ORİJİNAL ARAŞTIRMA ORIGINAL RESEARCH

Examination of Incidences of HIV Infection and Tuberculosis in Some Selected European Countries with Statistical Process Control

Seçilmiş Bazı Avrupa Ülkelerindeki HIV Enfeksiyonu ve Tüberkülozun İnsidanslarının İstatistiksel Proses Kontrol Yöntemi ile İzlenmesi

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ABSTRACT Objective: Statistical process control (SPC) is a method of analysis developed for examining the data of a process and which facilitates understanding of that process. The aim of this study is to investigate whether or not human immune deficiency virus (HIV) infection and tuberculosis (TB) were brought under control in some selected European countries between the years 1990 and 2016, as well as to examine the association between HIV and TB in the years when they went out of control. Moreover, the relationship between these diseases and selected Organisation for Economic Co-operation and Development criteria will be examined. **Material and Methods**: The time course of HIV and TB in some selected European countries was examined with SPC based on years, the HIV and TB incidence data on the World Health Organization (WHO) and Joint United Nations Programme on HIV and AIDS (acquired immune deficiency syndrome) databases between the years 1990 and 2016 were utilised. The mid-year population figures of the European countries were taken from the WHO database. The European countries (Germany, France, Great Britain, Spain, Italy, Hungary, Turkey, Poland and Ukraine) included in the study were selected based on the WHO European Region classification. **Results:** HIV and TB have been brought under control in Western European countries. However, in Central European countries, TB is under control, whereas HIV is out of control. In Ukraine, which represents the Eastern European countries, both infections are out of control. **Conclusion:** When an assessment is made in terms of factors that affect bringing HIV under control, it is striking that there are significant epidemiological and HIV treatment cascade differences between countries. When policies are being created especially for bringing the HIV infection under control, the policies of countries which have brought this infection under control also need to be examined.

Keywords: Statistical process control; HIV incidence;
tuberculosis incidence; Laney P control chart

ÖZET Amaç: İstatistiksel proses kontrol (İPK), bir sürecin verilerini incelemek için geliştirilen ve sürecin anlaşılmasını uygun hâle getiren analiz yöntemidir. Bu çalışmanın amacı, 1990-2016 yılları arasında seçilmiş bazı Avrupa ülkelerinde insan immün yetmezlik virüsü (HIV) enfeksiyonu ve tüberkülozun (TB) kontrol altında olup olmadığının araştırılması, ayrıca kontrol dışına çıktığı yıllardaki HIV ve TB birlikteliğinin incelenmesidir. Ayrıca bu hastalıklarla seçilmiş Ekonomik Kalkınma ve İşbirliği Örgütü gelişmişlik kriterlerinin ilişkisinin araştırılmasıdır. **Gereç ve Yöntemler:** Çalışma kapsamımızdaki seçilmiş bazı Avrupa ülkelerinin, yıllar bazında HIV ve TB seyrinin İPK ile incelendiği çalışmamızda, Dünya Sağlık Örgütü (DSÖ) ve Birleşmiş Milletler HIV/AIDS (kazanılmış immün yetmezlik sendromu) Ortak Programı veri tabanlarından, 1990-2016 yılları arasındaki HIV ve TB insidans verileri alınmıştır. Avrupa ülkelerinin yarıyıl popülasyonları, DSÖ veri tabanından alınmıştır. Çalışmaya alınan Avrupa ülkeleri (Almanya, Fransa, İngiltere, İspanya, İtalya, Macaristan, Türkiye, Polonya ve Ukrayna), DSÖ Avrupa Bölgesi sınıflandırmasına dayanılarak seçilmiştir. **Bulgular:** Batı Avrupa ülkelerinde, HIV ve TB kontrol altına alınmıştır. Orta Avrupa ülkelerinde, TB kontrol altında, HIV kontrol dışında seyretmektedir. Doğu Avrupa ülkelerini temsil eden Ukrayna'da ise her 2 enfeksiyon da kontrol dışında görülmektedir. **Sonuç:** HIV'in kontrol altına alınmasını etkileyen faktörler açısından bir değerlendirme yapıldığında, ülkeler arasında önemli epidemiyolojik ve HIV kaskadı farklılıkları olduğu dikkat çekicidir. Özellikle HIV enfeksiyonunu kontrol altına almaya yönelik politikalar oluşturulurken, bu enfeksiyonu kontrol altına alan ülkelerin politikalarının da incelenmesi gerekmektedir.

Anahtar Kelimeler: İstatistiksel proses kontrol; HIV insidansı;
tüberküloz insidansı; Laney P kontrol grafiği

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Health data which have been recorded forms the basis for understanding the distribution of diseases over a period of time. Many countries create up-to-date status information by recording new cases on a daily, weekly or monthly basis. By monitoring public health data in large amounts, it is also possible to acquire information about epidemics.[1] As with a range of methods applied for improving an ongoing system, statistical process control (SPC) is a versatile tool used in health service management and for assessing patient treatment processes.[2] The transfer of the SPC approach to the health sector occurred in the year 1949 when it began to be applied in a few biochemistry laboratories.[3]

SPC is a method of analysis developed for examining the data of a process and which facilitates understanding of that process.[4] The use of SPC charts for monitoring infectious diseases enables the relevant decisions to be taken. By monitoring the course of diseases over time with SPC charts, upward and downward trends can be determined, and as a result of this, control efforts can be given direction.

