study, he examined Measles in Vaccinated Individuals and the Future of Measles Elimination. if measles disposal is tardy for a ten-spot the risk of imported measles maintains, countries that have supplied measles will demand to monitor population immunity to measles virus across age groups, including older majors, and assigns the risk of decreasing dispensation [12]. Mina et al. (2015) in their study, using population-level information, they show that measles has a more elongated impact on host drag, extending over 2 to 3 years. They find that nonmeasles infectious disease mortality in high-income countries is firmly coupled to measles rate at this tardiness, in both the pre- and post-vaccine epochs. Our data maintain an comment for the long-term avails of measles immunization in arresting all-cause infectious disease. By arresting measles-associated immune retention detriment, accination protects polymicrobial herd immunity [18]. Bohlke et al. (2003) found the risk of developing anaphylaxis after 8 million doses of vaccination (measles-mumps-rubella, hepatitis B, diphtheria-tetanus-whooping cough, Influenzae type b and oral polio vaccine) as 0.65 per million doses [19]. Taylor et al. (2002) investigated whether measles, mumps, and rubella (MMR) vaccination is associated with bowel problems and developmental regression in children with autism, looking for evidence of a “new variant” form of autism. Five health districts in north east London. Recorded bowel problems lasting at least three months, age of reported regression of the child's development where it was a feature, and relation of these to MMR vaccination. Findings provide no support for an MMR associated “new variant” form of autism with developmental regression and bowel problems, and further evidence against involvement of MMR vaccine in the initiation of autism [20]. Long et al. (1990) studied on immunogenicity and adverse effects of 1553 doses of diphtheria and tetanus toxoids and whole cell pertussis vaccine (DTP) was performed in 538 children observed longitudinally from 2 months to 20 months of age. Subjects were randomized to the standard four-dose immunization schedule or to a three-dose Schedule. Data suggest

that age has more effect on the type and rate of adverse clinical events than does vaccine dose number. Existing antibody levels to vaccine components, lot of vaccine, breast-feeding, or gestational age did not affect rate or type of clinical reactions [21].

II. Materials and Method

In this study, child vaccination rates of 36 OECD countries in 2000-2017 period were examined. In this study, primarily non-hierarchical clustering and K-Means analysis were used. In addition, the positions of 22 OECD countries in two-dimensional space were determined by multidimensional scaling analysis and visually demonstrated. The equation used in clustering is given below.

$$k \cong \left(\frac{n}{2}\right)^{\frac{1}{2}} \quad (1)$$

Equality (1) expresses the number of clusters formed depending on the number of samples. k number of clusters represents n sample volume. In the study, non-metric multidimensional scaling analysis was performed. Accordingly, the equation for determining stress statistics is shown below.

$$\text{Stress}=\frac{\sqrt{\sum\sum\left(\hat{d_{ij}}-d_{ij}\right)^2}}{\sum\sum {d_{ij}}^2} \quad (2)$$

The Kruskal stress statistics specified in formula (2) are calculated to determine the suitability between distances and estimated distances. dij represents the distance between the elements [22]. Methods, findings and conclusion sections used in the later stages of the study are discussed.

In the study, K-Means analysis and multiple linear regression analysis were used with the help of hierarchical clustering.

Clustering; units are the definition of homogeneous groups calculated based on differences or similarities between variables [23]. In this method, the first step is to select a measure of distance or similarity. The clustering method to be used later is decided. In the third step, the type of clustering method to be used for the chosen method is selected and the result is interpreted [24]. Clustering ends with the interpretation of the results obtained from the data sets by experts in the field of application to draw correct results. In the study, the number of clusters was determined in the first place and clustering was created with the K-Average algorithm, which is one of the non-hierarchical methods.

A. K-Means Algorithm

In this method, individuals are divided into k clusters to minimize the sum of squares within groups. Observing vectors with variables x1, p represent points in space X, and in the same space, a1n is classified into the cluster that gives the lowest distance for each group of individuals [25].

$$\frac{1}{n}\sum_{i=1}^{n} min\|x_i - a_{in}\|^2 \quad (3)$$

The K-Means technique, which divides units into sets and sets out variable estimates of the resulting sets, divides the units into sets for k sets [25].

