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Analysis of under-five mortality by diseases in countries with different levels of development: a comparative analysis

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ABSTRACT

Objectives: The right to health is critical for children because they are sensitive beings who are more susceptible to disease and health problems. It would be beneficial to compare child mortality rates in countries with different levels of development and to conduct studies to address them by taking into account their causes. This study aims to analyze the situation of developed, developing and least developed countries in terms of causes under-5 child mortality (U5CM) determined by World Health Organization and to identify the similarities or differences of under-five mortality.

Methods: Child mortality rates per 1,000 live births between 2000 and 2017 years in between different age groups (0-27 days and 1-59 months) by causes (disease-specific) were obtained from World Health Organization for a total 15 countries including developed, developing and least developed countries. Regression analysis was performed to identify which causes have more impact on child mortality. In addition, the relationship between diseases was calculated using Euclidean distance, and diseases were clustered using k-means clustering algorithm for each country.

Results: As a result of mathematical and statistical analysis, it was seen that causes of child mortality have a significant relation with the development level of country where a child was born.

Conclusions: It has been observed that the causes of child mortality in countries with different levels of development vary depending on different factors such as geographical conditions, air quality population and access to medicine.

Keywords: World Health Organization, child mortality, Euclidean distance, linear regression, clustering

The risk of a child dying between birth and the age of 5, expressed per 1.000 live births, is referred to as the U5CM rate. 5.0 million in 2020 [1]. For efforts to improve child survival to be effective, it is necessary to have reasonably accurate information about the causes of child mortality. To determine the effectiveness of disease-specific interventions and assess trends in disease burden in relation to national and international goals, cause-of-death information is required [2].

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The global community agreed on multiple Millennium Development Goals (MDGs) including poverty, hunger, combating disease, environmental degradation and especially two-thirds reduce U5CM rate between 1990 and 2015 (MDG4) [3]. While more than 60 countries managed to achieve MDG4, the target globally was missed by half over declining in the 25 year[4]. It was seen that sustaining progress requires the mobilization and monitoring of resources and collecting appropriate data to assess progress were included in global initiatives. The Sustainable Development Goals (SDG), established in 2015 by United Nation (UN) General Assembly, and including the UN Global Strategy for Women's, Children's and Adolescent's health [5, 6]. The SDG child survival targets aim for all countries to achieve a under-five mortality rate of 2.5 percentage or less by 2030 [6]. However, studies show that the global number of child mortality remain larges and children continue to face widespread inequality in their chance of survival and if countries do not take actions millions children will die in next decade by preventable deaths [7].

According to studies conducted by United Nations Children's Fund (UNICEF) and World Health Organization (WHO) pneumonia, diarrhoea, malaria, preterm birth complications, acute respiratory infections and congenital anomalies continue to be a leading cause U5CM. Furthermore, the following diseases also cause U5CM from past to present: sepsis and other infectious conditions of the newborn (SOICN), birth asphyxia and birth trauma (BABT), HIV/AIDS, injuries, measles, meningitis, communicable diseases, noncommunicable diseases, tetanus.

Congenital anomalies (CAs) are functional or structural abnormalities that occur during intrauterine life. CAs can cause fetal death as well as long-term disability. Each year about 3.2 millions of children are born with a CA and 300,000 newborns with a diagnosis of birth defect die in 28 days [8]. CAs have a significant impact in children born preterm and increase prematurity [9]. Although main reason of CAs is unknown there are several environmental factors such as infection agents, chemical toxicants and individual exposures such as socioeconomic status [8].

Sepsis is a life-threatening medical condition that occurs when the body overreacts to an infection [10]. Every year more than one million neonates are dying because of sepsis which is the second major cause of neonates mortality [11].

Acute lower respiratory infections (ALRI) is one of the main causes of U5CM and human respiratory syncytial virus (RSV) is the most common viral pathogen identified in children with ALRI [12]. Globally in 2015, 1.4 million hospital admission and 27300 in-hospital deaths were due to RSV-ALRI in children younger than 6 months. Socioeconomic status, education, having more than two children at home, nutritional variables are significantly associated with cute lowery respiratory tract infections (ALRTI) [13]. The newborn is susceptible to bacterial and viral infections, The main cause of several disease lye under infection such as malaria, measles, meningitis. Especially ALRI are including pneumonia which is a major cause of morbidity and child mortality disease [14].

Birth asphyxia causes hypoxia and ischemia, resulting in widespread organ system damage. Birth trauma can also result in asphyxia, morbidity, and mortality, depending on the severity and anatomic location of the trauma. Every year, approximately four million neonates die as a result of birth asphyxia [15].