It is estimated that in the year 2017, 36.9 million people were living with HIV, that 1.8 million people were infected with HIV and 940,000 people were lost due to HIV infection worldwide.[5]

Although the number of HIV infection has shown a decrease between the year 2010 and the present, an increasing trend has been observed in some countries. Although an increase has been seen in European countries, this increase is reported to be very significant especially in Eastern European countries. The incidence of HIV infection in Eastern Europe is reported to be 0.062‰.[6]

Despite all the efforts to keep it in check, tuberculosis (TB) continues to be a serious public health problem globally. The World Health Organization (WHO) estimates that in the year 2016, there were 10.4 million new cases of TB and that there were 1.7 million TB-related deaths. 1.3 million of these deaths occurred in HIV negative patients, while 400,000 deaths occurred in those living with HIV.[7]

The HIV infection is one of the most important known risk factors for the disease of TB. The risk of developing TB disease is 20-30 times greater compared to HIV negative individuals.[8,9]

The aim of this study is to investigate whether or not the HIV infection and TB were brought under control in some selected European countries (according to the WHO's European Region, Western European countries such as Germany, France, Great Britain, Spain and Italy, Central European countries including Hungary, Turkey and Poland, and Eastern European countries like Ukraine) between the years 1990 and 2016, as well as to examine the association between HIV and TB in the years when they went out of control. Moreover, the relationship between these diseases and selected The Organisation for Economic Co-operation and Development criteria will be examined.[10]

MATERIAL AND METHODS

In our study, within the scope of which the time course of HIV and TB in some selected European countries was examined with SPC based on years, the HIV and TB incidence data on the WHO and The Joint United Nations Programme on HIV/AIDS databases between the years 1990 and 2016 were utilised.[11-13] The mid-year population figures of the European countries were taken from the WHO database.[14] The European countries included in the study were selected based on the WHO's European Region classification.

The SPC charts were made with a presence/absence analysis of infection. Therefore, analysis was made with control charts by taking infection rate as the basis. Since the sample size (mid-year population) was large, the examination that was made of over-dispersion and under-dispersion was carried out with the graphical method developed by Jones and Govindaraju.[15] The HIV and TB incidence processes between the years 1990 and 2016 were examined with the Laney P control chart in cases of over-dispersion and under-dispersion, and with the Shewhart P control chart when there was no dispersion. Correlations between variables were examined with the Spearman and Pearson correlation coefficients. Level of significance was taken $\alpha=0.05$.

STATISTICAL ANALYSIS

SPSS (IBM Corp. Released 2012. IBM SPSS Statistics for Windows, Version 21.0. Armonk, NY: IBM Corp.) and Minitab 17 [Statistical Software (2010). (Computer software). State College, PA: Minitab, Inc. (www.minitab.com)] softwares were used in the analyses.

RESULTS

The incidence data for HIV and TB in the countries selected for SPC between the years 1990 and 2016 are presented in per mil (‰) in Table 1.

Regarding TB incidences, incidence data could not be accessed for Turkey in 1993 and 1994, Spain in 1994, Italy in 2014, 2015 and 2016, and Ukraine in 2004. Ukraine's education and expenditure variables data are not available. With regard to HIV incidences, incidence data could not be accessed for Germany in 1990, 1991 and 1992. Correlation analyses between TB and HIV incidences with the education and expenditure variables in the selected European countries are given in Table 2.

The SPC charts for the HIV and TB incidences of the countries are presented in Figure 1, Figure 2, Figure 3 and Figure 4.

The HIV and TB control charts for when the data of the selected countries were evaluated together are shown in Figure 5.

The time course of HIV incidence in Germany can be seen in Figure 1a. The mean incidence rate was 0.03‰. HIV was under control between the years 1993 and 2014. It went out of control with an