In regression analysis, cause-effect relationships between variables are investigated. In other words, the rate of one or more of the variables affecting the others is checked. Multiple linear regression was used in this study.

Multiple Linear Regression Analysis is used to study the effect of variables on the dependent variable. With this analysis, relationships between variables can be found and estimates can be made for different values. In regression analysis, dependent variable and independent variables are defined. The relationship model between a dependent variable and independent variables;

$$Y_i = \beta_0 + \beta_1 X_{i1} + \beta_2 X_{i2} + \cdots + \beta_p X_{ip} + e_i \quad (4)$$

is given with equality. Where Y is the dependent variable and X is the independent variable. Variable number is p and parameter values are β (j=1,2,…,p) [26]. The findings and conclusions of the analyzes made in other parts of the study are explained.

III. Results and Discussion

A. Cluster Analysis

In the study, using the SPSS-22 package program, clustering and K-Mean analysis were performed with the child vaccination rate data of 36 OECD countries between 2000-2017 [https://data.oecd.org]. The results of the analysis are given below.

Hierarchical Clustering Findings

The purpose of hierarchical clustering is to make K-Average analysis more realistic and to determine the number of clusters. Hierarchical clustering is used in order to correctly interpret the analysis and obtain efficient results. According to the results of

the analysis, the countries are categorized into 3 groups. In the first cluster Germany, Ireland and Turkey is located. The second cluster includes Austria, Canada and New Zealand. The rest of the countries are in the third cluster. The points and distances that countries meet means that the rates of vaccination take close values and the percentages of vaccination between years are similar. In addition, the fact that the development indices of these countries have close values is an important factor in the formation of the cluster.

According to the dendrogram, three clusters were created in this way. The purpose of hierarchical clustering is to make K-Average analysis more realistic and to determine the number of clusters.

B. Non-Hierarchical Clustering Method Findings

Among the non-hierarchical methods, analysis was made using K-mean technique.

K-Means Technique Analysis

Among the hierarchical clustering methods, Ward method is generally thought to give optimum results [27]. The Ward method is the only method that allows clusters to occur by minimizing intra-group distribution[28]. In this method, the aim is to place the variance between the objects with a minimum [29].

The aim of ANOVA outputs is to investigate whether the variables differ. Clustering creates this difference itself and makes the difference between clusters the greatest. ANOVA outputs conclude that the variables differ by cluster.

The dendrogram created in the hierarchical cluster shows the number of clusters. In the analysis, firstly, the number of clusters was investigated with the hierarchical clustering method. As a result of the analysis, the dendrogram showed that 3 different groups were formed based on distance measurements between countries. 3- clustering was performed first by using K-Average technique. Grouping is done according to the vaccination data of the countries. The countries closest to each other were included in the same group by calculating the distance between them.

Table 1. Inter-Cluster distances

Cluster	1	2	3
1		2474.088	2640.818
2	2474.088		3101.851
3	2640.818	3101.851	

Table 1 shows the distance between the last cluster centers. Accordingly, it is determined that the two closest clusters are 1 and 2, and the two most remote clusters are 2 and 3. When the development levels and income rates of similar countries in clusters obtained by clustering results are analyzed, it is seen that countries have similar values. It can be said that there is a strong connection between them.

C. Multiple Linear Regression Analysis

In this study; Multiple linear regression analysis was performed for variables that affect and influence the level of vaccination coverage and child mortality rates in Turkey to determine the significance of these variables. The values of health expenditures, Gdp, diphtheria-tetanus-pertussis, measles and hepatitis-b vaccination rates were used. The data is generated based between 2000-2017 years for Turkey [https://data.oecd.org]. The purpose of performing multiple linear regression analysis is to reveal the relationship between variables with correlation analysis. In analysis; Correlation analysis was used to create a mathematical model of child mortality rate related to the specified variables and relationship analysis.

Model Summary

The model summary is given in Table 3 below. R^2 value was Table 2 assumes that error terms are independent of each other. This assumption is tested with the Durbin Watson coefficient.