Diarrhoea is defined as three or more loose or liquid stools per day. It is a symptom of an infection in the intestines, which can be caused by a number of bacteria, viruses, and parasites. Diarrhoea, a preventable and treatable disease, is one of the leading causes of infectious in under-5 children [16].

Road traffic accidents, drowning, burns, falls, poisoning, and acts of violence are just few of the causes of injuries. Every year, injuries claim the lives of 4.4 million individuals around the world, accounting for roughly 8% of all deaths [17].

Malaria, a life-threatening parasitic disease besides being preventable and curable, spread by bites from infected female Anopheles mosquitoes. In the African Region, under-5 children accounted for an estimated 80% of all malaria deaths [18].

Measles is a serious virus-borne disease that is typically spread through direct contact and air. In 2018, over 140.000 people died as a result of measles. The measles immunization activities have significantly reduced measles deaths [19].

The infection happens when the membranes cov-

ering the brain and spinal cord are infected. Bacterial meningitis, a major public health problem, in 10% to 20% of survivors, can result in brain damage or hearing loss [20].

Other communicable perinatal and nutritional conditions (OCPNC) are related with several contitions. Communicable diseases are illnesses that can be transmitted by more than one way, such as contact with blood and body fluids or inhaling a virus. Hepatitis A, B, and C, influenza, and salmonella are examples of communicable diseases [21].

Noncommunicable diseases are chronic diseases that are caused by factors that are genetic, physiological, environmental, and behavioral. NCDs claim the lives of 41 million people worldwide each year [22]. Preterm babies are those who are born alive before the 37th week of pregnancy. Preterm birth health problems are the biggest cause U5CM, accounting for about one million deaths in 2015 [23].

Tetanus is a serious infectious disease caused by Clostridium tetani spores. The disease is a major public health problem particularly in low-income nations with low immunization rates and contaminated birth practices [24].

Preventing the deaths of children can be accomplished by increasing access to skilled health professionals during pregnancy and childbirth, increasing access to nutrition and micronutrients, increasing access to water, sanitation, and hygiene, and providing vaccinations. Unfortunately, many of these rescue efforts are out of reach for the world's poorest countries [2].

Due to the scarcity of studies on the relationship between the causes of U5CM and the development of countries, this study has attempted to fill the gap in the literature. U5CM factors were analyzed in 15 countries based on three main categories according to their economic indices: developed, developing and least-developed countries. By comparing these countries rather than other studies, the effect of being economically strong on the U5CM was investigated. In addition, geographically distant countries were tried to be selected to see whether geographical factors contribute to U5CM. Through the findings of this study, countries can take action to prevent future U5CM by contributing to public health education and facilitating health institutes facilities. In addition, the world's poorest countries can access the life-saving interventions mentioned above with the support of international humanitarian organizations for children.

METHODS

In this study, number of deaths due to a specific cause, among under-5 children, per 1.000 live births for 15 countries is collected from World Health Organization (WHO) [2]. These countries are classified into three: (1) Developed: Australia, Canada, Germany, Norway, Singapore. (2) Developing: Colombia, India, Mexico, Tunisia, Turkey. (3) Least-developed: Bangladesh, Chad, Mali, Mozambique, Niger. This classification was made according to the Human Development Index (HDI) for 2019. This value is determined by incorporating a country's scores in a wide range of indicators, such as life expectancy, access to electricity for rural populations, GDP (Gross Domestic Product) per capita, imports and exports, homicide rate, multidimensional poverty index, internet availability, education, income inequality, and plenty more. These indicators are combined into a single value ranging from 0 to 1.0, with 1.0 being the maximum attainable level of human development [25]. Countries tried to be selected from different locations on the world to see the how differences between geographic, cultural and other conditions effect causes of U5CM. Firstly, dataset cleaning was performed in order to extract the appropriate information for our analysis. The new 18-year data contains 14 causes of death and two age group (0-27 days and 1-59-month). Mathematical and statistical analysis then applied to our data to investigate whether underlying cause of U5CM differ between developed, developing and least-developed countries. First, we created heat map and bar graphs to see the differences between the groups (based on the level of development of countries), then we performed linear regression analysis to identify which causes have more impact on U5CM. After that, we have calculated the relationship between diseases using Euclidean distance, and we clustered the diseases using k-means clustering algorithm for each country. In addition, we calculated the correlation between the countries in each group and we have shown the results as a correlation matrix.

