Correlation Analysis of the Terrorist Attacks and Social Attributes in The Gulf States

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ABSTRACT

Terrorist attacks are a significant threat to global security as they can cause a large number of deaths, economic losses, and trigger public panic. This paper focuses on the Gulf states as the survey region. This study comprehensively investigates the correlation between national-scale terrorist attacks and various potential factors in the social, political, economic, and military fields, based on the Spearman rank coefficient and gray correlation analysis. The potential factors are divided into two categories: those with a positive correlation and those with a negative correlation to terrorist attacks. The study shows a strong correlation between the adolescent fertility rate (births per 1,000 women aged 15-19) and the occurrence of terrorist attacks. This correlation has not been previously noted in relevant studies, indicating a need for greater attention to be paid to the impact of terrorist attacks on the human rights of children and adolescents.

Keywords

Terrorist attack, Gulf states, characteristic analysis, correlation analysis.

INTRODUCTION

Terrorist attacks involve violent acts against non-military targets, often motivated by political, religious, or ideological goals (Kydd & Walter, 2006; Richards, 2014). The definition used by the Global Terrorism Database (GTD) is adopted in this study, defining terrorist attacks as "the threatened or actual use of illegal force and violence by a non-state actor to achieve political, economic, religious, or social goals through fear, coercion, or intimidation." Terrorist attacks, characterized by obvious violence and inhumanity, can not only cause huge casualties and property losses but also create a panic atmosphere within a certain area for a long time (Holman et al., 2008; Roy et al., 2011; Yaya, 2009). Moreover, these attacks seriously affect and threaten political security

and social stability of all the countries and regions globally, posing a huge threat to international relations and the global economy through ripple effects (Mun et al., 2021). Globally, we have experienced a variety of tragic terrorist attacks. For example, the September 11 attacks were the worst terrorist attacks happened in the United States, resulting in 3,025 deaths and missing. This incident seriously weakened American people's sense of security and formed severe psychological impact on American people who experienced the terrorist attack firsthand (Tong et al., 2016). In 2004, 190 people were killed and more than 1,500 were injured in the Madrid metro bombings (Buesa et al., 2007). On the night of November 13, 2015, a series of terrorist attacks took place in Paris, France, killing 132 people and injuring more than 300, which induced a state of emergency declaration in France. In another well-known case, the multiple bomb attacks in Sri Lanka on April 21, 2019, resulted in more than 250 deaths and more than 500 injuries. The identification of 42 foreign nationals among the victims caused global shock and widespread concern. Although the GTD indicates a general decrease in the number of terrorist attacks worldwide in recent years, the overall volume remains substantial, with approximately 8,000 attacks recorded in 2020, equating to an average of 22 attacks per day (GTD, 2023). Considering the global impact of terrorist attacks and the serious humanitarian disaster they may bring, research on the characteristics of terrorist attacks itself and the potential related factors are in urgent need.

Terrorist attacks can indeed happen suddenly, but when analyzed on a regional level, patterns and risks of terrorist attacks can often be identified. The academic community has dedicated significant efforts to researching the spatiotemporal evolution and driving mechanisms of terrorism, which can provide valuable insights into the root causes and trends of terrorist attacks. Among the numerous studies, several commonly mentioned factors that are highly correlated with terrorist attacks have been frequently identified, including imperialism, political systems, race and religion, and social factors such as income inequality and unemployment rates (Leite et al., 2019; Sharma, 2013; Tin et al., 2022). Specifically speaking, most of the existing studies engaged in in-depth mining of GTD. Part of the research is the data rearrangement and statistical presentation of the GTD. For example, some scholars searched the GTD for all terrorist attacks against nuclear facilities, nuclear scientists, nuclear transport, and other nuclear industry-related targets in the period from 1970-2020, and found that terrorist attacks carried out by non-state perpetrators were rare, and none of the attacks finally resulted in radioactive fallout or environmental contamination (De Cauwer et al., 2023). Part of the research is knowledge mining or knowledge discovery based on GTD datasets. For example, in terms of temporal and spatial characteristics, a study discovered countries located in a hot spot neighborhood of terrorist attacks are likely to experience a large increase in the number of terrorist attacks in the next period. This suggests that the spatial distribution of terrorist attacks is an important feature, and indicates that terrorist attacks have a characteristic of spatial transmission (Braithwaite et al., 2007). In terms of influencing factors, it has been suggested by some studies that states that fail to respond to internal political strife, ethnic conflict, or "stateless areas" are more susceptible to terrorist attacks (Piazza, 2007). This highlights the importance of governance in a country or region when it comes to preventing terrorism. Of course, some other factors like religiosity (Varenia et al., 2021), the ethnicism (Cho, 2010), democracy and civil conflicts (Kim et al., 2020; Morris et al., 2021), the popularity of the national leaders (Krueger et al., 2009) were also revealed to be highly related to terrorist attacks.

