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Longitudinal ecological analysis of the relationship between childhood vaccination levels and population mortality and life expectancy in Türkiye

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Abstract

This longitudinal ecological study aimed to analyze the relationship between childhood vaccination levels and social mortality levels and life expectancy in Türkiye. The study used data on life expectancy, mortality rates, and vaccination rates for the period 1980-2023 from the Country Reports dataset compiled by the World Health Organization and published by the World Bank. The study is modeled on descriptive and correlational survey methods. The relationship and impact of vaccination rates on mortality and life expectancy over time were analyzed. Measles immunization rate ($r = 0.908$; $p < 0.01$), hepatitis B vaccinations (HepB3) immunization rate ($r = 0.875$; $p < 0.01$) and diphtheria, pertussis, and tetanus vaccine (DPT) immunization rate ($r = 0.873$; $p < 0.01$) were significantly and positively correlated with life expectancy. Measles immunization rate ($r = -0.571$; $p < 0.01$), HepB3 immunization rate ($r = -0.809$; $p < 0.01$) and DPT immunization rate ($r = -0.651$; $p < 0.01$) were significantly and negatively correlated with mortality. Effect of HepB3 on life expectancy was statistically significant and positive ($B = 0.229$; $p < 0.01$). Explanatory power of the model was 78.9% of total variance. According to regression analysis, effects of measles and DPT on life expectancy were insignificant ($p > 0.05$). Regression effects of HepB3 on mortality was statistically significant and negative ($B = -0.260$; $p < 0.01$). Explanatory power of the model was 69.8% of total variance. Regression effects of measles and DPT on mortality were insignificant ($p > 0.05$). As a result of vaccinations over time, mortality rates, particularly from hepatitis B, have decreased, and average life expectancy has increased significantly. Therefore, vaccination is an important, effective, and efficient health tool for society.

Keywords: Vaccination, mortality, life expectancy, population mortality

Introduction

Vaccination is an important public health tool for preventing disease and improving the quality of low-cost healthcare [1]. Health authorities, medical associations, and global health-related actors consider vaccination to be the most fundamental tool for protecting and improving public health [2]. The history of vaccination dates back to the 18th century, with production beginning in laboratories in the late 19th century and widespread implementation in the 21st century [3]. Vaccines, which are effective against more than 70 known bacteria, parasites, viruses, and fungi in humans, are of vital importance for public health [4]. While vaccination can improve public health and improve the quality of life, people worldwide experience health problems every year due to many diseases that can be prevented through vaccination [5]. Barutçu et al. [6] reported that vaccine hesitancy and refusal was another aspect of vaccination of population after pandemic, and may cause hesitation of vaccination. Therefore, although vaccination is an important and inexpensive tool for improving the quality of health for societies, it can be argued that its prevalence remains low today.

While there are many indicators of a society's health quality, mortality and life expectancy are the most frequently emphasized [7-9]. Stiefel et al. [7] reported in their studies that life expectancy is the most important outcome of studies on the health quality of societies. Jagger and Robine [8] defined life expectancy as the combination of individuals' health quality and quality of life. Poli et al. [9] proposed life expectancy as an indicator and outcome of quality of life not only at the societal level but also at the

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individual level. Mortality, on the other hand, is often reported in studies as an outcome and indicator of health policies [10-12].

Although vaccination is an important and effective tool for public health [2-4], in recent years, there have been studies that have raised doubts about vaccination, particularly those claiming it is associated with an increase in genetic and certain diseases. Some studies have reported various conditions, such as immunopathological damage [13]. Steefland [14] reported that, despite the benefits of vaccination, it is necessary to address public concerns, as well as public policy. Rose [15] reported that population-based studies may reveal problems related to chorionic gonadotropin and the autoimmune system. These and similar studies have increased doubts about the societal benefits of vaccination. To address these concerns, the relationship between vaccination and mortality and life expectancy, important indicators of public health, can be examined over time. For this purpose, this study analyzed the relationship between childhood vaccination rates in Türkiye and societal mortality and life expectancy.

While discussions about vaccines and their relationship to life expectancy continue, establishing the relationship between childhood vaccination and life expectancy and mortality on a population basis will provide quantitative data and resources to the literature. This would also allow for a broader perspective on the effects of vaccination.