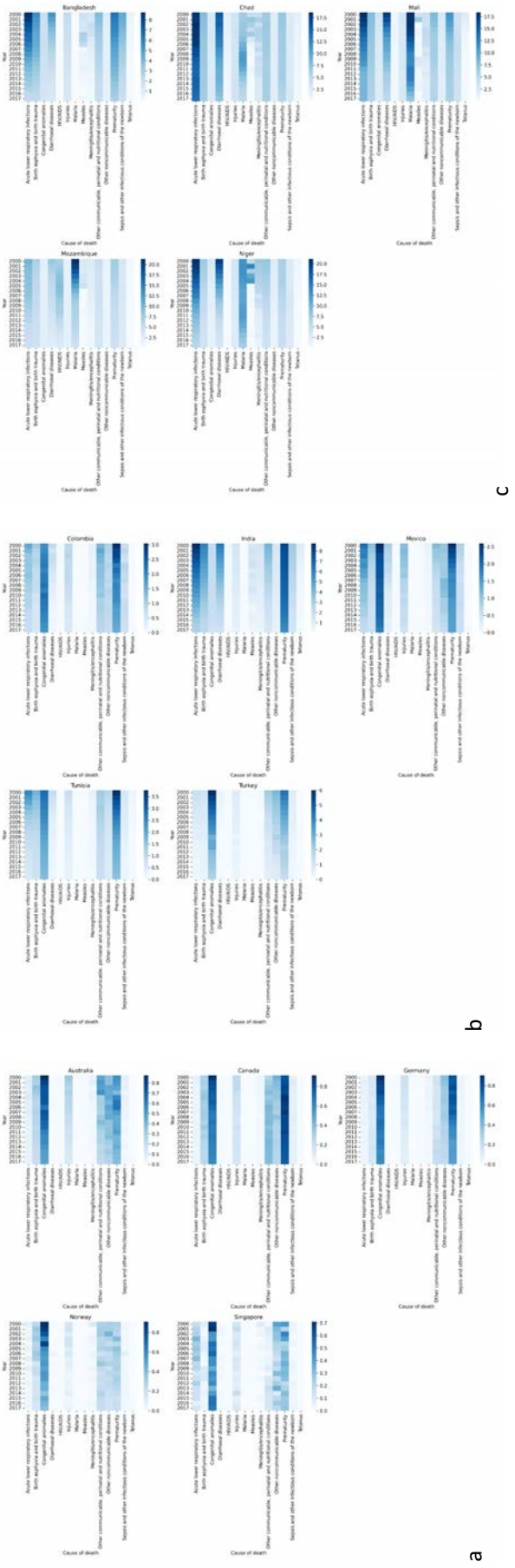

Fig. 1. The heat map graphics shows child mortality rates by cause between 2000 and 2017 years' in (a) developed, (b) developing and (c) least-developed countries.