Table 2. Model summary

Model	R	R^2	Adjusted R^2	Standard Error of Forecast	Durbin Watson (DW)
	0.861[a]	0.633	0.741	0.003	0.980

The rate of error terms affecting each other, that is, whether there is autocorrelation or not, is tried to be obtained. Durbin-Watson value ranges from 0 to 4. In Table 3, 0.98 is the Durbin Watson test value and this is an acceptable value. It was also determined that there was an autocorrelation for the Durbin-Watson coefficient as it did not meet the requirement of $1.5 < DW < 2.5$.

The following hypotheses were established in the model, where independent variables are thought to predict the dependent variable found as %74.1. It is evaluated that the rate of dependent variable explanation of the independent variables used in the analysis is above the average.

H_0 = Model is meaningless.

H_s = Model is meaningful

Table 3. ANOVA

Model	Total of Squares	Degree of permissiveness	Average of Squares	F	Degree of Significance (p)
Regression	1490939.593	5	298187.919	6.86	0.003[b]
Remains	521512.907	12	43459.409		

Table 4. Multiple linear regression model / Independent variables and coefficients

Model		B	Standard coefficients		t	Significance Level
			Std. error	Beta		
1	Constant (Child Mortality)	51.426	1538.141		0.033	0.974
	Healths(HS)	-285.774	147.106	-0.375	-1.943	0.076
	Gdp	-0.056	7.930	-0.002	-0.007	0.994
	Diptheria(D)	-27.933	22.352	-0.666	-1.250	0.235
	Measles(K)	17.756	15.978	0.364	1.111	0.288
	Hepatitis(H)	31.137	21.068	0.968	1.478	0.165

Dependent variable: mortality rate

ANOVA table summary is given above in Table 3. The F value was found to be 6.86 and the significance value to be 0.003. Since the p significance level formed as a result of the test is less than 0.05, the explanatory significance of the model is statistically significant and the H0 hypothesis is rejected. In other words, the model established is meaningful (p = 0,003 <0.05). The rejection of the H0 hypothesis indicates that the model.

The table of coefficients obtained from the regression analysis is examined in Table 4 is significant.

When the standardized beta value is examined in the coefficients table according to Table 4, it should be seen that the most important variable affecting the child mortality rate is the hepatitis-b vaccination rate. When the "t" statistic values are examined, it is seen that the variables in the model are significant at 5% significance level. Looking at the Pearson correlation table, there is a high level of relationship between child mortality rates, measles vaccine (17.756) and hepatitis-b (31.137), while health expenditures (-285.774), Gdp (-0.056) and diphtheria-tetanus-pertussis (-27.933). A low-level relation was found between. Considering the significance levels of the correlation coefficient between dependent and independent variables; child mortality rates and amount of hepatitis-b and diphtheria-tetanus-pertussis vaccination were significant. The correlation between other variables was found to be less important in the model. Given the importance level, it can be said that Gdp data is also effective in the model. Considering that two of the relationship levels are positive, the increase in both independent variables can be considered as a factor that increases the dependent variable value.

The multiple linear regression equation in the model is shown below:

Multiple Linear Regression Equation

Child Mortality (CM) = 51.4 – 285.7SHS – 0.056GDP 27.9D + 17.7M + 31.1H

Vaccines are the most effective method of protecting child and adult health and preventing infectious diseases in terms of cost and reliability. Although the success of childhood vaccination programs in our country is quite high; Increasing concerns over vaccine applications and their effects in recent years draw attention. Even though there is an increase in vaccination rates in our country, hesitations about vaccines increase as in many countries. Therefore, the need to reconsider the factors affecting vaccine applications has arisen. While a certain majority advocates that vaccines are necessary for public health; another section draws

attention to serious complications and negative effects on immunity during infancy and beyond.

In this area, there are specific studies in the literature (disease etc.) and reviews in general. These non-OECD countries and the vaccine has not been demonstrated on an analysis of Turkey in terms of area studies based on actual numerical data. For this reason, it is thought that the study will contribute to the literature in this direction.

