

The Effects of Refugee at Traffic Accidents in Jordan

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Abstract -- Overall world, road accidents occupied the 9th cause of death for people of all ages in 2012-2016. 60% of the world's vehicles are in low- and middle-income countries but have about 93% of the world's fatalities on the roads. In this study, the traffic accident data for the period 1981- 2019 were analyzed. The traffic accidents in Jordan were increasing due to the increase in vehicles and population. The auto ownership increased from 15 in 1981 to 6.24 person/vehicle in 2019. The accidents were increasing by 1153% during the study period, resulting in fatalities and injuries. Despite the growth of the motorization level from 68 to 160.1 from 1981 to 2019, the severity rate decreasing from 0.722 to 0.119 for the same period. As a result of this study, the immigration of people (citizens and others) from out-border, had little effects on the accident development, where the refugee of other people had no effects on the development of accidents. This result emphasized that the relationships between traffic accidents and an increase in vehicle numbers are more significant than that of the population increase. The rate of casualty accidents decreases with time regardless of the growth of auto ownership, that because of the legislation change and rise in awareness culture. The traffic accident rate was analyzed considering several indexes such as the motorization and severity levels. Despite that the motorization index is increasing with time in a similar trend as the accident rate, the severity level is decreasing due to the reduction of casualty accidents, and inversely proportional to the motorization index. The motorization level (vehicles/1000 population) represents the best indicator of accident growth with both variables; vehicles and population.

Keywords -- Traffic accident, Jordan, Accidents trends, Accidents models, Safety, Refugee.

I. INTRODUCTION

I.1 The Problem of Traffic Accidents

Death and injuries resulting from road traffic crashes remain a serious problem globally, and current trends predict to continue in the nearest future. The report stated that 1.35 million person deaths in 2016, the 9th major reason for death during 2012-2016, and the major death reason for children and age less than 29 years. In general, 3% of the gross domestic product was the cost of traffic accidents in most countries. Where 60% of the world's vehicles are in low- and middle-income countries but have about 93% of the world's fatalities on the roads. Despite the increase in absolute number, the rate of road traffic accident death has remained constant at around 18 deaths per 100,000 populations over the last 15 years. And this is the same for Eastern Mediterranean countries. Overall worldwide, between 2010 and 2016 the death rates declined from 135 to 64 deaths for every 100,000 vehicles despite vehicles increased. In 2016, high-income countries have 15% population, 40% world's motor vehicles, and 7% of road traffic deaths. Middle-income countries have 76% of the population, 59% world's motor vehicles, and 80% of the death of road accidents. Only 1% of the world's motor vehicles are in low-income countries, 13% of deaths occur in these countries which have 9% of the population [1].

I.2 The Problem of Traffic Accidents

Jordan, like other developed countries in the world, has a steady increase in the number of population and vehicles. In the year 2019, the population reached 105.540 million, and the number of registered vehicles reached about 1.69,00 million vehicles, in addition to the entry of hundreds of thousand foreign vehicles to the Kingdom. 158,160 traffic accidents; of which 10431 casualty accidents resulted in 590 deaths and injuries of 16354 injuries, and a financial cost more than 310 million dinars [2].

In Jordan, during the period (1981-2019) and (2001- 2019), about 2.574 and 2.075 million accidents occurred respectively, with an average of 109 thousand accidents/year at the last one. There are many studies conducted to analyze the trends and characteristics of traffic accidents.

Al-Omari and Obaidat [3] analyzed pedestrian accidents in Irbid city- Jordan. The research resulted that 32.5% and 23.8% were fatalities and injuries of pedestrians respectively in 2010 from the whole traffic accident. During 1999 - 2001, the results showed that non-intersections were the major locations of pedestrian accidents, during normal conditions with low-speeds.

AL-Omari et al. [4] investigated the trends and characteristics of the traffic accident data in Jordan between 1998 and 2010. Therefore, the accident's data analyzed depend on the speed limit, driver age, type, weather, pavement surface, different time kinds, and severity level. The authors developed regression models to predict the number of traffic accidents and fatalities with registered vehicles/1000 population.

Al-Omari et al. [5] investigated the essential elements which will reduce traffic accidents, and may reduce the impact of accidents. The authors used the Accident Hazard Scale (AHS) to achieve the objective. The authors concluded that the most dangerous Jordanian governors were Al-Mafraq, Irbid, Amman, and Al-Zarqa. Due to time analysis, the most hazardous months were July, August, September, and June, while Fridays and Thursdays had the highest accident during the week. For the most days, the evening peak hours (2-4 PM), was the most hazardous period

I.3 The Problems and Challenges of Refugee

Very rare studies were done on the refugee problems at Jordan. All these studies concerned about the economical and social effects of refugees on the local societies. The following studies are examples of the effects of Syrian refugees (2012-2019) on Jordan and their distributions.

Stave and Hillesund (2015) reported that; "according to UNHCR, there are currently about 616,000 Syrian refugees in Jordan, of whom more than 500,000 live in Jordanian communities outside camps". This was about 10 % of the total population in Jordan before the crisis. More than 76% of Syrian refugees were lived in the northern governorates of Jordan. For example, they form about 52% of Mafraq, 12% of Irbid, and 7% of the Amman Governorates population.

A surveying study by Tiltnes et al. (2019) stated that most of the Syrian refugee population in Jordan was resident at Amman, Zarqa, Irbid, Mafraq, and the refugee camps. The average time of their living in Jordan was 4.6 years from the beginning of the crisis to the study date (11/ 2017 - 1/ 2018). In their study, the authors were taken information from 7,632 households and 40,950 individuals based on the population census in 2015. The study selected randomly 1,121 clusters (locations) outside camps and 82 clusters inside camps. They found that 48 % of refugees were below 15 years. The results showed that the major household income during a year was wage income (61%) then 14% as private transfer income. The yearly household income was around JD 3000 for large three governorates, and about JD 2000 for other governorates and who were in the camps. About the education; 15% of adults aged 20 and above have achieved a secondary or post-secondary degree. Another 24 % have completed basic education. 26% did not complete elementary school.

The Syrian refugees were come to Jordan during many years, the following are the percentage distribution for a sample (n= 41,228): 3% at 2011, 22% at 2012, 40% at 2013, 11% at 2014, 2% at 2015, 2% at 2016, 0% at 2017, and 19% borne in Jordan. In the same surveying with (n=40,993), the authors concluded that 81% of the refugees come from Syria to Jordan after 15 /3/ 2011, with 15% of them were children.

Simpson and Abo Zayed (2019) reported that at the beginning of the Syrian conflict in 2012, 200,000 people were residents at the Za'atari refugee camp in Jordan. A 547,000 out of a total of 673,000 Syrians in Jordan, live outside of camps, and that the majority roughly 471,000 live outside of Amman Governorate, while in Irbid, Mafraq, and other non-capital cities. They found that for the period 2012–2015; the outbreak of the Syrian civil war brought around 400,000 refugees to Irbid. After 2015 to 2019; the closing of Jordan's border with Syria slowed the growth rate of Irbid's refugee. Since March 2013, the number of refugees in camps has declined, and the number in cities has doubled. They reported that Jordanians widely blame Syrian refugees for increased traffic congestion, but this issue seems more to do with an increase in population density, a lack of central planning for the road network, and a rapid increase in Jordanian car ownership rates since the 1990s. Some Syrians own cars that they drove across the border from Syria. Among lower-income Syrians, carpooling in someone's van is the most efficient way of getting around.