TABLE 1: The incidence data for HIV and TB in the countries (‰).																
	Turkey		France		Great Britain		Spain		Italy		Hungary		Poland		Germany		Ukraine	
Years	TB	HIV	TB	HIV	TB	HIV	TB	HIV	TB	HIV	TB	HIV	TB	HIV	TB	HIV	TB	HIV
1990	0.44	0.0003	0.16	0.14	0.10	0.05	0.20	2.80	0.07	1.90	0.35	0.00	0.42	0.02	0.18	-	0.32	0.0003
1991	0.45	0.0005	0.15	0.15	0.11	0.05	0.23	2.60	0.07	1.80	0.35	0.01	0.43	0.01	0.17	-	0.32	0.0004
1992	0.45	0.0006	0.15	0.16	0.11	0.05	0.25	2.30	0.08	1.80	0.38	0.01	0.43	0.01	0.18	-	0.35	0.0005
1993	-	0.0008	0.17	0.16	0.11	0.05	0.24	2.00	0.08	1.80	0.41	0.01	0.44	0.01	0.17	0.03	0.38	0.0008
1994	-	0.0008	0.16	0.17	0.11	0.05	-	1.80	0.10	1.70	0.40	0.01	0.43	0.01	0.16	0.03	0.40	0.0006
1995	0.38	0.001	0.15	0.16	0.11	0.05	0.22	1.60	0.10	1.40	0.42	0.01	0.41	0.01	0.15	0.03	0.42	0.03
1996	0.33	0.0015	0.13	0.14	0.11	0.05	0.21	1.40	0.07	1.20	0.43	0.01	0.4	0.01	0.14	0.02	0.46	0.10
1997	0.42	0.0017	0.12	0.11	0.11	0.05	0.24	1.30	0.08	1.20	0.41	0.01	0.36	0.02	0.14	0.03	0.56	0.17
1998	0.41	0.0014	0.10	0.10	0.11	0.05	0.23	1.30	0.10	1.10	0.39	0.01	0.34	0.02	0.13	0.02	0.55	0.16
1999	0.35	0.0015	0.10	0.10	0.11	0.06	0.21	1.20	0.08	1.10	0.35	0.01	0.31	0.01	0.12	0.02	0.66	0.11
2000	0.28	0.0018	0.10	0.10	0.11	0.07	0.20	1.10	0.06	1.10	0.30	0.00	0.29	0.02	0.11	0.02	0.67	0.11
2001	0.27	0.0022	0.10	0.12	0.10	0.09	0.17	1.10	0.08	1.10	0.29	0.01	0.27	0.02	0.08	0.04	0.75	0.12
2002	0.27	0.0023	0.10	0.13	0.12	0.11	0.18	1.10	0.07	1.00	0.27	0.01	0.26	0.01	0.08	0.02	0.84	0.15
2003	0.27	0.0021	0.10	0.14	0.12	0.12	0.24	1.10	0.08	0.80	0.27	0.01	0.27	0.02	0.09	0.02	1.63	0.17
2004	0.26	0.003	0.08	0.15	0.12	0.13	0.14	1.00	0.07	0.80	0.22	0.01	0.23	0.02	0.08	0.03	-	0.22
2005	0.29	0.004	0.08	0.16	0.14	0.13	0.17	1.00	0.07	0.70	0.18	0.01	0.22	0.02	0.07	0.03	0.84	0.24
2006	0.28	0.004	0.08	0.14	0.14	0.12	0.18	1.00	0.07	0.60	0.17	0.01	0.21	0.02	0.06	0.03	0.89	0.29
2007	0.27	0.0049	0.09	0.15	0.13	0.12	0.16	1.00	0.05	0.60	0.15	0.01	0.21	0.02	0.06	0.03	0.81	0.29
2008	0.25	0.0055	0.09	0.13	0.13	0.12	0.17	1.00	0.07	0.50	0.14	0.01	0.19	0.02	0.05	0.03	0.82	0.33
2009	0.23	0.0065	0.08	0.12	0.13	0.11	0.16	1.00	0.07	0.50	0.13	0.01	0.20	0.03	0.05	0.03	0.79	0.35
2010	0.22	0.0072	0.08	0.12	0.13	0.10	0.15	1.00	0.08	0.50	0.15	0.02	0.18	0.03	0.05	0.03	0.74	0.36
2011	0.20	0.0088	0.07	0.10	0.13	0.10	0.14	1.00	0.06	0.50	0.13	0.02	0.21	0.03	0.05	0.03	0.75	0.38
2012	0.19	0.0142	0.07	0.11	0.13	0.10	0.12	1.00	0.05	0.50	0.12	0.02	0.19	0.03	0.05	0.04	0.90	0.37
2013	0.17	0.0173	0.07	0.09	0.12	0.09	0.11	0.90	0.05	0.50	0.11	0.02	0.19	0.03	0.05	0.04	0.81	0.39
2014	0.17	0.0234	0.07	0.09	0.10	0.10	0.10	0.90	-	0.50	0.08	0.03	0.17	0.03	0.05	0.04	0.70	0.37
2015	0.16	0.03	0.07	0.09	0.09	0.10	0.09	0.90	-	0.50	0.09	0.03	0.16	0.03	0.07	0.05	0.67	0.29
2016	0.15	0.03	0.07	0.08	0.09	0.08	0.10	0.90	-	0.50	0.08	0.02	0.16	0.03	0.07	0.04	0.65	0.32

TB: Tuberculosis; HIV: Human immune deficiency virus.

	HIV						TB				
	Education		Expenditure		TB		Education		Expenditure		
Countries	r value	p value	r value	p value	r value	p value	r value	p value	r value	p value	
Turkey	0.989	<0.001	0.965	<0.001	-0.956	<0.001	-0.896	<0.001	-0.901	<0.001	
France	-0.629	0.001	-0.620	0.001	0.647	<0.001	-0.957	<0.001	-0.963	<0.001	
Great Britain	0.276	0.239	0.662	<0.001	0.644	<0.001	-0.107	0.654	0.176	0.381	
Spain	-0.969	<0.001	-0.978	<0.001	0.891	<0.001	-0.902	<0.001	-0.880	<0.001	
Italy	-0.967	<0.001	-0.979	<0.001	0.520	0.009	-0.637	0.003	-0.558	0.005	
Hungary	0.826	<0.001	0.736	<0.001	-0.683	<0.001	-0.986	<0.001	-0.958	<0.001	
Poland	0.874	<0.001	0.774	<0.001	-0.848	<0.001	-0.941	<0.001	-0.919	<0.001	
Germany	0.596	0.003	0.628	0.001	-0.478	0.018	-0.891	<0.001	-0.919	<0.001	
Ukraine	-	-	-	-	0.696	<0.001	-	-	-	-	

TABLE 2: The correlations between TB and HIV incidences with The Organisation for Economic Co-operation and Development variables in the countries.

TB: Tuberculosis; HIV: Human immune deficiency virus.