In the study, clustering was performed first. According to the results of the analysis, the countries are categorized into 3 groups. In the first cluster Germany, Ireland and Turkey is located. The second cluster includes Austria, Canada and New Zealand. The rest of the countries are in the third cluster. Considering the data of the first cluster, while there was an increasing percentage in Germany until 2006, it has decreased by 1% since 2007. Ireland has an increasing profile between the two countries, with a vaccination rate of 86% in 2000 and 95% in 2017. Referring to the figures in Turkey's years, the acceleration increases until 2013; There has been a decrease in acceleration since 2014. In 2017, there is a decrease in rates compared to 2016 with a rate of % 96. Considering the countries in the second cluster, Austria has an irregular acceleration profile that has decreased or increased by 2 years until 2009. It has continued to increase since 2010. However, when we look at 2018, a serious decrease rate of 8% has been determined compared to 2017. When looking at Canada, it had a 94% rate until 2007 and it has decreased to a serious decrease rate of 14% since 2008. New Zealand has a gradually increasing acceleration with the figures of these two countries until 2017. There was a 1% decrease in 2018. Countries in the other cluster have similar vaccination rates. Considering these results, similar vaccination rates are observed in clustered countries, but declines are experienced over the years. A different dimension was added to the study by researching to what extent the determined factors may affect these decreases.

In the multiple regression analysis, child mortality data was used as dependent variables. Health spending, Gdp, diphtheria, measles and hepatitis-b vaccination rates were determined as impact factors. According to the results obtained, child mortality rates and hepatitis-b and diphtheria-tetanus-pertussis vaccination amount were found to be important. The correlation between other variables was found to be less important in the model. Looking at the level of importance, Gdp data can also be said to be effective in the model. Considering that two of the relationship levels are positive, the increase in both independent variables can be considered as a factor that increases the dependent variable value.

This study is thought to be based on an important numerical resource for other researches to be conducted in this direction. As the constraints of the study, if the current resource or data shortage which is the one of the most important difficulties encountered during the research is eliminated, it is considered that studies that will contribute to the literature may increase by developing. Vaccination analysis by countries can be investigated in the light of clear data, different regression analyzes and adding various variables to the model.

IV. CONCLUSION

Vaccines are the most effective method of protecting child and adult health and preventing infectious diseases in terms of cost and reliability. Although the success of childhood vaccination programs in our country is quite high; Increasing concerns over vaccine applications and their effects in recent years draw attention. Even though there is an increase in vaccination rates in our country, hesitations about vaccines increase as in many countries. Therefore, the need to reconsider the factors affecting vaccine applications has arisen. While a certain majority advocates that vaccines are necessary for public health; another section draws attention to serious complications and negative effects on immunity during infancy and beyond.

In this area, there are specific studies in the literature (disease etc.) and reviews in general. These non-OECD countries and the vaccine has not been demonstrated on an analysis of Turkey in terms of area studies based on actual numerical data. For this reason, it is thought that the study will contribute to the literature in this direction.

In the study, clustering was performed first. According to the results of the analysis, the countries are categorized into 3 groups. Countries in these three groups have been determined and the economic analysis of the projected countries were interpreted. In the multiple regression analysis, child mortality data was used as dependent variables. Results are summarized in the Table 5.

This study is thought to be based on an important numerical resource for other researches to be conducted in this direction. As the constraints of the study, if the current resource or data shortage which is the one of the most important difficulties encountered during the research is eliminated, it is considered that studies that will contribute to the literature may increase by developing. Vaccination analysis by countries can be investigated in the light of clear data, different regression analyzes and adding various variables to the model.

Table 5 Summary result table

Clustering	**Clusters**		**Cluster Distances**	
	1. Germany, Ireland, Turkey		1-2: 2474.088	
			1-3: 2640.818	
	2. Austria, Canada, New Zealand		2-1: 2474.088	
			2-3: 3101.851	
	3. Others		3-1: 2640.818	
			3-2: 3101.851	
Multiple Regression Analysis	Dependent Variable	Independent Variable (The most Important)	R^2	Significance
	Child Mortality	Hepattis-b and and diphtheria-tetanus-pertussis vaccination	0.741	0.003

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