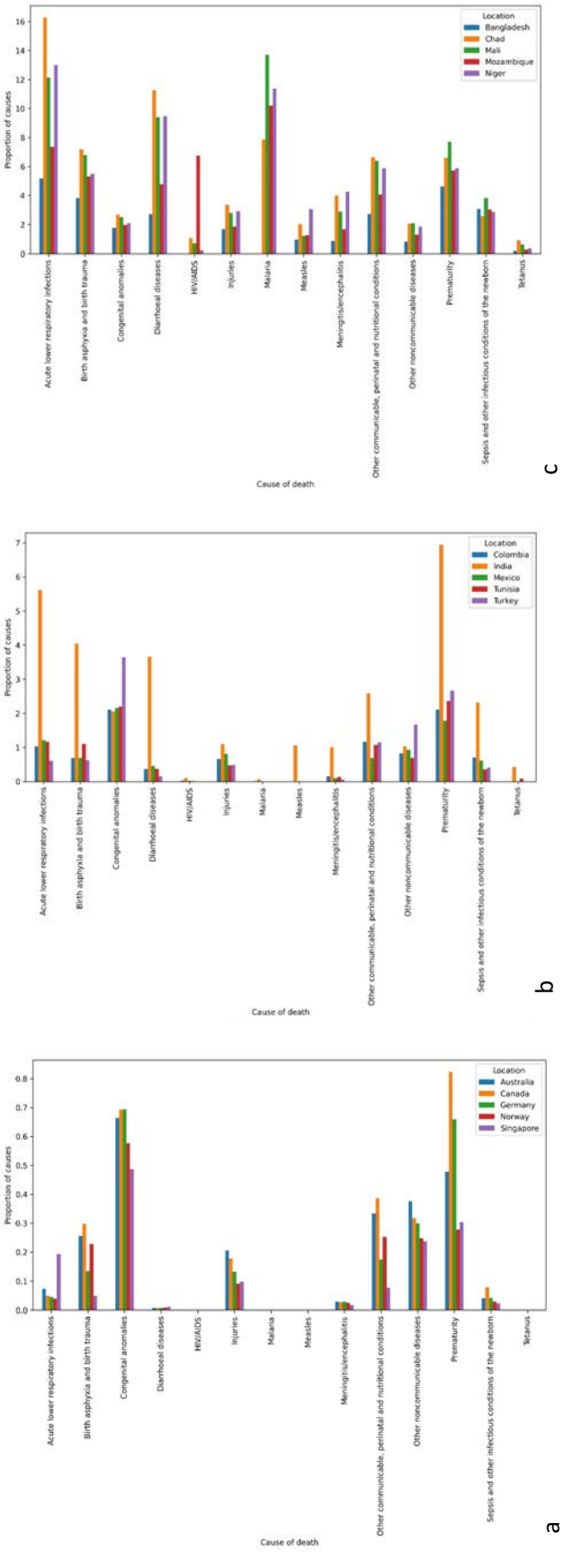

Fig. 2. The graphics show the child mortality rates by cause in (a) developed (b) developing and (c) least-developed countries.

Statistical Analysis

In this section, to obtain consistent outcomes we performed five mathematical and statistical analyses using Microsoft Office Excel and seaborn, scipy, and sklearn packages in Python.

Heat Map and Bar Graphs

According to the development levels of countries, the disparities between the groups (developed, developing and least-developed) are analyzed based on the causes of U5CM and the results are given in Figs. 1 and 2.

Regression Analysis

Linear regression analysis is performed to identify which causes have more impact on U5CM and shows how much diseases are effective in the developing, developed and least-developed countries in Table 1. In the regression analysis the statistical significance level accepted is 0.01 (confidence level is 99%).

Correlation Matrix

The correlation between the countries in each group is calculated to see how much the countries in the same group correlate with each other. The correlation matrix, given in *Supplementary* Table 1 and it shows how countries related with each other's in terms of causes of U5CM.

Euclidean Distance Measurement

In order to show how diseases are related with each other and affect U5CM in a country, we calculated Euclidean distance measures in between two diseases. Euclidean distance results for Germany, Turkey,

Table 1. Regression analysis of developed, developing and least-developed countries based on causes of child mortality

	Developed	Developing	Least-Developed
	coefficient	coefficient	coefficient
Intersection	7.769	103.531	396.477
Period *	-0.003	-0.050	-0.192
Age group *	-0.043	-0.105	3.437
BABT *	0.113	-0.499	-5.069
CA *	0.542	0.504	-8.584
Diarrhoeal disease *	-0.071	-0.929	-3.265
HIV/AIDS *	-0.079	-1.897	-9.036
Injuries *	0.060	-1.222	-8.260
Malaria *	-0.079	-1.913	-2.157
Measles *	-0.079	-1.715	-9.082
Meningitis/encephalitis *	-0.055	-1.639	-8.046
OCPNC *	0.164	-0.597	-5.644
Other noncommunicable diseases *	0.215	-0.901	-9.160
Prematurity *	0.428	1.242	-4.677
SOICN **	-0.037	-1.053	-7.708
Tetanus *	-0.079	-1.826	-10.313

BABT = birth asphyxia and birth trauma, CA = congenital anomalies, OCPNC = other communicable perinatal and nutritional condition, SOICN = sepsis and other infectious conditions of the newborn

*Statistically significant (*p*-value less than 0.01) in all development level groups.

** Statistically significant in two development level groups.

Table 2. Euclidian distance measures of underlying diseases of child mortality in Germany

Causes of child mortality	ALRI	BABT	CA	Diarrhoeal diseases	HIV/AIDS	Injuries	Malaria	Measles	Meningitis/ encephalitis	OCPNC	Other noncommunicable diseases	Prematurity	SOICN	Tetanus
ALRI	0													
BABT	0.8828	0												
CAs	3.9490	3.4218	0											
Diarrhoeal diseases	0.3029	0.9266	4.1672	0										
HIV/AIDS	0.3586	0.9384	4.2059	0.0611	0									
Injuries	0.7104	1.1591	3.4997	1.0035	1.0597	0								
Malaria	0.3638	0.9403	4.2101	0.0659	0.0092	1.0657	0							
Measles	0.3621	0.9398	4.2088	0.0643	0.0081	1.0639	0.0036	0						
Meningitis/encephalitis	0.1446	0.9111	4.0446	0.2078	0.2581	0.8139	0.2646	0.2630	0					
OCPNC	1.1004	0.3309	3.2089	1.1779	1.1944	1.2505	1.1964	1.1958	1.1456	0				
Other noncommunicable diseases	2.1260	2.3916	3.0435	2.4186	2.4765	1.4389	2.4821	2.4803	2.2341	2.3476	0			
Prematurity	4.7889	3.9728	2.6424	4.8667	4.8762	4.7034	4.8776	4.8773	4.8381	3.8033	4.9777	0		
SOICN	0.4802	0.6131	3.9574	0.3609	0.3545	1.0911	0.3548	0.3549	0.4411	0.8910	2.4944	4.5329	0	
Tetanus	0.3638	0.9403	4.2101	0.0659	0.0092	1.0657	0	0.0036	0.2646	1.1964	2.4821	4.8776	0.3548	0