FIGURE 1: Statistical process control charts for HIV incidences of Western European countries A: Germany; B: France, C: Great Britain; D: Spain and E: Italy.
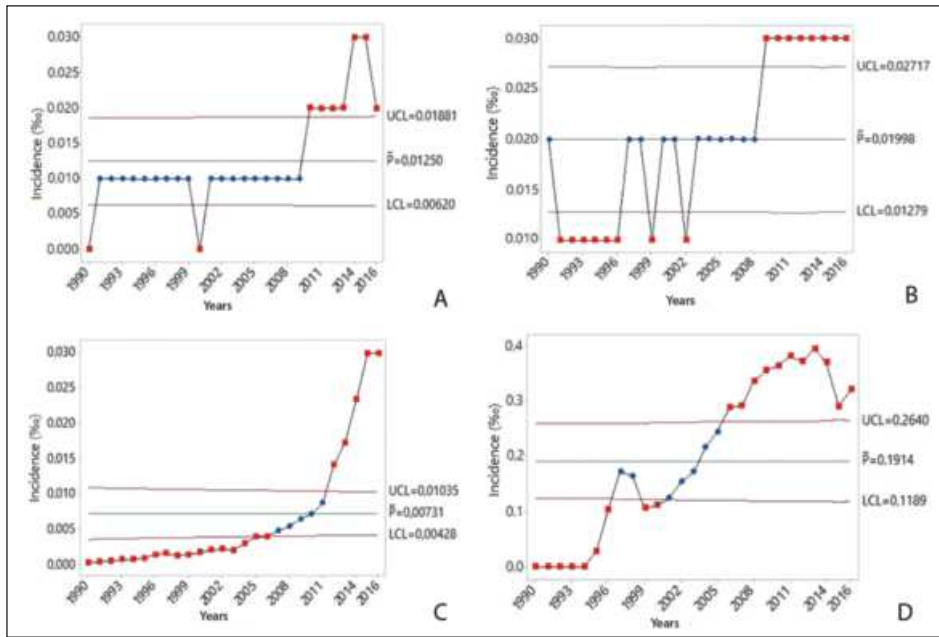UCL: Upper control limit, LCL: Lower control limit.

FIGURE 2: Statistical process control charts for HIV incidences of Central and Eastern European countries A: Hungary; B: Turkey; C: Poland; and D: Ukraine.
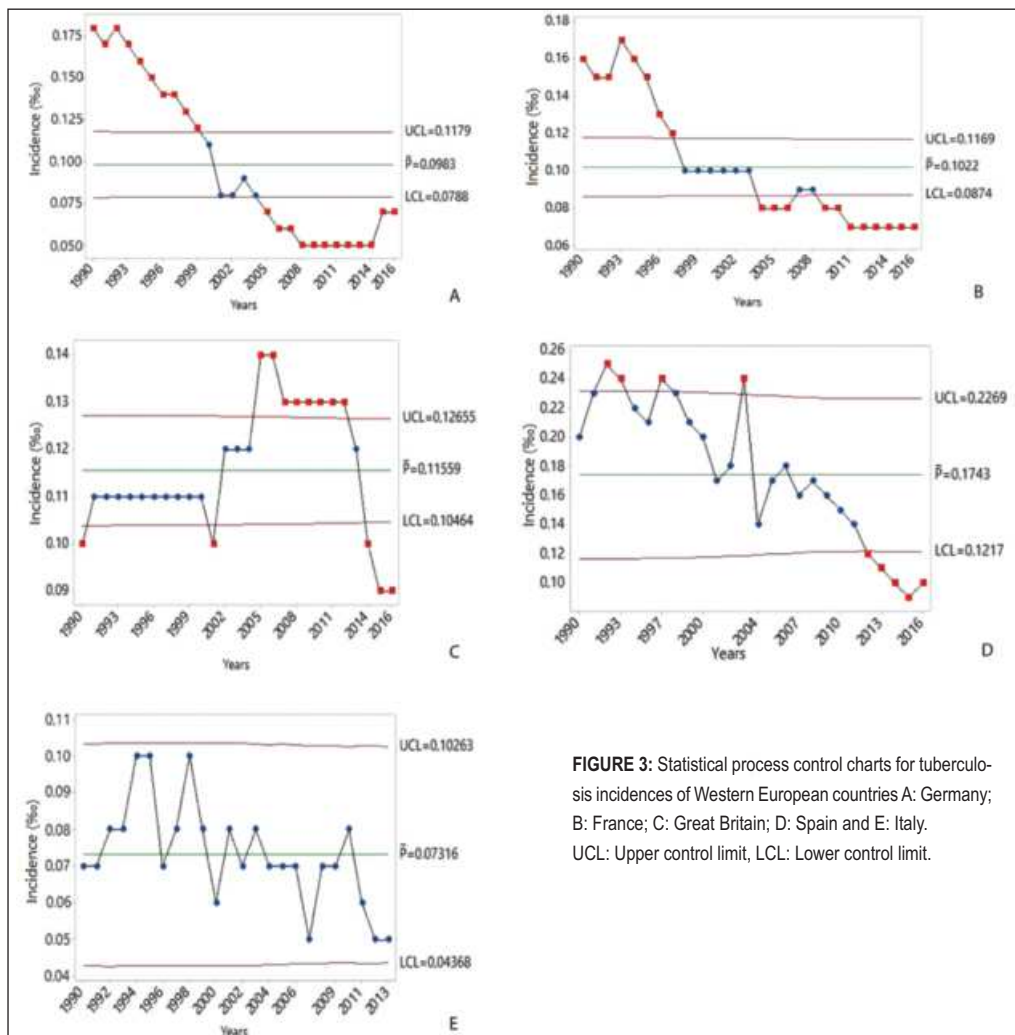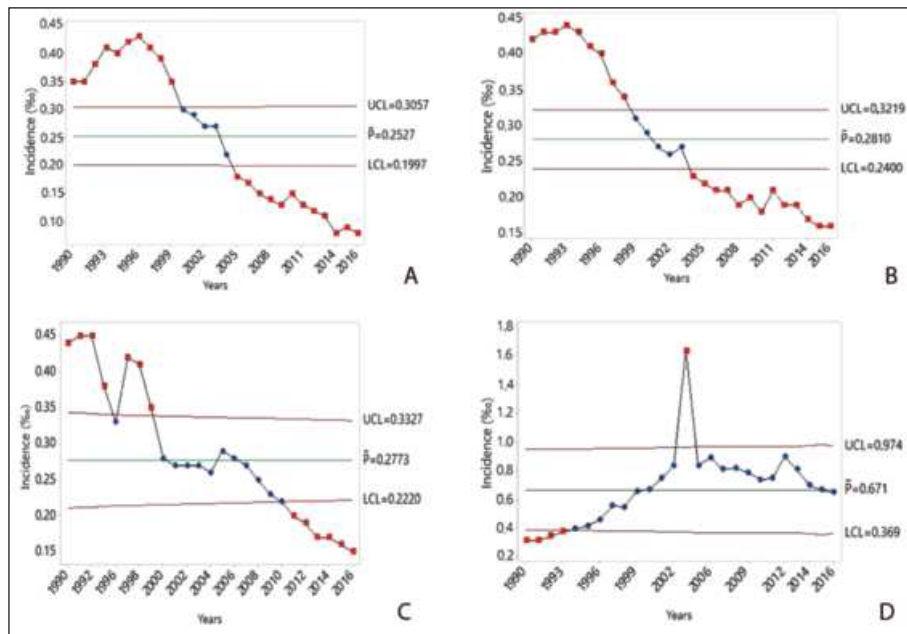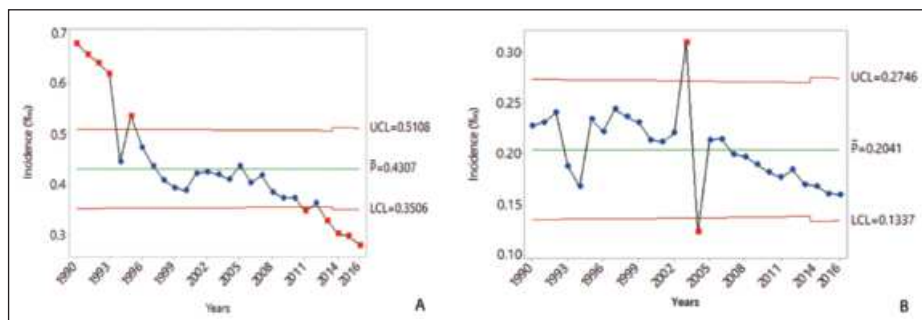UCL: Upper control limit, LCL: Lower control limit.