Material and Methods

Research Model

The study is modeled on descriptive and correlational survey methods. Data on vaccination, life expectancy, and mortality were first described using longitudinal parity analysis. A correlational screening model was then used to analyze the effects of vaccination on life expectancy and mortality.

Parameters

The study used data on life expectancy, mortality rates, and vaccination rates for the period 1980-2023 from the Country Reports dataset compiled by the World Health Organization (WHO) and published by the World Bank. Because the vaccination and life expectancy data cover the period from 1980 to 2023, these dates were used as the dataset range. The dependent and independent data for the study are presented below.

Dependent Variables:

Life expectancy at birth, total (years)

The number of years a newborn infant would live if the mortality trends that were in place at the time of its birth continued to exist is known as its life expectancy at birth.

Mortality from CVD, cancer, diabetes or CRD between exact ages 30 and 70 (%)

The percentage of 30-year-olds who would pass away before turning 70 from any of the following causes, assuming that they would experience the current mortality rates at every age and that they would not die from other types of death (such as injuries or HIV/AIDS), is known as mortality from cancer, cardiovascular diseases (CVD), diabetes mellitus or chronic respiratory diseases (CRD).

Independent Variables:

Immunization, measles (% of children ages 12-23 months)

Measles vaccination rates for children aged 12 to 23 months are calculated as the proportion of children who were vaccinated against measles before to the survey or before the 12-month mark. After getting a single dose of the vaccine, a kid is deemed sufficiently immune against measles.

Immunization, HepB3 (% of one-year-old children)

The percentage of children aged 12 to 23 months who got hepatitis B vaccinations (HepB3) prior to the survey or at any point before that period is known as the child immunization rate, or hepatitis B. After receiving three doses, a youngster is deemed sufficiently immunized.

Immunization, DPT (% of children ages 12-23 months)

Child immunization, diphtheria, pertussis, and tetanus vaccine (DPT), measures the percentage of children ages 12-23 months who received DPT vaccinations before 12 months or at any time before the survey. A child is considered adequately immunized against diphtheria, pertussis (or whooping cough), and DPT after receiving three doses of vaccine.

Considering that childhood vaccination plays a crucial role in both physical growth and development, as well as the formation of many physical and immune parameters, we wanted to examine its effects in later life, taking into account that it should also be administered during childhood. As with all other vaccine studies, the time difference allows us to focus on the results in later life.

As in the other population based studies, multiple linear regression carries a risk of multicollinearity due to highly correlated independent variables, and this may be a limitation of the study.

Ethical Considerations

Because the research was conducted using WHO and World Bank data and does not include personal or patient information, but rather represents cumulative patient levels, it is not subject to ethics committee approval. Therefore, patient consent is not required for this research. The research was conducted in accordance with the Declaration of Helsinki and Good Clinics guidelines. AI generated content was not used in the research.

Statistical Methods

Mean and standard deviation values, along with median and variation ranges, were used to describe the research data. The Kolmogorov-Smirnov test was used to test the normality of the measurement parameters. Because the distribution of the dependent variables, life expectancy and mortality, followed a standard normal distribution, Pearson's correlation analysis

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was used in relational screening analyses. For impact analysis, linearization regression analysis was used in regression analyses. All analyses were performed using SPSS 25.0 for Windows (Armonk, New York: IBM Corp.), with a 95% confidence interval and a significance level of 0.05. Due to the normality requirement of the dataset being below 30 measurements vertically and the selection of parametric tests, time series and autocorrelation test analyses were not performed.

Results

Measles immunization percentage was 27.0% in 1980, and reached to 95.0% in 2023. HepB3 percentage in 2000 was 71.0%, and increased to 99.0% in 2023. DPT percentage in 1980 was 42.0%, and increased to 99.0% in 2023. Life expectancy in 1980 was 62.74 years, and 77.16 years in 2023. Disease related mortality rate was 22.50% in 2000 and, decreased to 15.40 in 2021 (Table 1).

Although a small decreases in 2000, 2010 and 2020, life expectancy in Türkiye was a sharp increasing trend within the time period (Figure 1).