ALRI = acute lower respiratory infection, BABT = birth asphyxia and birth trauma, CA = congenital anomalies, OCPNC = other communicable, perinatal and nutritional conditions, SOICN = sepsis and other infectious conditions of the newborn

Table 3. Euclidian distance measures of underlying diseases of child mortality in Turkey

Causes of child mortality	ALRI	BABT	CA	Diarrhoeal diseases	HIV/AIDS	Injuries	Malaria	Measles	Meningitis/ encephalitis	OCPNC	Other noncommunicable diseases	Prematurity	SOICN	Tetanus
ALRI	0.0000													
BABT	5.5240	0.0000												
CAs	19.0510	19.5407	0.0000											
Diarrhoeal diseases	3.7180	4.6041	22.0752	0.0000										
HIV/AIDS	5.1740	4.6981	23.1375	1.5325	0.0000									
Injuries	1.6743	5.4957	20.0549	2.9120	4.2596	0.0000								
Malaria	5.1848	4.7010	23.1467	1.5420	0.0141	4.2717	0.0000							
Measles	5.1844	4.7008	23.1463	1.5417	0.0143	4.2710	0.0030	0.0000						
Meningitis/encephalitis	4.6789	4.5978	22.7467	1.0773	0.5194	3.7537	0.5310	0.5304	0.0000					
OCPNC	5.5454	3.6387	16.0589	6.8356	7.5729	6.2739	7.5790	7.5788	7.2960	0.0000				
Other noncommunicable diseases	9.8333	14.2657	15.0075	13.3475	14.7465	10.5519	14.7586	14.7581	14.2329	12.1492	0.0000			
Prematurity	19.8015	16.0905	15.3173	20.5762	20.7540	20.4475	20.7559	20.7558	20.6722	14.3033	23.1511	0.0000		
SOICN	5.8771	1.4679	20.9829	3.9617	3.6493	5.5901	3.6493	3.6493	3.6834	5.0356	15.1265	17.1732	0.0000	
Tetanus	5.1848	4.7010	23.1467	1.5420	0.0141	4.2717	0.0000	0.0030	0.5310	7.5790	14.7586	20.7559	3.6493	0.0000

ALRI = acute lower respiratory infection, BABT = birth asphyxia and birth trauma, CA = congenital anomalies, OCPNC = other communicable, perinatal and nutritional conditions, SOICN = sepsis and other infectious conditions of the newborn

Table 4. Euclidian distance measures of underlying diseases of child mortality in Mali

Causes of child mortality	ALRI	BABT	CA	Diarrhoeal diseases	HIV/AIDS	Injuries	Malaria	Measles	Meningitis/ encephalitis	OCPNC	Other noncommunicable diseases	Prematurity	SOICN	Tetanus
ALRI	0													
BABT	95.401	0												
CAs	82.814	41.583	0											
Diarrhoeal diseases	17.735	91.946	73.386	0										
HIV/AIDS	88.989	50.897	11.236	78.063	0									
Injuries	73.966	51.742	13.359	63.808	16.298	0								
Malaria	31.594	123.647	108.370	40.052	113.343	98.031	0							
Measles	84.407	52.869	16.724	72.787	14.432	18.244	109.001	0						
Meningitis/encephalitis	73.948	48.268	12.410	63.732	16.391	10.224	99.125	18.929	0					
OCPNC	48.462	59.096	35.427	40.229	41.603	25.922	73.518	38.820	27.860	0				
Other noncommunicable diseases	77.966	51.871	11.207	67.217	11.481	5.301	102.110	14.815	9.360	30.390	0			
Prematurity	98.744	11.016	49.934	96.414	59.408	59.824	126.986	61.071	56.374	65.431	60.147	0		
SOICN	96.347	20.154	26.039	89.750	33.146	38.220	123.872	37.037	34.893	53.308	36.900	29.778	0	
Tetanus	94.555	45.916	12.842	84.304	9.514	23.037	119.686	18.975	22.007	47.329	18.974	53.804	27.870	0

ALRI = acute lower respiratory infection, BABT = birth asphyxia and birth trauma, CA = congenital anomalies, OCPNC = other communicable, perinatal and nutritional conditions, SOICN = sepsis and other infectious conditions of the newborn

and Mali are given in Table 2-4. Results of other countries is given as *Supplementary* Table 2-13.