The report published by West Asia-North Africa Institute (2019); stated that; "in 2016, there were approximately 361,000 working-age Syrians in Jordan, 55% of whom (110,500) were thought to be employed and 85,900 in search of work". They distributed as 40% at business services, 28% at construction, 14% at wholesale and retail trade, and 11% at agriculture. By mid- 2014, the World Food Programmer's introduced assistance to around 500,000 Syrian refugees.

II. OBJECTIVES

The following are the objectives of this research:

- 1- To investigate the effects of refugees at traffic accident trends in Jordan.
- 2- To develop a model that predicts traffic accidents due to refugee

III. DATA RESOURCES

The development of the population was taken from the reports published by the Jordanian Department of Statistics [8]. The traffic accident data obtained from the yearly reports published by the Jordanian Traffic Institute [2]. The information about the refugees collected from different resources. There was no data published about the Jordanian return back from Kuwait in 1990 and 1991, therefore it was estimated from the analysis of the traditional formal data. The same procedure was followed for the Iraqi people refuge in 2003 and 2004. The data about the Syrian people and refugees who entered Jordan were collected from different resources, then analyzed and adjusted the formal traditional data.

III.1 Syrian Refugees Statistics

The UNHCR in its report (11/12/2012) stated that there are currently 14 camps in Turkey, 3 in Iraq, and 3 in Jordan. The reports mentioned the most recent statistics for the number of Syrian refugees registered or under registration in each country, amounting to 154,387 refugees in Lebanon, 142,664 refugees in Jordan, 136,319 refugees in Turkey, 64,449 refugees in Iraq, and 11,740 refugees in North African countries. Jordan, for example, estimates that there are about 100,000 refugees who have not yet registered.

Yarmouk Water Company stated that in 2015: the population of Al-Mafraq Governorate reached 313,700, including 95,000 refugees in the Za'atari camp and 150,000 refugees outside the camp in the cities and villages of the governorate. Al-Rai Newspaper wrote that Jordan hosts the highest percentage of refugees compared to the population at end of 2018 = 673400

A report by Al-Rai (Jordanian newspaper) published in 5/3/2019 mentioned that the United Nations High Commissioner for Refugees (UNHCR) revealed through its updated data on 13/1/2019 that the number of Syrian refugees in the Kingdom has reached about 671,550 refugees. Where the Syrian refugees located in Amman governorate with number 197080 refugees (29.4%), then the governorate of Mafraq with 164020 refugees (24.4%) from the total number in Jordan, and the governorate of Irbid with 140640 refugees (21%), where Zarqa Governorate with 96950 refugees (14.4%).

A report by Al-Arabi Aljadeed in 12/26/2019 states that the High Commissioner for Refugees in Jordan announced that 30 thousand Syrian refugees returned to their homes voluntarily from Jordan in 2019. The number of refugees registered in Jordan has now reached 744795 refugees, including about 655000 Syrians and 67000 Iraqis, 15000 Yemenis, 6000 Sudanese, and 2500 refugees out of a total of 52 other nationalities registered with UNHCR. 83% of refugees are outside refugee camps in urban areas. The total work permits issued to Syrian refugees in Jordan currently about 165,000, representing 45% of the total refugee population of working age

In a study of refugee distribution in the governorate of Irbid for Greater Irbid Municipality in 2016, the percent's were varying from 6% to 37%. Most Syrian refugees were lived in Irbid city with 120350 people that increased the whole people in the city to more than 450 thousand. About 200 thousand Syrian refugees were added to 684 thousand Jordanian people in the Greater Irbid Municipality to reach more than 1 million people lived in this area. The people of this municipality increased by 600 thousand (67%) for 5 years.

A report by Alrabia net (Arabian TV) published on 17/9/2019 mentioned that about 153,000 Syrian people, of whom about 33,000 are refugees (registered with the United Nations) as refugees) were left Jordan's Border when it opened on October 2018 [18].

Human Rights Watch report published in 2020 stated that according to the UNHCR, Jordan also hosted some refugees from other countries during 2019, including 67,500 Iraqis, 14,600 Yemenis, 6,100 Sudanese, and 1,700 from other countries [19].

IV. DATA ANALYSIS

IV.1 Population Development

The population increased in Jordan gradually as many countries over the years. The Department of Statistics reported that in 1980 the population was 2.233 million, and increased up to 3.11 million in 1989. At the First Gulf War in Kuwait in 1990, many Jordanian and Palestinian peoples came back to Jordan, therefore the people were suddenly increased to 3.453 million, and reached to 5.329 million in 2002. At Second Gulf War in Iraq in 2003, many Iraqi people and few Jordanian and Palestinian people came back to Jordan, therefore the people were suddenly increased to 5.480 million. After that, many Iraqi people departed to other countries. The population increased gradually up to 6.249 million in the end of 2011. In the beginning of 2012, many Syrian refugees entered Jordan during 4 years until the population reached to 9.798 million at the end of 2016, and the population increased gradually despite of departed some of the them to other countries until reach to 10.309 and 10.554 millions in the end of 2018 and 2019 respectively.

These increases during the periods from 1980 to 2019 were illustrated in Fig. 1a, which are rising gradually according to time with little variation. Table 1 shows the relations of increasing by the equations and their R^2 values, where Y_1 : population, and x : year.

TABLE 1 Relations and R² for Trend Lines of Population with Time Periods.

Years Periods	Population Trends			
	1981 -1989	1981 - 2002	1981 - 2011	1981 -2019
	$Y_1 = 937.57x + 22196$	$Y_1 = 1535.4x + 19816$	$Y_1 = 1377.4x + 21270$	$Y_1 = 23001e^{0.0374x}$
	$R^2 = 0.9915$	$R^2 = 0.9823$	$R^2 = 0.9836$	$R^2 = 0.9682$

To study the effects of a sudden increased in population due to the issues that happened, the period must be divided into sub-period depending on the refugee's accidents during this period (1981-2019). Fig. 1b illustrates these periods; the first period (1981-1989) seems to increase gradually with an average of 90 thousand per year by a percentage of 3.8%. The equation represents this increasing with $R^2 = 9915$ as follows:

$$Y_2 = 937.57x + 22196 \tag{1}$$

During the periods 1990 to 2002, Fig. 1b seems to increase gradually with an average of 125 thousand per year by a percentage of 6.7% in the first year, then by 3.8% until reduced to 2.4% in 2002. The equation represents this increasing with $R^2 = 0.9814$ as follows:

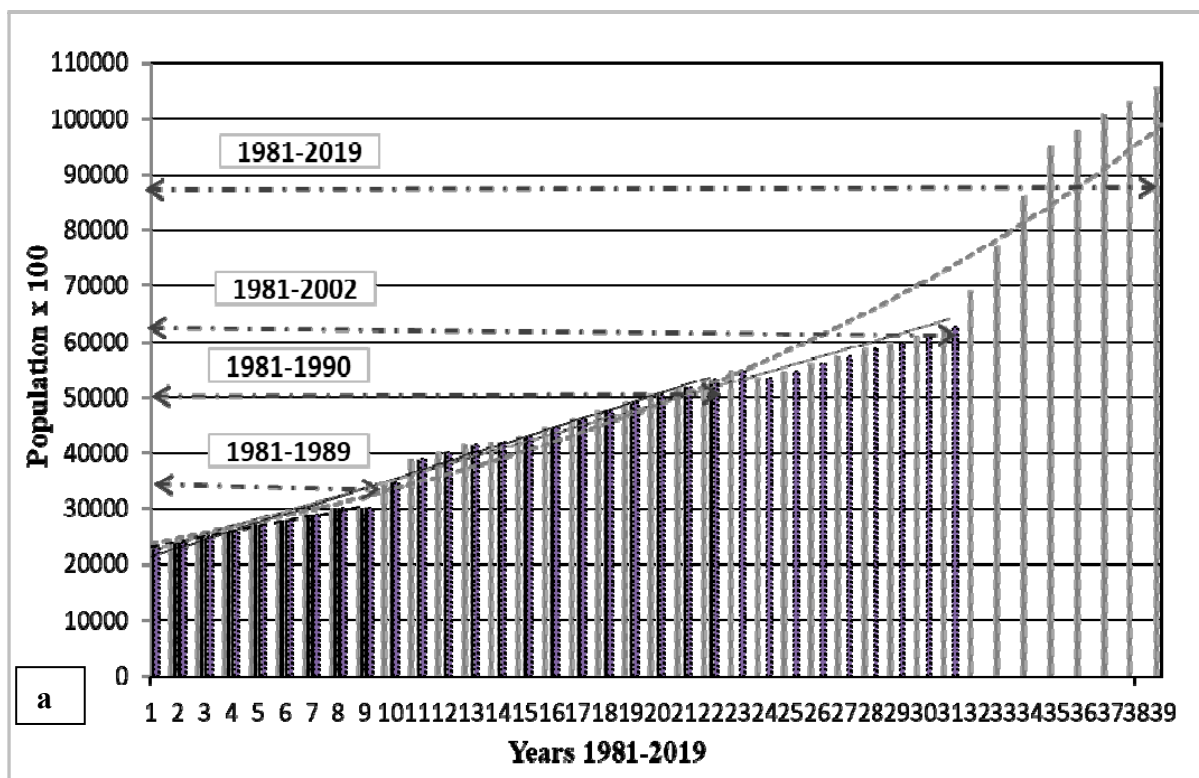
$$Y_2 = 1401.1x + 34996 \tag{2}$$

During the periods 2003 to 2011, Fig. 1b shows the increasing gradually with an average of 196 thousand per year by a percentage of 7% in the first year, then 3.0% until reached 3.2% in 2010 and 4.4% in 2011. The equation represents this increasing with $R^2 = 0.9438$ as follows:

$$Y_2 = 1104.8x + 52051 \tag{3}$$

During the periods 2012 to 2015, Fig. 1b shows the increasing rapidly with an average of 816 thousand per year. Not all the Syrian people have entered Jordan as refugees especially when the borders were opened officially in 2012 until early of 2014. Therefore, no formal posted data about the number of Syrian people who entered Jordan officially. The refugees entered Jordan across unofficial points. From 2016 to 2019 the population increased by 260 thousand per year until it reached 10.544 million in 2019. During 2018 and 2019 few hundred thousands of Syrian people and refugees went back to Syria (less than 200 thousand) and more than this immigrated to other countries. Other refugees came to Jordan during these years; in 2019 more than 90 thousand were registered. The equation represents this increasing with $R^2 = 0.9922$ as follows:

$$Y_2 = -733.75x^2 + 11755x + 57599 \tag{4}$$



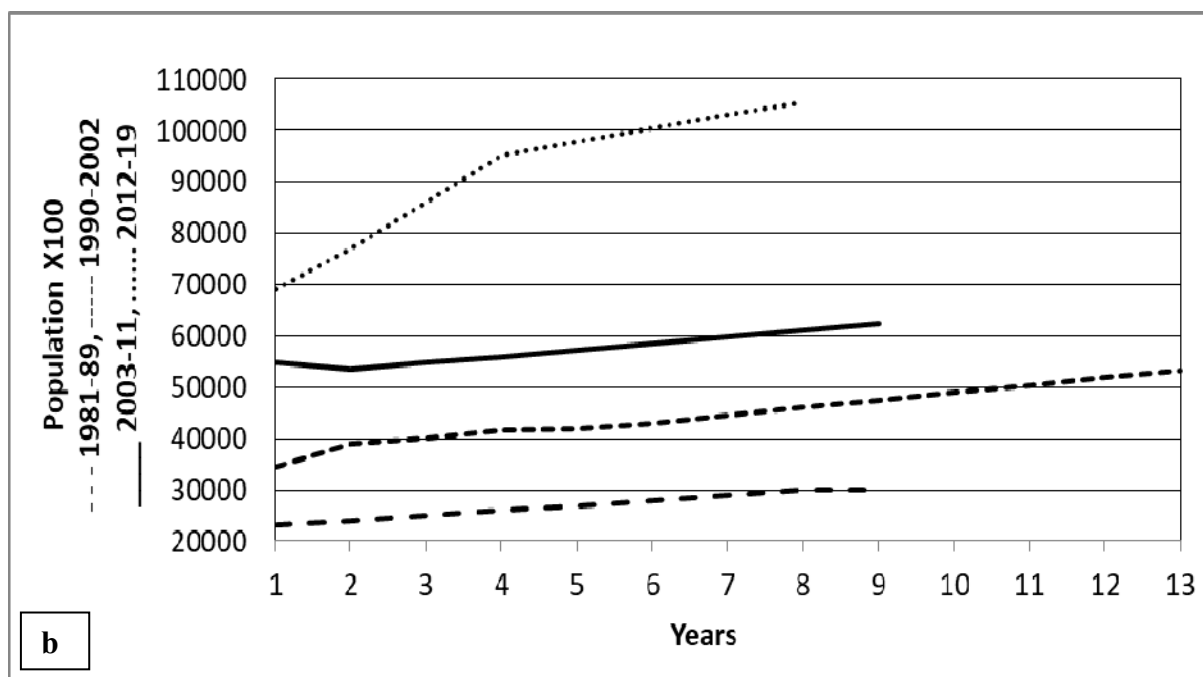


Fig. 1. Development of population with year's periods.

IV.2. Vehicles Development

The number of vehicles increasing with time in Jordan. In general, the ratio of persons per vehicle is decreasing with time. Despite this, there were some sudden increased due to forced migration from outsiders, that were happened during the study periods of this research: in 1990 from Kuwait, in 2003 from Iraq, and the latest was from Syria 2012 to 2016.

The ratios between the numbers of vehicles to the population were calculated. It was found that 58 person/vehicle in 1971, then decreased to 15 (1981), 12 (1986), 5.7 (2011), 6.5 (2016), and 6.24 person/vehicle in 2019. Fig. 2a shows the trend of this relationship. The auto ownership (Y_3) person/ vehicle could be represented by Equation (5) as a function of time (year) with $R^2 = 0.934$ as follows:

$$Y_3 = 47.837X^{-0.851} \tag{5}$$

The number of registered vehicles was increasing as shown in Fig. 2b from 156924 vehicles in 1981 until reached to 169000 in 2019. The Motorization Index which is the vehicle number /1000 people gives an indicator for this ratio. Fig. 3a shows the trend of this relationship, it could be represented by the equation with $R^2 = 0.8228$ as follows:

$$MI = 0.0671x^2 + 0.3562x + 68.956 \tag{6}$$

The first period was (1980-1989). Fig. 2b seems to increase gradually with an average of 10 thousand per year with a percentage of 4.2%. The equation represents the registered vehicles (Y_3) with $R^2 = 0.9899$ as follows:

$$Y_3 = -124.85x^2 + 2451x + 13374 \tag{7}$$

During the period (1990 to 2002), Fig. 2b seems to increase gradually with an average of 10.7 and 26.4 thousand per year for 1990-1994 and 1995-2002 respectively. The vehicles that brought by the people who were come from Kuwait in 1990 and 1991 were registered later after the Government introduced some facilities for their owners. There was no formal posted data about this number of vehicles, but it could be estimated by the increase over the normal growth during that period. Therefore about 9 thousand for each year of 1990 and 1991 were the additional increase in the vehicles due to the immigration of Jordanian citizens and others from Kuwait. The equation represents the registered vehicles (Y_3) with $R^2 = 0.9962$ as follows:

$$Y_3 = 166.09x^2 + 71.333x + 25548 \tag{8}$$

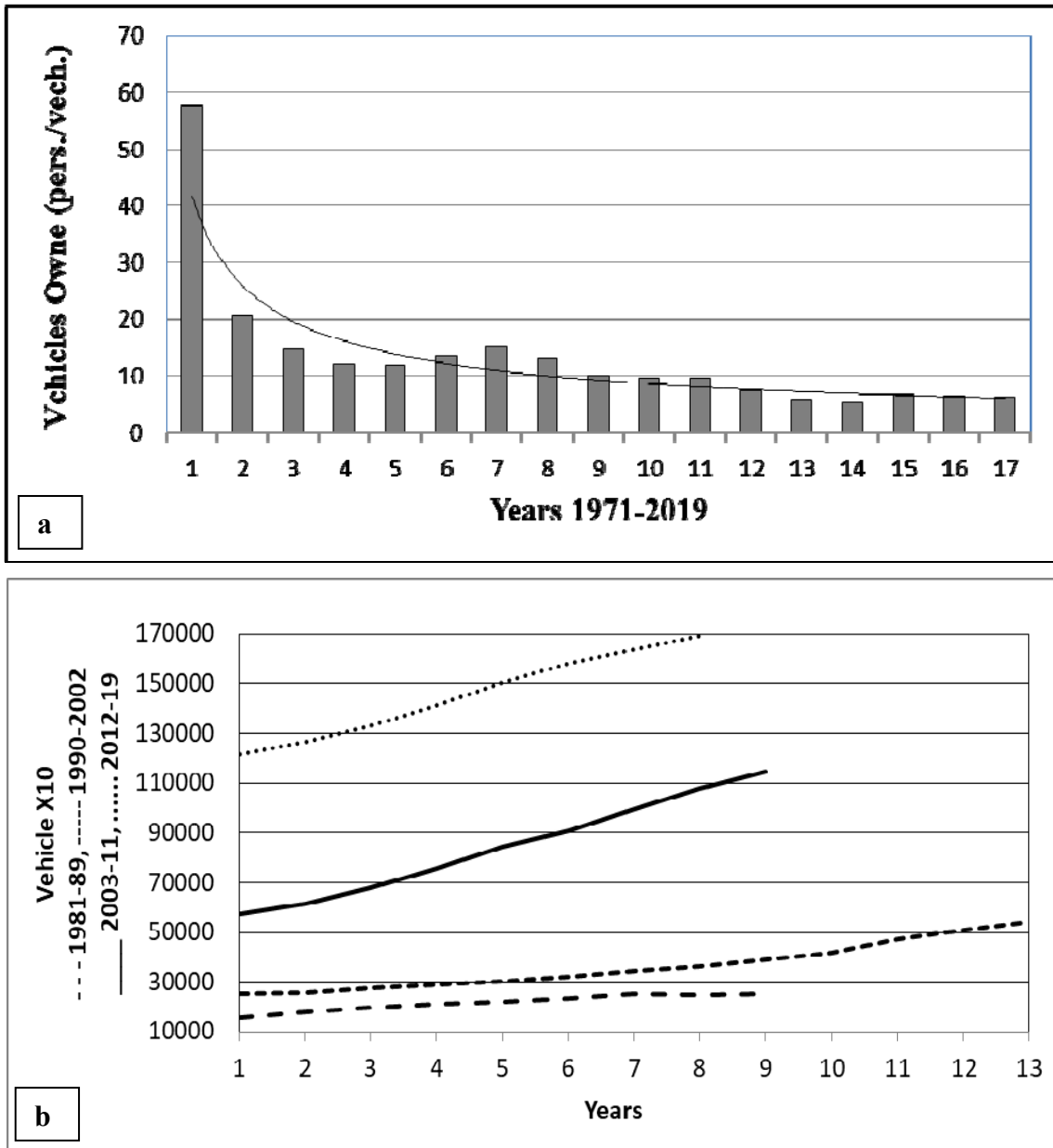


Fig. 2b. Development of vehicle number with years periods.

During the periods 2003 to 2011, Fig. 2b seems to increase gradually with an average of 67.2 thousand per year by a percentage of 8%. There was no formal posted data about the number of vehicles brought by Iraqi refugees and a few of Jordanian people, that because most of them were not registered later as Jordanian vehicles. It could be noticed by the increase in accidents over the normal growth during this period. The equation represents the registered vehicles (Y_3) with $R^2 = 0.9982$ as follows:

$$Y_3 = 158.73x^2 + 5867x + 49905 \quad (9)$$

During the periods 2012 to 2019, Fig. 2b seems to increase rapidly from 2012 to 2015 with an average of 67.8 thousand per year by a percentage of 4.8%. This seems less growth for the period 2003-2011. Not all the Syrian people have entered Jordan as refugees especially when the borders were opened officially in 2012 and early of 2013. Therefore, no formal posted data about the number of vehicles brought by Syrian people who entered Jordan officially. These vehicles were very little, and usually not registered later as Jordanian vehicles were the refugees who entered Jordan across unofficial point had not any vehicles. The equation represents the registered vehicles (Y_3) with $R^2 = 0.994$ as follows:

$$Y_3 = -55.559x^2 + 7695.6x + 112223 \quad (10)$$

IV.3. Accidents Development

The number of reported accidents was increasing as in Fig. 3a, from 13567 accidents in 1981 until reaching accidents 156569 in 2019. Some notable increase happened from 2009 to 2011, which were 122793, 140014, and 142588 accidents, then with very little until 2016. Fig. 3a shows the trend of this relationship. The accidents (Y_4) could be represented by the equation as a function of time (years) with $R^2 = 0.9579$ as follows:

$$Y_4 = 0.098x^2 + 0.5592x + 6.7495 \quad (11)$$

The first period (1981-1989) seems to increase gradually from 13567 accidents in 1981 to 18336 accidents in 1989, with an average of 0.53 thousand per year by a percentage of 3.5% as shown in Fig. 3b. The following equation represents the accident numbers (Y_4) with $R^2 = 0.6787$:

$$Y_4 = 56.79x^2 - 86.767x + 14348 \quad (12)$$

During the periods 1990 to 2002, accidents seem to increase gradually from 17838 to 52913 accidents with an average of 2.7 thousand per year by a percentage of 7.7%. A little decrease in accidents happened in 1990 due to mandatory procedures by the government which restricted the movement of the vehicles during the First Gulf War. It is noticed that the years from 1996 to 1999 have rapid growth more than other years in the same period. The equation represents the accident numbers (Y_4) with $R^2 = 0.9695$ as follows:

$$Y_4 = 27.75x^2 + 3056.1x + 12474 \quad (13)$$

During the periods 2003 to 2011 accidents seem to increase gradually from 62115 to 142588 accidents with an average of 8.9 thousand per year by a percentage of 8.1%. There was no sudden increased of accidents at the beginning of this period due to an Iraqi refugee. The equation represents the traffic accident numbers (Y_4) with $R^2 = 0.9575$ as follows:

$$Y_4 = -44.793x^2 + 10673x + 51462 \quad (14)$$

During the periods 2012 to 2019, accidents seem to increase very little from 143100 to 156569 accidents, with an average of 1.7 thousand per year with a percentage of 1.1%. The equation represents the accident numbers (Y_4) with $R^2 = 0.9488$ as follows:

$$Y_4 = 390.46x^2 - 1751.4x + 144976 \quad (15)$$

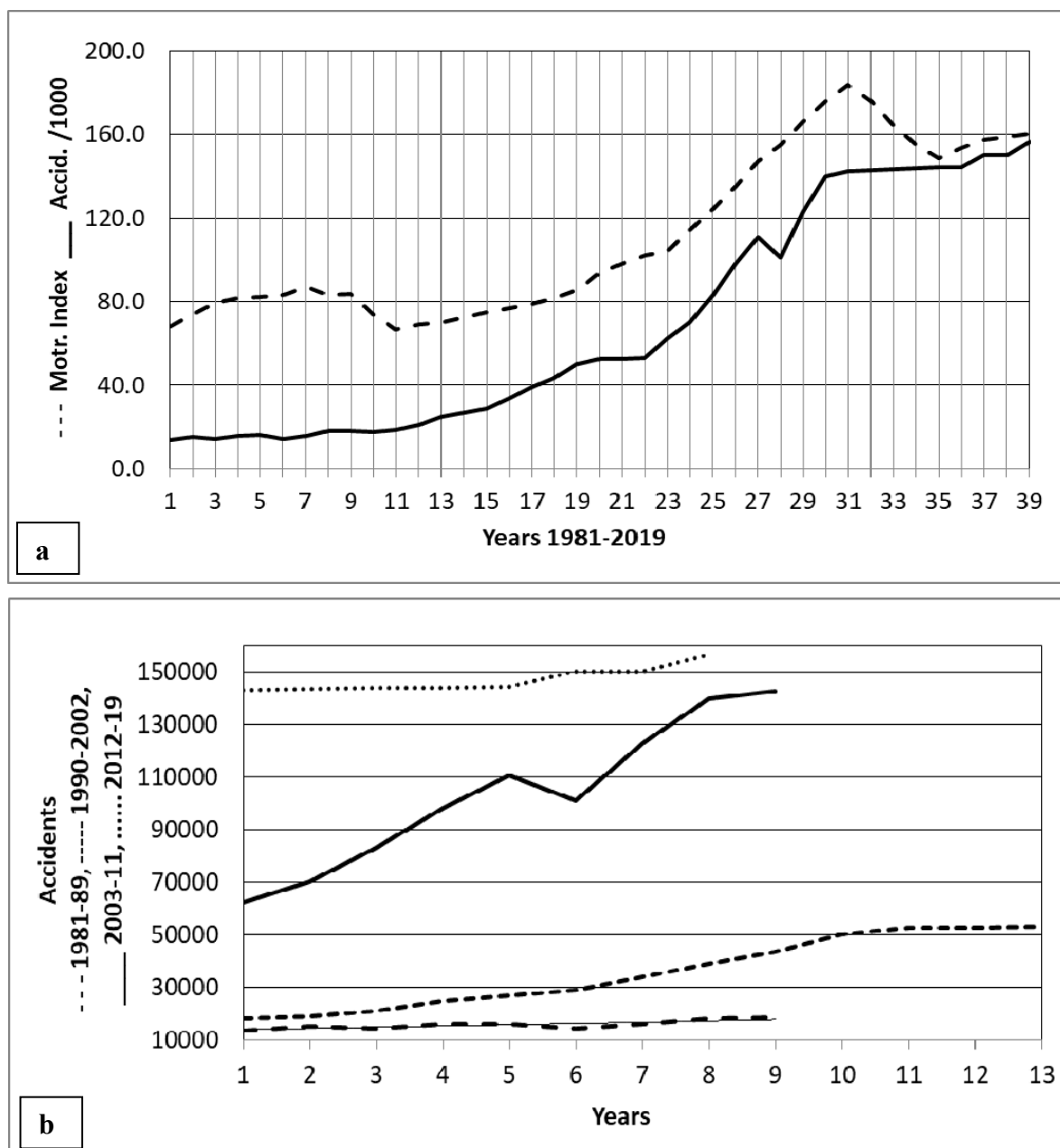


Fig. 3b. Development of accidents number with year's periods.

V. RESULTS AND DISCUSSION

To have an obvious comparison between the accidents is increasing with population and vehicles increasing each year Fig. 4a is drawn. In this figure, to get clear comparasion between the numbers: the population is divided by 100 and vehicle number is divided by 10, therefore the curves could be drawn on the same scale. In general, all factors have the same trends with time as shown in Fig. 4a. If the analysis does for each period, there are some differences in their increasing, these years' periods related to the immigration and refugee to Jordan. To accomplish the effect of two variables; population and registered vehicles together, the motorization index was considered.

During the first period (1981-1989), the growth of vehicle number increase (160%) slightly more than the population (131%), where accidents increased with a little rate (135%). The motorization index (vehicle/ 1000 population) increases from 68 to 83.5 as shown in Fig. 3a. This means that the ratio of (person/vehicle) reduced from 14.7 to 11.98 person/vehicle as shown in Fig. 2a. Another indicator of the development of the accident is the accidents/ 10^4 vehicle. Therefore for this period is reduced from 865 (1981) to 730 (1989). Table 2 includes the trend line equations for these variables and their R^2 for this period.

During the periods 1990 to 2002, a sudden increase in population due to return Jordanian people from Kuwait. The previous increase ratio was 3.3% for 1989, but it was 14.6% and 12.6% for 1990 and 1991 respectively. That means; an additional 11.3% (390 thousand) and 8.7% (338 thousand) people for each year. The growth of vehicle numbers increased by (213%), which was largely more than the population (154%), where accidents increased (297%) with a huge rate. The Motorization index (vehicle/1000 population) increases from 73.7 to 101.9 as shown in Fig. 3a. This means that the ratio of (person/vehicle) reduced from 13.56 to 9.55 person/vehicle as shown in Fig. 2a. Another indicator of the development of the accidents is the accidents/10⁴ vehicle, therefore for this period, it reduced from 730 (1989) to 701 (1990), then increased gradually to 975 (2002). Table 2 includes the trend line equations for these variables and their R² for the period. The sudden increase more than the normal increase of population in 1990 and 1991 by about 720 thousands reduced the ratio of accidents/10⁵ population from 601 (1988) and 609 (1989) to 517 (1990) and 482 (1991), then increase gradually until reached to 1016 (2001) and 993 (2002).

During the periods 2003 to 2011, a sudden increase in population due to Iraqi refugees and return few Jordanian people from Iraq. The previous increase ratio was 2.83% for 2002, but it was 9.67% and 13.1% for 2003. That means an additional 6.84% (375 thousand) for 2003. The growth of vehicle number increase by 200% and the accidents increased by 230% with a huge rate where the population with 114%. The Motorization index (vehicle/1000 population) increases from 104.3 to 183.6 as shown in Fig. 3a. This means that the ratio of (person/vehicle) reduced from 9.59 to 5.68 person/vehicle as shown in Fig. 2a. Another indicator for the development of the accidents is the accident/ 10⁴ vehicle, therefore for this period, it increased gradually from 1087 (2003) to 1243 (2011). Table 2 includes the trend line equations for these variables and their R² for this period. The sudden increase more the normal increase of the population in 2003 by about 375 thousand increased the ratio of accident/ 10⁵ population from 1133 (2003) and 2282 (2011).