Mortality percentages related to diseases were in sharp decreasing trend in Türkiye for 2000-2021 except 2009 and 2021. On the other hand, decreasing amount was significant from 2000 to 2021 (Figure 2).

Mean life expectancy was 71.59 ± 4.53 with 62.74-77.74 ranges. Mortality mean was 18.33 ± 1.74 percentage ranged from 15.20 to 22.50. Measles immunization level mean was 82.11 ± 15.84, HepB3 mean was 90.67 ± 10.22 and DPT mean was 82.66 ± 15.88 (Table 2).

Measles immunization rate ($r = 0.908$; $p < 0.01$), HepB3 immunization rate ($r = 0.875$; $p < 0.01$) and DPT immunization rate ($r = 0.873$; $p < 0.01$) were significantly and positively correlated with life expectancy (Table 3).

Measles immunization rate ($r = -0.571$; $p < 0.01$), HepB3 immunization rate ($r = -0.809$; $p < 0.01$) and DPT immunization rate ($r = -0.651$; $p < 0.01$) were significantly and negatively correlated with mortality (Table 3).

Linear regression model on effects of immunization on life expectancy showed that effect of HepB3 on life expectancy was statistically significant and positive ($B = 0.229$; $p < 0.01$). Explanatory power of the model was 78.9% of total variance. Effects of measles and DPT on life expectancy were insignificant ($p > 0.05$) (Table 4).

Effect of HepB3 on mortality was statistically significant and negative ($B = -0.260$; $p < 0.01$). Explanatory power of the model was 69.8% of total variance. Effects of measles and DPT on mortality were insignificant ($p > 0.05$) (Table 4).

Table 1. Immunization levels, life expectancy and mortality parameters for Türkiye for 1980-2023

Year	Measles	HepB3	DPT	Life expectancy	Mortality	Year	Measles	HepB3	DPT	Life expectancy	Mortality
1980	27.00		42.00	62.74		**2002**	83.00	72.00	78.00	72.61	20.50
1981	52.00		64.00	63.19		**2003**	75.00	68.00	68.00	72.91	19.90
1982	64.00		58.00	63.74		**2004**	81.00	77.00	85.00	73.22	19.30
1983	63.00		56.00	64.27		**2005**	91.00	85.00	90.00	73.51	18.90
1984	62.00		56.00	64.81		**2006**	98.00	82.00	90.00	73.80	18.60
1985	61.00		55.00	65.34		**2007**	96.00	96.00	96.00	74.13	18.20
1986	64.00		45.00	65.87		**2008**	97.00	92.00	96.00	74.38	18.00
1987	67.00		86.00	66.38		**2009**	97.00	94.00	96.00	74.68	18.60
1988	82.00		86.00	66.90		**2010**	97.00	96.00	97.00	74.96	18.60
1989	71.00		79.00	67.37		**2011**	98.00	96.00	97.00	74.82	18.50
1990	78.00		84.00	67.84		**2012**	96.00	97.00	97.00	75.55	18.20
1991	73.00		72.00	68.29		**2013**	98.00	97.00	98.00	76.17	18.00
1992	78.00		77.00	68.60		**2014**	94.00	96.00	96.00	76.45	17.90
1993	72.00		76.00	69.02		**2015**	97.00	97.00	97.00	76.54	17.70
1994	76.00		87.00	69.40		**2016**	98.00	98.00	98.00	76.60	17.40
1995	65.00		67.00	69.73		**2017**	96.00	96.00	96.00	77.04	17.00
1996	72.00		72.00	70.25		**2018**	96.00	98.00	98.00	77.45	16.70
1997	79.00		79.00	70.67		**2019**	97.00	99.00	99.00	77.74	16.60
1998	81.00		81.00	71.14		**2020**	95.00	98.00	98.00	76.53	15.20
1999	82.00		79.00	70.75		**2021**	96.00	96.00	95.00	75.72	15.40
2000	87.00	71.00	85.00	71.93	22.50	**2022**	95.00	99.00	99.00	77.59	
2001	91.00	77.00	88.00	72.27	21.50	**2023**	95.00	99.00	99.00	77.16	

HepB3: Hepatitis B vaccinations, DPT: Diphtheria, Pertussis (or whooping cough), and Tetanus