K-means Clustering

According to Euclidean distance measurements, diseases are clustered using k means algorithm for each country (Table 5) to see if the same diseases are associated with each other in countries with the same level of development. Fig. 3 represents the clustering results of 3 groups (developed, developing or least-developed countries) based on k means algorithm with k is 3. Clustering results for each country were compared with the clusters of the group to which each country belongs (Fig. 3) and similarity rates are calculated for each country (Table 5).

RESULTS

In this section, firstly, regression analysis results are given, then the findings for each disease are explained in itself, and finally correlation between countries based on the causes of U5CM is expressed.

Coefficient and p-value variables of regression analysis (Table 1) were analyzed based on age group, year and disease. If the p-value of the variable is less than the significance level (0.01), we assume that the variable is statistically significant. According to the Table 1 all variables (age group, year and disease) statistically significant (p-value less than 0.01) in all development level groups except SOINC (It is statistically significant in developed and least-developed countries).

The remainder of this section, the findings for each disease are explained in itself.

While ALRI highly result in U5CM in India as a developing country (Fig. 1b), and Chad, Mali and Niger which are least-developed countries (Fig. 1c) it cause a small number of deaths in developed countries (Fig. 1a). Compared to other developed countries, the highest death rate is seen in Singapore (Fig. 2a). BABT has one of the highest mortality rates in India among developing countries (Fig. 1b) and in Chad among developed countries (Fig. 1c). CAs are the most common problem in the developed countries (Fig. 1a) and developing countries (Fig. 1b). Diarrheal diseases which are caused by infection, have highest percentage as U5CM reason in India (Fig. 1b) when it

Table 5. Disease clusters of fifteen countries (a) developed, (b) developing and (c) least-developed countries based on causes of child mortality.The similarity of the clustering results of each country to the clustering results of the group to which that country belongs.

a)

Causes of child mortality	ALRI	BABT	CAs	Diarrhoeal diseases	HIV/AIDS	Injuries	Malaria	Measles	Meningitis/ encephalitis	OCPNC	Other non-communicable diseases	Prematurity	SOICN	Tetanus	Similarity rate in the group
Norway															0.92
Germany															0.85
Canada															0.85
Singapore															0.78
Australia															0.78

b)

Causes of child mortality	ALRI	BABT	CAs	Diarrhoeal diseases	HIV/AIDS	Injuries	Malaria	Measles	Meningitis/ encephalitis	OCPNC	Other non-communicable diseases	Prematurity	SOICN	Tetanus	Similarity rate in the group
Tunisia															0.78
India															0.78
Colombia															0.65
Turkey															0.57
Mexico															0.57

c)

Causes of child mortality	ALRI	BABT	CAs	Diarrhoeal diseases	HIV/AIDS	Injuries	Malaria	Measles	Meningitis/ encephalitis	OCPNC	Other non-communicable diseases	Prematurity	SOICN	Tetanus	Similarity rate in the group
Mali															1
Chad															1
Bangladesh															0.92
Niger															0.78
Mozambique															0.65

Fig. 3. Disease clusters based on development levels of countries.

compared to other developing countries and commonly seen in Chad, Mali and Niger (Fig. 1c). Unlike these countries diarrheal diseases are hardly ever seen in developed countries (Fig. 1a). While HIV has no effect on U5CM in developed countries, and has a small effect in developing countries, it is effective in least-developed countries, especially Mozambique (Fig. 2). Injuries are related with ALRI in developing countries, and with CAs in least-developed countries. Malaria is commonly seen in least developed countries except Bangladesh as the reason of U5CM (Fig. 1c). In developed and developing countries it almost has no effect on U5CM rate (Figs. 2a and 2b). While Measles can be shown as one of the causes of U5CM in least-developed countries, it has no effect in developed countries and in developing countries except India (Fig. 2). Meningitis/encephalitis cause the most U5CM in least-developed countries among other countries (Fig. 2). Other communicable and noncommunicable diseases cause a number of deaths in all development level groups (Fig. 2). Prematurity is the second highest cause of U5CM in the developed countries especially in Canada and Germany, and the common reason of U5CM in developing countries especially in India (Figs. 1a and 1b). SOICN also cause a number of deaths in all development level groups (Fig. 2). While tetanus has no effect in developed countries, it has a small effect in developing and least-developed countries on U5CM (Fig. 2).