FIGURE 3: Statistical process control charts for tuberculosis incidences of Western European countries A: Germany; B: France; C: Great Britain; D: Spain and E: Italy.
UCL: Upper control limit, LCL: Lower control limit.

FIGURE 4: Statistical process control charts for tuberculosis incidences of Central and Eastern European countries A: Hungary; B: Turkey, C: Poland and D: Ukraine. UCL: Upper control limit, LCL: Lower control limit.

FIGURE 5: Statistical process control charts for when the data of the selected countries were evaluated together A: HIV and B: Tuberculosis. UCL: Upper control limit, LCL: Lower control limit.

incidence rate of 0.05‰ in 2015. The process was again brought under control in 2016. SPC chart for TB incidence can be seen in Figure 3a. The mean incidence rate was 0.098‰. While incidence was out of control between the years 1990 and 1999, as from 2000, it was brought under control with an incidence rate of 0.11‰. It is not known whether TB cases have HIV infection in Germany.[16] While the HIV incidence went out of control in 2015, TB incidence increased in the same year; but it was kept under control.

The SPC chart for HIV incidence in France can be seen in Figure 1b. The mean incidence rate was 1.26‰. While HIV was under control in 1990 and 1991, from 1992 onwards, it went out of control with

an incidence rate of 1.6‰. The process was kept under control in 2006. The mean incidence rate of TB was 0.1‰. It can be seen in Figure 3b that TB was out of control between 1990 and 1997. The incidence was brought under control as of 1998 with a rate of 0.1‰. While sudden and continuous increases were observed in HIV, this was not reflected in TB.

The mean HIV incidence rate was 0.09‰ in Great Britain. It can be seen in Figure 1c that incidence was under control between the years 1990 and 2001. However it exceeded the upper control limit by increasing to 0.11‰ in 2002, HIV infection was again brought under control in the year 2010, with a rate of 0.1‰. The time course of TB incidence can be seen in Figure 3c. The mean incidence rate was

0.1‰. The process was kept under control till the year 2004, however it exceeded the upper control limit by increasing to 0.14‰ in the year 2005. TB infections were again brought under control in the year 2013, with a rate of 0.12‰. HIV and TB infections were out of control together between the years 2005 and 2009, they followed a similar trend between the years 1990 and 2016.