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Figure 1. Life expectancy change during 1980-2023

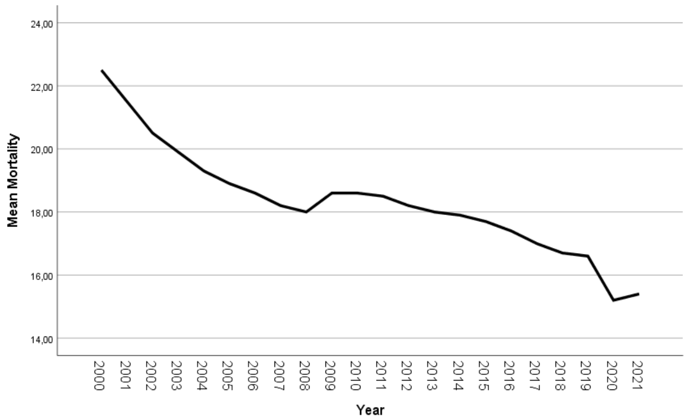

Figure 2. Mortality change during 1980-2023

Table 2. Descriptive statistics of immunization, life expectancy and mortality levels for 1980-2023 time period

Parameters	Mean	Standard deviation	Median	Minimum	Maximum
Measles	82.11	15.84	82.50	27.00	98.00
HepB3	90.67	10.22	96.00	68.00	99.00
DPT	82.66	15.88	86.00	42.00	99.00
Life expectancy	71.59	4.53	72.44	62.74	77.74
Mortality	18.33	1.74	18.20	15.20	22.50

HepB3: Hepatitis B vaccinations, DPT: Diphtheria, Pertussis (or whooping cough), and Tetanus

Table 3. Pearson's correlation for relationship between immunization, life expectancy and mortality

Parameters	Life expectancy		Mortality	
	r	p	r	p
Measles	0.908**	< 0.001	-0.571**	0.006
HepB3	0.875**	< 0.001	-0.809**	< 0.001
DPT	0.874**	< 0.001	-0.651**	0.001

**p < 0.01, HepB3: Hepatitis B vaccinations, DPT: Diphtheria, Pertussis (or whooping cough), and Tetanus

Table 4. Linear regression model on effects of immunization on life expectancy and mortality

Parameters	Unstandardized coefficients		Standardized coefficients	t	p	95.0% confidence interval for B	
	B	Std. error	Beta			Lower bound	Upper bound
Life expectancy							
(Constant)	67.269	3.014		22.319	< 0.001	60.982	73.556
Measles	-0.112	0.074	-0.375	-1.508	0.147	-0.267	0.043
HepB3	0.229	0.049	1.296	4.699	< 0.001	0.127	0.331
DPT	-0.026	0.089	-0.109	-0.290	0.775	-0.212	0.160
							R^2: 0.789; $F_{(3-23)}$: 29.752; $p < 0.01$
Mortality							
(Constant)	24.347	3.496		6.963	< 0.001	17.001	31.693
Measles	0.039	0.092	0.141	0.421	0.679	-.155	0.232
HepB3	-0.260	0.056	-1.549	-4.626	< 0.001	-.379	-0.142
DPT	0.149	0.107	0.664	1.394	0.180	-.075	0.373
							R^2: 0.698; $F_{(3-21)}$: 17.187; $p < 0.01$

B: Regression coefficient, HepB3: Hepatitis B vaccinations, DPT: Diphtheria, Pertussis (or whooping cough), and Tetanus

Discussion

This study examined the effects of vaccination rates on mortality and life expectancy over time, analyzing the relationships between data from 1980 to 2023. The results found a positive correlation between vaccination and life expectancy and a negative correlation between mortality. The effect of hepatitis B vaccines on mortality and life expectancy was significant, while the effect of Measles and DPT vaccines was not statistically significant.

Although studies on vaccination suggest that vaccination is the most appropriate, effective, and cost-effective method for public health [16-19], there are also studies and opinions suggesting that vaccination is harmful, particularly after the COVID-19 pandemic [20-22]. Long et al. [21] report that the disinformation process spread on social media following the pandemic has increased the perception that vaccines are actually harmful and deliberate. Agrawal et al. [22] reported that misinformation about vaccination in the wake of COVID-19 has caused moral harm. It can be stated that generally speaking, false or speculative information is the most significant source of negative information about vaccination.