Based on the Euclidean distance results in Table 2 and *Supplementary* Table 2 to 5, we can infer that in developed countries, ALRI, diarrheal diseases, HIV/AIDS, sepsis, measles, meningitis/ encephalitis, and other infectious conditions of the newborn, tetanus are related with each other. ALRI are also generally related with diarrheal diseases in developing and least-developed countries. Prematurity and BABT shows relations in all developed and least-developed countries. Prematurity also shows relationship with SOICN in all developed countries, and Mozambique, Mali, and Chad. Besides, in Australia, Norway, Canada and Germany prematurity also has relationship with CAs. Likewise, prematurity has relevance with CAs in developing countries except India (Table 3, *Supplementary* Table 6 to 9). Prematurity also shows relationship with BABT in India, Tunisia and Mexico. Unlike in developed and developing countries, CAs have a connection with HIV/AIDS, injuries, malaria, measles, meningitis/encephalitis, SOICN, tetanus in least developed countries (Table 4, *Supplementary* Table 10 to13). Clustering results in Table 3 and Fig. 3, it is seen that in developed countries, Norway has the most correlated ratio as 0.92 similarity rate in the group and Australia and Singapore has the lowest similarity rate

with 0.78. It might be because of geographic conditions of the countries (Table 5a). In developing countries, Tunisia and India shows highest rate of similarity in the group as 0.78, Colombia follows them with the rate of similarity as 0.64. However, Turkey and Mexico have the lowest similarity rate in the group as 0.57 (Table 5b). In least-developed countries, Chad and Mali has the highest similarity rate in the group as 1. Mozambique has the lowest similarity in the group with 0.64 similarity rate. Bangladesh and Mozambique differs from the group with the malaria disease than Mozambique (Table 5c).

DISCUSSION

Economic development level has an impact on preventing and treatment disease and improve under-5 children survival chance. However, even if the countries have same economic development level, there are many other reasons associated with U5CM such as geographic conditions, eating habits, culture, exposure to chemicals.

Diarrhoea and ALRI in children 1-50 months of age are almost ten times higher than U5CM from 0-28 days of diarrhea and ALRI. Diarrheal diseases are caused by viral pathogens such as rotavirus, adenovirus and norovirus and bacterial pathogens such as cholera, shigella, campylobacter. The highest risk factors for diarrheal diseases are unsafe water supply, child growth failure, lack of access to handwashing facility, unsafe sanitation in least developed countries [26]. India differs from the other developing countries since it has the highest ALRI, BABT, diarrhoeal diseases, measles, meningitis, tetanus and sepsis and other connectional inflectional diseases U5CM. Cases of infectious diseases are high in India and the causes of epidemics range from lack of sanitation, urbanization change to lack of fresh water [27]. India is the country with the highest number of preterm births all over the world, and there are many causes of preterm birth such as infections, multiple pregnancies, diabetes, high blood pressure [23]. U5CM in India are caused by BABT, sepsis, diarrheal diseases most of which can be avoided by increases in delivery and postnatal care [28].

HIV/AIDS is a major burden in Mozambique which ranks among the 10 countries with the highest HIV burden in the world, with HIV in adults aged 15 to 49 years [29]. HIV can be transmitted from mother to infant during pregnancy, childbirth and breastfeeding [30]. Therefore, cause of U5CM in Mozambique due to HIV/AIDS is highly correlated with the prevalence of HIV/AIDS in the country. A study from Mozambique showing behavioral factors such as men having sex with men or women for money, goods, favor are more associated with HIV prevalence than demographic factors [31]. In the Fig. 2c, malaria hits Mali with highest U5CM rate in the least-developed countries. Because Mali has a subtropical and arid climate, it receives significant rainfall during part of the year and experiences a rainy season for part of the year and extremely dry weather for the rest of the years. Various environmental problems such as deforestation, desertification, soil erosion expose Mali to have many problems related to floods during the rainy season. These conditions create ideal environments for malaria transmission in Mali [32]. Chad has the highest prevalence of ALRIs in the least-developed countries. Globally, 50% of ALRIs deaths occur in sub-Saharan Africa, and Chad is among the 10 countries with the highest prevalence of ALRIs [33]. ALRI is caused by bacterial, fungal, or viral infections of the respiratory tract leading various difficulties [34]. A study was performed to examine the prevalence and predictor of ALRIs among under-5 children in 28 sub-Saharan African countries, including women with under-5 children and the results showed that ALRI was associated with mothers' employment status, child's age, child receiving intestinal parasite and type of toilet facility in the household [35].