During the periods 2012 to 2019, a sudden increase in population due to refugees of Syrian people from Syria. The previous increase ratio was 2.22% for 2011, and it was 9.67% and 13.1% for 2003. That means an additional 6.84% (375 thousand) for 2003. The growth of vehicle number increases 139% more than the population (165%), where accidents increased by 139% with a little rate. The Motorization index (vehicle/ 1000 population) increases from 190 (2012) to 199.5 (2014) then reduced to 148.2 (2015) and increased gradually to 160.1 (2019) as shown in Fig. X3a. This means that the ratio of (person/vehicle) reduced from 5.26 (2012) to 5.0 person /vehicle (2014), then jumped to 6.75 (2015) and reduced to 6.24 in 2019 as shown in Fig. 2a.

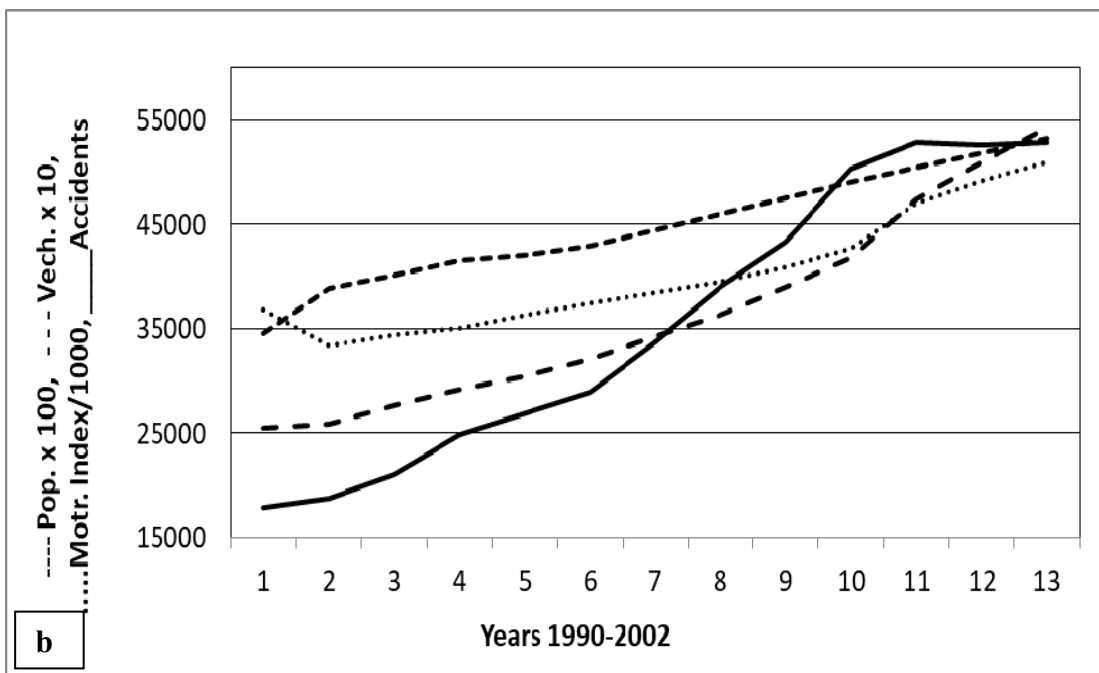
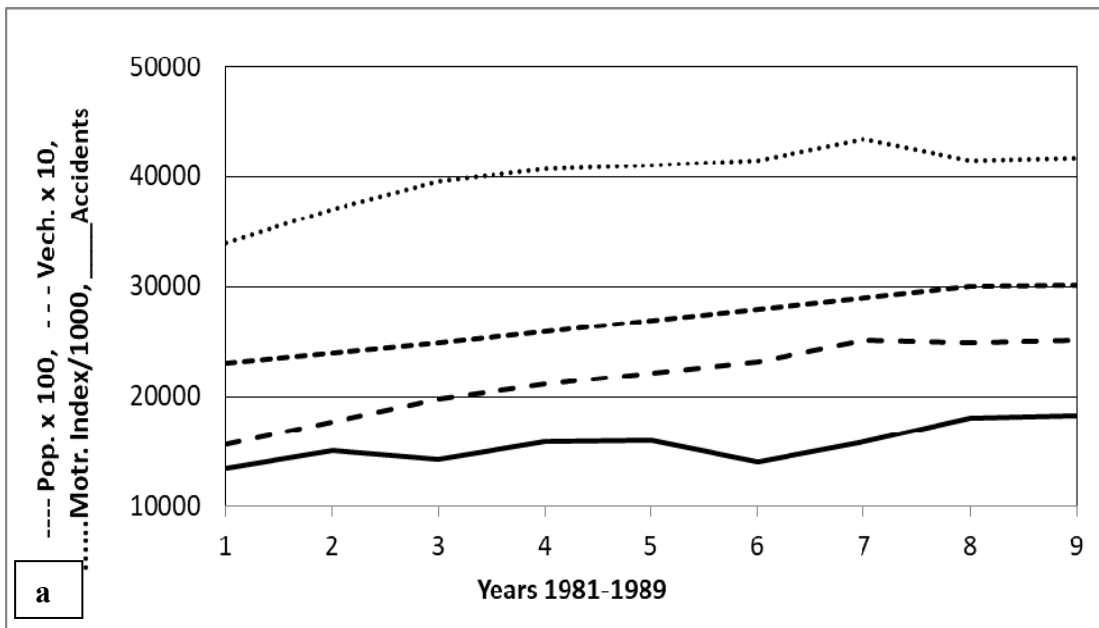
Another indicator for the development of the accidents is the accident/10⁴ vehicle, therefore for this period, it decreased from 1179 (2012) to 1021 (2015) then to 962 (2016) and slowly decreased to 926 in 2019. Table 2 includes the trend line equations for these variables and their R² for this period. The sudden increase more than the normal increase of population in 2015 by about 2,856 thousand (143%) resulted in decreasing the ratio of accident/ 10⁵ population from 2282 (2011) to 2074 (2012) to 1516 (2015) and 1484 (2019).

In general, the motorization index is the most suitable to represent the development of accidents during the whole period. It is very flexible to vary with time to be in the same trends as accidents varying. This means that in normal conditions, the development of the population and the number of registered vehicles is in the same trend which increasing. Any sudden increase in population due to immigration and refugee will be reflected in the motorization index. Fig. 3a shows this principle.

Another analysis for the development of the accident rate is to have both factors as accident /10⁴ vehicles and accident/10⁵ populations. Fig. 5 shows these with years according to the study period. It seems that the accident/10⁴ vehicle show higher value than the accident /10⁵ population from 1981 until 2002, then the inflection point occurred, that is the accident numbers were increased with few hundreds over 52000 during the years 2000, 2001, and 2002, and the registered vehicle had the same ratio of increasing, then sudden increased by ten thousand in 2003. Another factor that affected the development of accidents is that a sudden high increase in fuel prices occurred in 2008, that reduced usage of a private car, led to fewer traffic accidents, which were decreased to 1728 /100000 population and 1116 /10000 vehicle The severity rate could be used to assess the general danger of accidents as shown in Fig. 6a. Equations (16) represent these models with highly R² = 0.9249 which is more suitable to predict future cases.

$$SR = 1.0113e^{-0.057x} \quad (16)$$

Overall world, this trend is going down in most countries, that is, despite the growth of population and auto ownership which means the ratio of dangerous goes down.