The mean HIV incidence rate was 1.28‰ in Spain. It can be seen in Figure 1d that incidence was out of control between the years 1990 and 1995, from 1996 onwards, it was brought under control with an incidence rate of 1.4‰. The time course of TB incidence can be seen in Figure 3d. The mean incidence rate was 0.17‰. TB incidence was exceeded the control limit by increasing to 0.25‰ in the year 1992. While the process had been under control and out of control in some years until 2003, it was brought under control in 2003 with an incidence rate of 0.14‰.

The time course of HIV incidence in Italy can be seen in Figure 1e. The mean incidence rate was 0.96‰. While the process was out of control between the years 1990 and 1997, in 1998 it was brought under control with an incidence rate of 1.1‰. The time course of TB incidence in Italy can be seen in Figure 3e. It can be seen that the process was under control with the mean incidence rate was 0.07‰. When the HIV incidence went out of control, TB infection got close to the upper control limit by increasing the TB incidence rate. TB incidence was only slightly above or mostly below from the center line and it was kept under control due to the control of HIV incidence.

The time course of HIV incidence in Hungary can be seen in Figure 2a. The mean incidence rate was 0.01‰. The incidence went out of control in 2010 with an incidence rate of 0.02‰ and it can be seen that the process has been still out of control in 2016. SPC chart of TB can be seen in Figure 4a. The mean incidence rate was 0.25‰. It was out of control between the years 1990 and 1999, from 2012 onwards, it was brought under control with an incidence rate of 0.3‰.

The time course of HIV incidence in Turkey can be seen in Figure 2b. The mean incidence rate was

0.007‰. While HIV advanced under control between the years 1990 and 2011, from 2012 onwards, it went out of control with an incidence rate of 0.33‰. The mean incidence rate of TB was 0.3‰. It can be seen in Figure 4b that in 1990, TB was out of control, with a rate of 0.44‰. While the process was kept under control in 1996 with an incidence rate of 0.33‰, in 1997 it again exceeded the upper control limit by increasing to 0.42‰. It is seen that TB infections were again brought under control in the year 2000, with a rate of 0.28‰. HIV has shown an increasing trend for the last 25 years.

The mean HIV incidence rate was 0.02‰ in Poland. While the process was kept under control until 2008 as seen in Figure 2c, in 2009 it exceeded the upper control limit by increasing to 0.03‰. It has been still out of control in the year 2016. The time course of TB incidence in Poland can be seen in Figure 4c. The mean incidence rate was 0.28‰. The incidence was out of control between the years 1990 and 1998, whereas it was brought under control in the year 1999, with a rate of 0.31‰. HIV status of TB patients is not tested routinely in Poland.[17]

The mean HIV incidence rate was 0.2‰ in Ukraine. While the process was kept under control between the years 1990 and 2005, in 2006 it exceeded the upper control limit by increasing to 0.3‰. It has been still out of control in the year 2016 as seen Figure 2d. The time course of TB incidence in Ukraine can be seen in Figure 4d. The mean incidence rate was 0.7‰. The incidence was out of control only in the year 2003, with a rate of 1.63‰, the process was under control in the other years.

When the data for all countries included in the study are analyzed together, while HIV incidence was found to be out of control between 1990 and 1993, it was below the upper control limit and continued to decrease from 1994 onwards. In 2016, which was the last year to be observed in our study, HIV incidence was calculated as 0.28‰. While TB incidence continued under control until 2002, it went out of control in 2003 with a sudden increase and was again taken under control immediately afterwards in 2004 with a sudden decrease. In 2016, TB incidence was calculated as 0.16‰.

While HIV incidence has decreased as education and expenditure have increased in France, Spain and Italy, it has increased in Germany, Turkey, Hungary and Poland. In Britain, while no relationship between HIV incidence and education was found, incidence was seen to increase as expenditure increased.

With regard to TB, a decrease in TB incidence with an increase in education and expenditure was observed in France, Spain, Italy, Germany, Turkey, Hungary and Poland. No relationship between TB incidence and education and expenditure was observed in Britain.

When examining the relationship between incidence of HIV and TB in the selected countries in our study, while there was a positive relationship between HIV and TB in France, Britain, Spain, Italy and Ukraine, a negative relationship was seen in Germany, Hungary, Poland and Turkey.

DISCUSSION

Analyses can be made by monitoring process data with SPC. The SPC technique is a method that makes it possible to examine changes in process characteristics over time with statistical methods within the determined limits by means of control charts. Control charts are an important tool used in health-related processes for analyzing and improving these processes. Control charts assist in reducing rates of diseases, side effects of medicines or implementations, surgical complications, and surgical site infections.[18] Control charts consist of a central line and upper and lower control limits. If a process remains within the upper and lower control limits, this can indicate that the process is proceeding under control.

The fact that epidemic diseases spread rapidly emphasizes the need for efforts to keep them under control. SPC charts are one of the methods used for observing the course of a disease, monitoring its process and developing measures against it.

Global efforts to keep HIV and TB under control are continuing. By providing information about the control of infectious diseases, SPC charts make it possible for the relevant decisions to be taken. By monitoring the course of diseases over time with SPC charts, upward and downward trends can be deter-

mined, and as a result of this, control efforts can be given direction.

In our study, in which incidences of HIV and TB were examined based on countries according to years, by evaluating these according to similarities and differences seen between the years 1990 and 2016, the course of these infections over time in the selected countries was examined, and changes in incidences of HIV and TB were investigated in terms of education and income levels.