Studies examining the impact of vaccination on life expectancy report a common result: a decrease in societal mortality and an increase in life expectancy [23-25]. Rughinis et al. [23] reported that the impact of vaccination on life expectancy was clearly seen worldwide, especially after the pandemic. Schöley et al. [24] reported that although there was a decrease in average life expectancy during the pandemic, this decrease was limited thanks to vaccination, and vaccination increased life expectancy. Andre et al. [25] reported that vaccination reduced mortality rates and increased life expectancy thanks to the reduction in disease worldwide.

While general studies have been conducted on the societal benefits of vaccination [2-5], no studies have been found examining the contribution of individual vaccine types to mortality and life expectancy over time. In our study, measles, HepB3, and DPT immunization rates were significantly and positively correlated with life expectancy and negatively correlated with mortality. The effect of HepB3 on life expectancy was statistically significant and positive, whereas its effect on mortality was significant and negative. The effects of measles and DPT on mortality and life expectancy were insignificant. In conclusion, although the effects with measles and DPT were not significant, the relationships were significant according to correlation analysis. Based on this, it is possible to state that vaccination for the entire population is an indispensable public health tool based on data over time. In Türkiye, HepB3 coverage rates were reported as %99 events in 2024 for 1-year-olds. This success in vaccination may decrease mortality.

Although results of the study shows significant correlations, findings do not prove causality, and further research is needed for causality statement. The insignificant results of Measles and DPT in the regression may also be lack of cofounders as limitations or concept of ecological fallacy.

Limitations of the Study

The most significant limitation of the study is the lack of longitudinal studies on vaccination. Therefore, while the study is a pioneering one, no studies were found globally or in Türkiye to compare the results. Another significant limitation of the study is that, although demographic differences, healthcare expenditures, and healthcare opportunities and accessibility—all of which may differ depending on the type of vaccination—exist within society, these differences were not adequately documented statistically. While significant progress has been made in vaccination both in Türkiye and globally, vaccination has faced challenges in the past. The fact that only HepB3 was significant in the regression results may indicate a multicollinearity or model specification problem. The concept of ecological fallacy may be another limitation of the study, and may be further researched in prospective studies.

Another important limitation of the study is that we connect vaccination directly to life expectancy without taking into account other important factors that changed between 1980 and 2023, such as improvements in healthcare infrastructure, socioeconomic development, and access to clean water. On the other hand, population studies generally have similar limitations, and our study suggests a source to further studies.

The study's contribution to the literature and clinical practice

Vaccination's most significant contribution to the literature is its pioneering role among studies that address vaccination holistically, temporally, and on a population basis. While numerous studies have been conducted in the literature on public health or the effects of vaccination, not enough studies have been found that focus on the impact of vaccination across an entire population using a reliable data source like the WHO. This indicates that this study ranks among the pioneering studies in its field.

The study's contribution to clinical practice is that it highlights the importance of vaccination for healthcare professionals, especially pediatricians. This will help them understand that vaccination in clinical practice is not only a patient-related issue but also a significant issue affecting society. It also provides quantitative data to help public administrators understand the societal benefits of vaccination.

Conclusion

As a result of vaccinations over time, mortality rates, particularly from hepatitis B, have decreased, and average life expectancy has increased significantly. Therefore, vaccination is an important, effective, and efficient health tool for society.

Our study demonstrates that vaccination quantitatively helps to improve quality of life and reduces mortality across the entire population, including all diseases, adverse side effects, complications, or similar causes. However, larger-scale, multivariate studies are needed to assess the alleged side effects and adverse outcomes of vaccination.

Ethical Approval

Because the research was conducted using WHO and World Bank data and does not include personal or patient information, but rather represents cumulative patient levels, it is not subject to ethics committee approval.

Patient Consent

Patient consent is not applicable because the study uses aggregated WHO and World Bank data, does not involve direct participant contact, and contains no identifiable personal or patient information.

Conflict of Interest

The authors confirm the absence of any conflicts associated with this work.

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