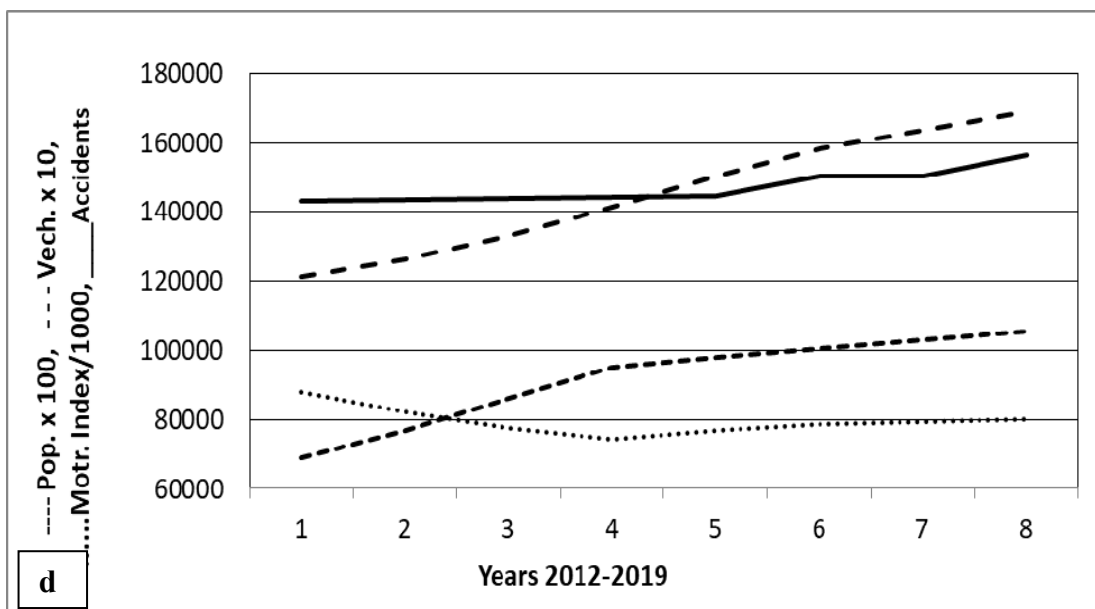
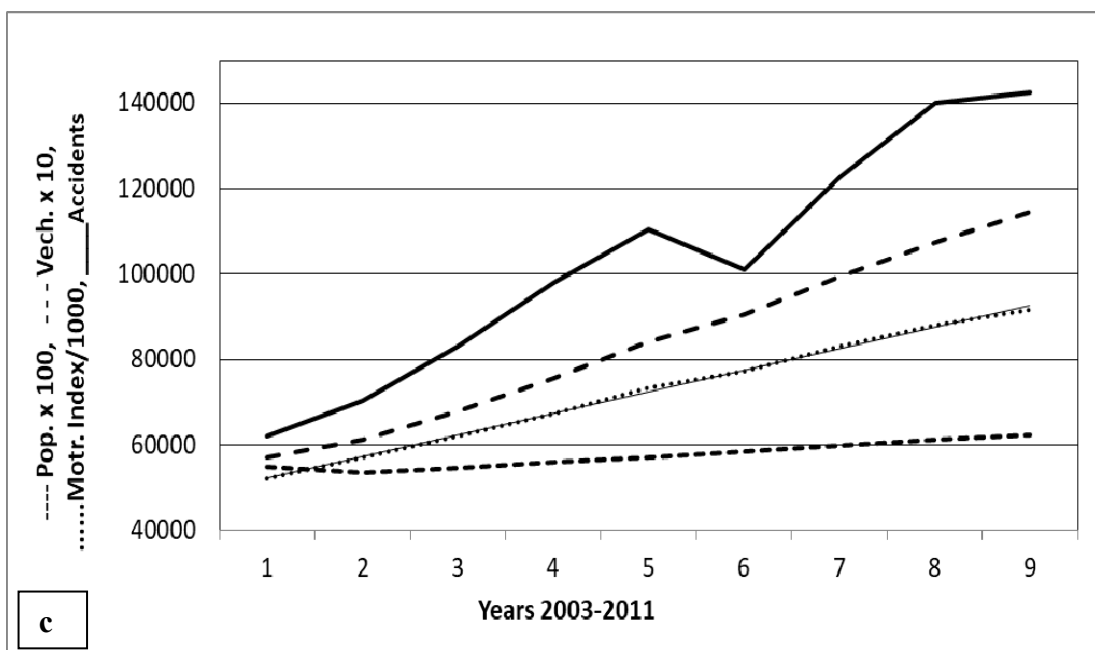


Fig. 4. Development of population, vehicles, accidents, and motorization index with year's period.

In this study, it was decreased from 0.72 (1981) to 0.59 (1989), then jump to 0.67 (1990), this because the accident was reduced from 18336 (1989) to 17838 (1990), while the numbers of human injuries and death were increased from 10816 (1989) to 11932 (1990). In general, it went down according the years: from 0.67 (1990), 0.38 (2002), 0.36 (2003), 0.14 (2011, 2012), until reached 0.12 (2018, 2019). This decreasing rate because the numbers of human injuries and death accidents were reduced as numbers because for development in drivers behaviors depend on law and awareness, and as ratios to total accident numbers which increased with small rate too. For example, the human injury and death accidents to total accidents were respectively as follows: 19911:52913 (2002), 22172:62115 (2003), 20645:142588 (2011), 19688:143100 (2012), and 18591:156569 (2019).

TABLE 2 Relations and R² for trend lines for population, vehicles, accidents, and motorization index with year's periods.

Factors	Years Periods			
	1980 -1989	1990 - 2002	2003 - 2011	2012 -2019
Population	$Y_2 = -21.152x^2 + 1149.1x + 21808$	$Y_2 = -7.6389x^2 + 1508x + 34729$	$Y_2 = 85.703x^2 + 247.8x + 53623$	$Y_2 = -733.75x^2 + 11755x + 57599$
	R ² = 0.9941	R ² = 0.9817	R ² = 0.9729	R ² = 0.9922
Vehicles	$Y_3 = -124.85x^2 + 2451x + 13374$	$Y_3 = 166.09x^2 + 71.333x + 25548$	$Y_3 = -53.268x^2 + 5581.3x + 46315$	$Y_3 = 115428 e^{0.0499x}$
	R ² = 0.9899	R ² = 0.9962	R ² = 0.9989	R ² = 0.9911
Accidents	$Y_4 = 56.79x^2 - 86.767x + 14348$	$Y_4 = 27.75x^2 + 3056.1x + 12474$	$Y_4 = 158.73x^2 + 5867x + 49905$	$Y_4 = 390.46x^2 - 1751.4x + 144976$
	R ² = 0.6787	R ² = 0.9695	R ² = 0.9982	R ² = 0.9488
Motorization Index	$MI_1 = -233.6x^2 + 3218x + 31409$	$MI_1 = 150.99x^2 - 751.99x + 35916$	$MI_1 = -44.793x^2 + 10673x + 51462$	$MI_1 = 681.52x^2 - 6874x + 93127$
	R ² = 0.9544	R ² = 0.9766	R ² = 0.9575	R ² = 0.8502