France, Germany, Poland and Great Britain, which make up 40% of TB cases in European countries, do not record HIV results of TB patients in their own countries due to their confidentiality regulations.[19] Therefore, it can be considered that HIV results are higher than the incidences given in the WHO database.

While HIV is increasing more slowly when compared to previous years, it is seen that the rate of increase is considerably higher in Eastern European countries.[20] The WHO states that TB/HIV coinfection has increased from 5.5% to 9% in the European Region in the last 5 years.[21] However, African countries represent the area where the risk of coinfection between TB cases and HIV is the highest. The great majority of co-infected cases were reported to be in the WHO's Africa Region and South-East Asia Region in 2014. Compared with these regions, TB and HIV are much less prevalent on the continent of Europe.[19]

In our study, we determined that HIV and TB have been brought under control in Western European countries like France, Britain, Germany, Spain and Italy.

However, in Central European countries like Hungary, Poland and Turkey, TB is under control, whereas HIV is out of control. In Ukraine, which represents the Eastern European countries, both infections are out of control. When an assessment is made in terms of factors that affect bringing HIV under control, it is striking that there are significant epidemiological differences between countries.

When HIV is examined in general, while a significant portion of new cases in Western European countries consists of the male sex with men (MSM)

group, the intravenous drug use (IDU) group occupies first place in Eastern Europe. In Turkey, which is classed as a Central European country, the MSM group is steadily increasing among new cases.[22-25] The MSM group is very important in terms of HIV risk.[26] However, in Turkey the IDU group makes up a smaller proportion.

The success of programmes aimed at preventing HIV infection especially among intravenous drug users can also explain the differences among countries.

Another important factor is the differences regarding the HIV treatment cascade. HIV treatment cascade also calls the HIV care continuum is a frame of models of the HIV care process.[27] While the rate of patients diagnosed ranges between 82-88% in Western European countries like Spain, France, Italy, Germany and Britain, the rate is determined to be between 57% and 87% in Central European countries like Poland and Hungary.[28]

In Turkey, however, this rate was determined as 41% in a cohort consisting of 3,242 patients, while this rate was determined to be 60% in Ukraine.[29,30]

Regarding rates of access to antiretroviral therapy (ART), this was seen to be 88-96% in Western European countries and 63% and 53% in Poland and Hungary, respectively.[27] This rate was 88% in Turkey.[30]

In terms of rates of viral suppression in patients receiving ART, significant differences also exist, with higher rates in Western European countries.[28]

For diagnosis of HIV, differences between countries in using European Centre for Disease Prevention and Control guidelines for creating an HIV testing policy were determined.[31]

Another important factor affecting countries' programmes for controlling TB and HIV was the migrants and refugees coming to Europe especially from Syria, Iraq, Afghanistan, Eritrea and Somalia. Since prevalence of HIV is generally low in those countries, HIV control programmes in Europe might not have been considerably affected. On the other hand, another striking feature is that 35% of new HIV infections in Europe consisted of immigrants.[32]

CONCLUSION

In conclusion, we have shown with the SPC method in our study that especially in Central and Eastern Europe, HIV infection is not under control. Therefore, epidemiological and HIV cascade programme results and primary prevention policies among Western European countries where HIV infection is under control and countries where it is not under control should be examined in detail and the necessary policies should be created. Secondary prevention policies that depend only on ART should not be relied upon alone.

Authorship Contributions

Idea/Concept: İlker Ercan; Design: İlker Ercan, Özlem Toluk; Control/Supervision: İlker Ercan; Data Collection and/or Processing: Özlem Toluk; Analysis and/or Interpretation: İlker Ercan, Halis Akalın, Özlem Toluk; Literature Review: Halis Akalın, Özlem Toluk; Writing the Article: Özlem Toluk; Critical Review: İlker Ercan, Halis Akalın.

REFERENCES

1. Zhang J, Qiu P, Chen X. Statistical monitoring-based alarming systems in modeling the AIDS epidemic in the United States, 1985-2011. Curr HIV Res. 2016;14(2):130-7.[Crossref] [PubMed]

2. Thor J, Lundberg J, Ask J, Olsson J, Carli C, Härenstam KP, et al. Application of statistical process control in healthcare improvement: systematic review. Qual Saf Health Care. 2007;16(5):387-99.[Crossref] [PubMed] [PMC]

3. Karkalousos P, Evangelopoulos A. The history of statistical quality control in clinical chemistry and haematology (1950-2010). International Journal of Biomedical Laboratory Science (IJBLS). 2015;4(1):1-11.[Link]

4. Stapenhurst T. Part 1: Statistical process control (SPC). Mastering Statistical Process Control: A Handbook for Performance Improvement Using Cases. 1st ed. Oxford: Elsevier Butterworth-Heinemann; 2005. p.415. [Link]

5. UNAIDS. Reference reports UNAIDS data 2017.(accessed 18.07.2019). [Link]

6. Gokengin D, Oprea C, Begovac J, Horban A, Zeka AN, Sedlacek D, et al. HIV care in Central and Eastern Europe: How close are we to the target? Int J Infect Dis. 2018;70:121-30.[Crossref] [PubMed]

7. Matteelli A, Rendon A, Tiberi S, Al-Abri S, Voniatis C, Carvalho ACC, et al. Tuberculosis elimination: where are we now? Eur Respir Rev. 2018;27(148):180035. [Crossref] [PubMed]