Results showed that CAs and prematurity were associated diseases, BABT were associated with OCPNC and non-communicable in U5CM in developed countries. In the literature, it has been shown that there is a correlation between CAs and preterm birth [36]. Prematurity, CAs, BABT and OCPNC are in same group in Australia and Canada. However, in Germany, BABT and OCPNC are in the same group with acute lowery respiratory infections, diarrheal diseases, HIV, malaria, measles, meningitis, sepsis and tetanus. Singapore has the same group with Germany except for acute lower respiratory infection which is in different group in Singapore. Unlike other developed countries, prematurity in Norway is in different group from CAs. Canada has the highest prematurity rate of

U5CM and the highest rate in the group of BABT, SOICN and other communicable conditions. Because preterm birth can cause serious health complications for the baby and increases chronic health conditions that makes the baby susceptible to infections and serious health problem later in their life [37]. Prematurity is associated with CAs in developing countries except India, where prematurity is associated with BABT, and Tunisia, where prematurity is not associated with other diseases (Table 5b). Many different conditions such as low-income, education, susceptibility to infections, population are the reasons of prematurity in India. Bangladesh is geographically far from other least-developed countries however, many disease associations are common in India like CAs are highly related with infectious diseases such as HIV/AIDS, injuries, malaria, measles, meningitis/encephalitis, SOICN, tetanus. ALRI is also associated with diarrheal diseases. Unlike developed countries, in least developed countries water pollution, population, access to the clean food may cause children to be susceptible to infections. In developing countries, Colombia, Turkey and Mexico CAs correlate with prematurity. However, in India, prematurity is associated with BABT.

Even if Mozambique increases investments in malaria control and provide free malaria services, malaria remains a major burden for Mozambique's economy and health system [38]. WHO recorded 229 million cases of malaria in 2019, of which 409,000 deaths in 87 endemic countries and 67 % deaths in under-5 children. Worldwide, 95 % of the malaria cases occurred in 29 countries [39]. Although malaria is preventable, detectable and treatable, it is still more common in poor regions and causes socioeconomics impacts. Especially children and women are at high risk because of their low immunity. In the Chimoio region of Mozambique, under-5 children are three times more prone to malaria than adults [40]. Malaria remains a major public health problem in Africa including Mozambique, Chad, Mali and Niger. Especially in Mozambique, malaria birth defects are particularly prevalent in middle- and low-income countries. Besides poverty, the main reasons for the differences in birth prevalence rates of serious birth defects between high- and low-income countries. Many reasons may be associated with birth prevalence rates, including consanguineous marriage, inequalities in maternal and child health services, advantages of carrying sickle cell for malaria survival [41].

It has been shown that diseases are associated with various effects on countries such as high or low income, education level, health insurance, population, geographic condition, genetic background and culture. Projections for 2030 show that diarrheal diseases and lower respiratory infections will be outranked if countries do not act to prevent diseases. Strategic plans should specify a focus on improving administration of medicine for intestinal worms, more health education to mothers who have under-5 children on ALRIs, reducing poverty and improving the sanitation status of households through the provision of improved toiled facilities. According to current trends, more than 48 million under-5 children will die between 2020 and 2030 however if all countries met the SDG target for U5CM by 2030, around 11 million of these deaths could have been prevented [7]. Countries should evaluate their health plans according to outcomes of these results. It is important to develop national health strategies, and planning health policies and interventions, and track progress towards child survival.

CONCLUSION

Trends in child mortality causes help decision makers assess needs, prioritize interventions, and monitor progress. This study presents information on the proportional distribution of U5CM in countries with different economic levels of development. The findings obtained at the end of the study show that U5CM are caused by different diseases in countries with different levels of development. These differences are due to factors such as the geographical conditions, income levels and populations of the countries. According to our analysis, while diseases that cause mortality in developed and developing countries are mostly caused by genetic factors and birth complications, child mortality in socio-economically unstable least-developed countries are mostly due to lack of adequate sanitation, hygiene and clean water, as well as inability to get vaccine.

Authors' Contribution

Study Conception: MS, NŞE, PG; Study Design: MS, NŞE, PG; Supervision: MS, PG; Funding: MS,

NŞE, PG; Materials: MS, NŞE, PG; Data Collection and/or Processing: NŞE, PG; Statistical Analysis and/or Data Interpretation: MS, NŞE, PG; Literature Review: NŞE, PG; Manuscript Preparation: MS, NŞE, PG and Critical Review: MS, NŞE, PG.

Conflict of interest

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Supplementary Tables 1 to 13

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