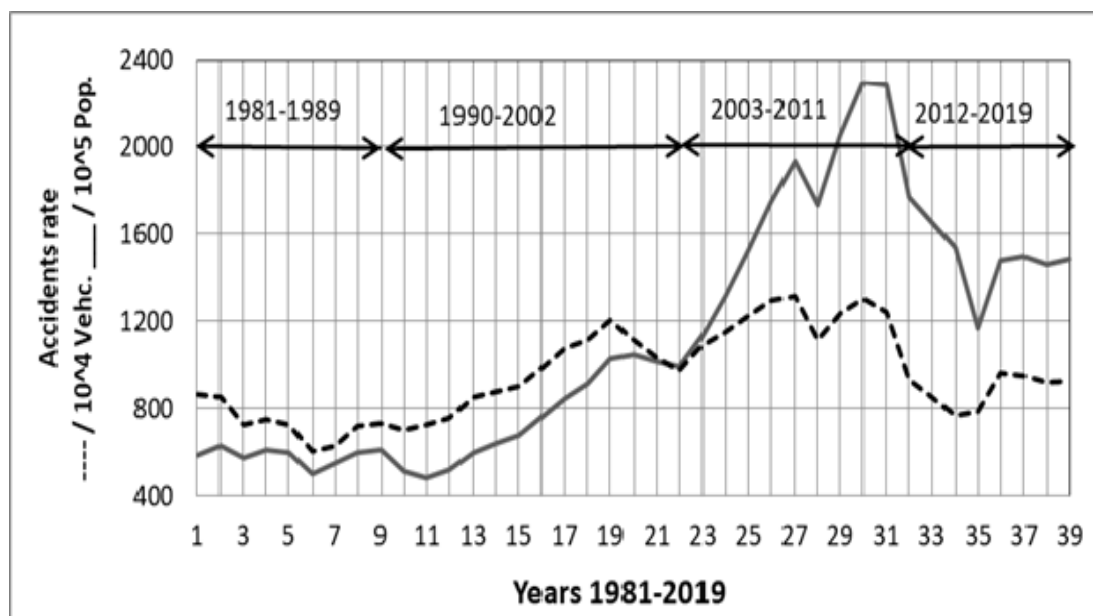


Fig. 5. Development of accidents rate /10000 vehicles and /100000 population with years.

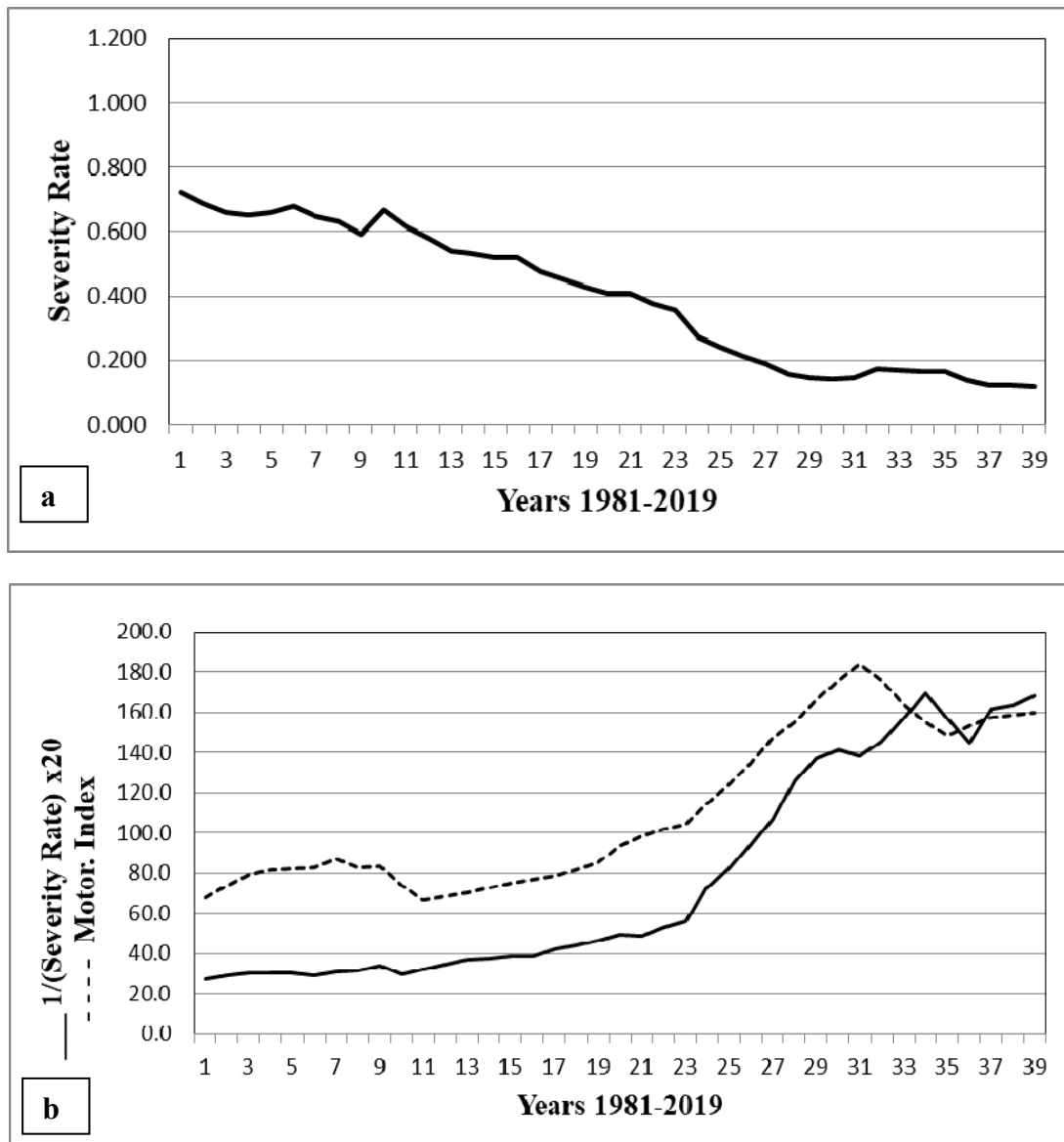


Fig. 6. (a) Severity rate by years, (b) Severity rate with Motorization index by years.

VI. CONCLUSIONS

The following conclusions can result from this study:

1. The population is growing at a normal rate, and going slow with time (3.8% in the 1980s to 2.3% in the 2010s).
2. Few sudden increasing occurred as results of immigration from outside;
 - i - In 1990 and 1991 due to the First Gulf War, hundreds of thousands of Jordanian and Palestinian people had come from Kuwait, some of them with their vehicles. Despite of this, the accidents did not show a significant sudden increase.
 - ii - In 2003 due to the Second Gulf War, hundreds of thousands of Iraqi and tens of thousands of Jordanian people had come from Iraq, few of them with their vehicles. The accidents showed little suddenly increase. This period showed significantly increased compared with other periods
 - iii - From 2012 to 2015, more than two million Syrian and other Arab people were refugees to Jordan due to the war in their countries; none of them brought their vehicles. Despite of this, the accidents did not show any sudden increase. This period showed the lowest increase compared with other periods.
2. The accident development rate depends on registered vehicles' growth more than population growth. Where the rate of (accident /10000 vehicles) increased with years by some oscillator until 2012. After this. The rate suddenly decreased due to refugees, then decreasing with a little rate.
3. During the study period (1981-2019), traffic accidents increased by 1153% mainly as a result of auto ownership increasing as a major factor, and with a population growth as a minor factor.
4. The number of accidents/100,000 population and the number of accidents/10,000 registered vehicles showed increasing trends: 588: 865 in 1981 to 2290: 1302 in 2010, then reduced to 1484: 926 in 2019 respectively.
5. The motorization level (registered vehicles/1000 population) represents the best indicator of accident growth with both variables; vehicles and population.
6. The immigration of citizens from out-border had a little effect on accident growth, while the refugees had not any significant effects on accidents. This emphasisd that the accidents depend on vehicles increasing more than the population increasing.
7. The severity level decreased over the study period from 0.722 (1981) to 0.119 (2019).
8. The severity level inversely proportional with motorization index,

DECLARATIONS OF INTEREST

None

DATA AVAILABILITY

The data that support the findings of this study are available from the corresponding author upon reasonable request.

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