8. Tavares AM, Fronteira I, Couto I, Machado D, Viveiros M, Abecasis AB, et al. HIV and tuberculosis co-infection among migrants in Europe: a systematic review on the prevalence, incidence and mortality. PLoS One. 2017; 12(9):e0185526.[Crossref] [PubMed] [PMC]

9. Shivakoti R, Sharma D, Mamoon G, Pham K. Association of HIV infection with extrapulmonary tuberculosis: a systematic review. Infection. 2017;45(1):11-21.[Crossref] [PubMed] [PMC]

10. OECD [Internet]. © Organisation for EconomicCo-operation and Development [cited 4 January 2019]. Available from: [Link]

11. World Health Organization Regional Office for

Europe. European Health Information Gateway, Health for All Explorer. "Rate of new HIV diagnoses." 2018. Available at (accessed 30.03.2018). [Link]

12. World Health Organization Regional Office for Europe. European Health Information Gateway, Health for All Explorer. "Incidence of tuberculosis." 2018. Available at(accessed 30.03.2018) [Link]

13. UNAIDS. People living with HIV receiving art (#) (as of 30 June). 2018. Available at (accessed 02.05.2018). [Link]

14. World Health Organization Regional Office for Europe. European Health Information Gateway, Health for All Explorer. "Mid-year population." 2018. Available at (accessed 01.08.2018). [Link]

15. Jones G, Govindaraju K. A graphical method for checking attribute control chart assumptions. Quality Engineering. 2001;13(1):19-26. [Crossref]

16. European Centre for Disease Prevention and Control/WHO Regional Office for Europe. Tuberculosis surveillance and monitoring in Europe 2018-2016 data. Stockholm: European Centre for Disease Prevention and Control; 2018 .[Link]

17. Korzeniewska-Koseła M. Tuberculosis in Poland in 2016. Przegl Epidemiol. 2018;72(2): 189-205. [PubMed]

18. Benneyan JC. The design, selection, and performance of statistical control charts for healthcare process improvement. Int J Six Sigma and Competitive Advantage. 2008;4(3): 209-39.[Crossref]

19. van der Werf MJ, Ködmön C, Zucs P, Hollo V, Amato-Gauci AJ, Pharris A. Tuberculosis and HIV coinfection in Europe: looking at one reality from two angles. AIDS. 2016;30(18): 2845-53. [Crossref] [PubMed] [PMC]

20. World Health Organization Regional Office for Europe [Internet]. © 2019 WHO [cited 3 May 2019]. HIV/AIDS. Available from: [Link]

21. World Health Organization Regional Office for Europe [Internet]. © 2019 WHO [cited 2 May 2019]. TB/HIV co-infections up 40% across Europe over the last five years. 2017. Available from: [Link]

22. Nakagawa F, Phillips AN, Lundgren JD. Update on HIV in Western Europe. Curr HIV/AIDS Rep. 2014;11(2):177-85.[Crossref] [PubMed] [PMC]

23. Bailey H, Turkova A, Thorne C. Syphilis, hepatitis C and HIV in Eastern Europe. Curr Opin Infect Dis. 2017;30(1):93-100.[Crossref] [PubMed]

24. Põder A, Haldre M. HIV in Europe. Clin Dermatol. 2014;32(2):282-5.[Crossref] [PubMed]

25. Gökengin D. Türkiye'de HIV infeksiyonu: hedefe ne kadar yakınız? [HIV infection in Turkey: how close are we to the target?]. Klimik Journal. 2018;31(1):4-10.[Crossref]

26. Sargin F, Goktas S. HIV prevalence among men who have sex with men in Istanbul. Int J Infect Dis. 2017;54:58-61.[Crossref] [PubMed]

27. Kay ES, Batey DS, Mugavero MJ. The HIV treatment cascade and care continuum: updates, goals, and recommendations for the future. AIDS Res Ther. 2016;13:35.[Crossref] [PubMed] [PMC]

28. Porter K, Gourlay A, Attawell K, Hales D, Supervie V, Touloumi G, et al; ECDC Dublin Declaration Monitoring Network. Substantial heterogeneity in progress toward reaching the 90-90-90 HIV target in the WHO European Region. J Acquir Immune Defic Syndr. 2018;79(1):28-37.[Crossref] [PubMed] [PMC]

29. Drew RS, Rice B, Rüütel K, Delpech V, Attawell KA, Hales DK, et al. HIV continuum of care in Europe and Central Asia. HIV Med. 2017;18(7):490-9.[Crossref] [PubMed] [PMC]

30. Gokengin D, Cimen C, Cagatay AA, Gencer S, Akalin H, Ceran N, et al. HIV cascade of care in Turkey: data from the HIV-TR cohort. HIV Medicine. 2019;20:112-3.[Link]

31. Sullivan AK, Sperle I, Raben D, Amato-Gauci AJ, Lundgren JD, Yazdanpanah Y, et al. HIV testing in Europe: Evaluating the impact, added value, relevance and usability of the European Centre for Disease Prevention and Control (ECDC)'s 2010 HIV testing guidance. Euro Surveill. 2017;22(48):17-00323.[Crossref] [PubMed] [PMC]

32. Pavli A, Maltezou H. Health problems of newly arrived migrants and refugees in Europe. J Travel Med. 2017;24(4). [Crossref] [PubMed]