As to the terrorist attacks themselves, GTD provides detailed information on the location, type of attack, weapons used, and target type of terrorist incidents. Researchers have employed hierarchical analysis and K-means clustering analysis to categorize these terrorist attacks (Li et al., 2021). Additionally, studies have evaluated the heterogeneity of attack types worldwide using methods such as chi-square tests (De Cauwer et al., 2022; Ulmer et al., 2022). For instance, Pan conducted a quantitative analysis, fully exploring the correlations between terrorist organizations and other event attributes in the GTD. Based on machine learning techniques, he proposed a method to predict terrorist organizations using other indicators (Pan, 2021). Last but not least, some studies aim to provide additional information beyond the GTD dataset. For instance, an evaluation index system for the harmfulness of terrorist attacks could be constructed using the projection pursuit model. This system could be used to score all terrorist attacks in the GTD based on their consequences. This information was a valuable addition to the GTD dataset. Time series methods, such as the grey metabolic model (Deng et al., 2021), can be used to predict the future risk of terrorist attacks. These studies enriched and deepened our understanding of the GTD dataset. However, the factors linked to terrorist attacks usually intertwine to form a complex network. It's sometimes hard to distinguish which factors are the causes of terrorist attacks and which are the effect of terrorist attacks, since some factors are mutually causal with terrorist attacks, which is also a point worth further study.

The Middle East is a region with a high-incidence of terrorism. According to the GTD, the Middle East has an average of 1,165 terrorist attacks per year from 1970 to 2020, accounting for 27% of the global total. The Gulf region has long been the focus of geopolitics and conflicts, which has created a breeding ground for terrorism and seriously affected the security and stability of local countries and regions. From 2014 to 2021, the Islamic State (ISIS) carried out several terrorist attacks in the region, including violence in areas controlled by Iraq and Syria, as well as terrorist attacks in other countries. This has resulted in a severe security situation in relevant areas. Multiple factors, including political conflicts, wars, terrorism, social inequality, and natural disasters, have

continuously caused unrest in the Middle East, leading to humanitarian disasters and crises in many countries. The issue is also highlighted by the adolescent fertility rate indicator studied in this research. According to the World Bank data, the countries and regions with the highest rankings are mainly concentrated in Africa and the Middle East. Taking Iraq as an example, the adolescent fertility rate in 2021 reached 62.19‰, which although has decreased compared to previous years, is still significantly higher than the world average of 42‰. As a foundation for subsequent global-scale studies, this paper selects the Gulf states as the survey region, including Bahrain, Iran, Iraq, Kuwait, Qatar, Saudi Arabia, the United Arab Emirates and Oman. Spearman correlation analysis and Gray correlation analysis were used to explore the characteristics of terrorist attacks and related factors. It should be noted that correlation analysis in this paper is distinct from causation analysis, which means that causality cannot be strictly inferred. The causation analysis of terrorist attacks is relatively more complex and will be furtherly studied in the future. However, the authors believe that the paper could still have a great contribution. To the best of the authors' knowledge, this paper makes the first attempt to reveal the correlation of social multi-source data and terrorist attacks in the Gulf states. Also, some of the key findings provided by this paper are original and represent the first proposals.

OVERALL STRUCTRUE

As a preliminary study in the authors' research plan, the overall framework of this paper is straightforward. In this study, the Gulf states are selected as the survey region. Two main datasets, GTD and the World Bank dataset, are utilized in this study. The basic characteristics of terrorist attacks are analyzed in depth using the GTD, while additional associated factors are retrieved from the World Bank dataset. The Spearman's rank coefficient analysis and Grey relation analysis are two well-known and commonly used methods. They are employed in this study to investigate the correlations between terrorist attacks and related factors. Several important findings could be obtained by this study by quantitatively defining the relationship between terrorist attacks and the factors of socio-economic system, such as identifying which factors are most relevant to terrorist attacks. The results from this study are crucial for addressing the risk of terrorist attacks and assisting the communities in making targeted preparations.

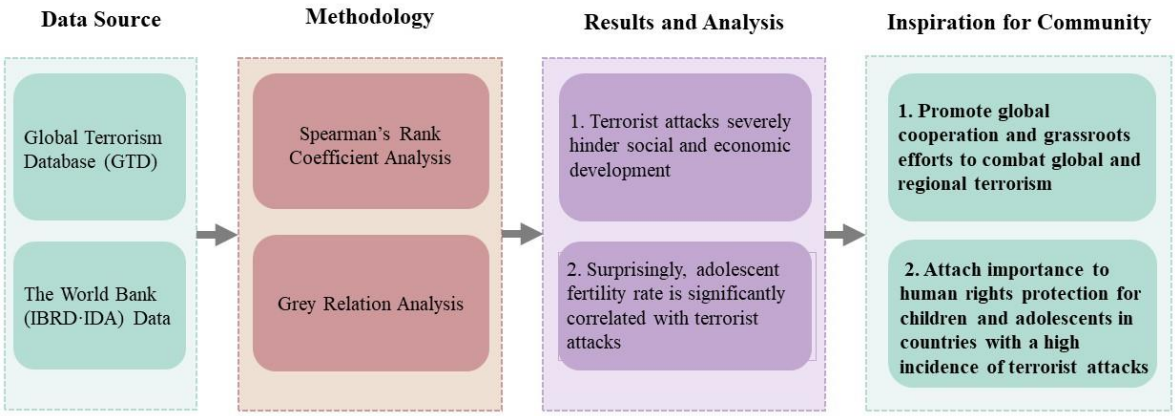


Figure 1. The overall structure of this paper

STUDY AREA AND DATASET

Survey Region

The Persian Gulf, abbreviated as "the Gulf", is one of the most important inland seas in the world, located in southwestern Asia between the Arabian Peninsula and Iran. The term "Gulf States" is a widely accepted concept, rather than a strictly defined geographic term with clear boundaries. In this study, the "Gulf States" refer to the eight countries along the Persian Gulf coast: Bahrain, Iran, Iraq, Kuwait, Qatar, Saudi Arabia, United Arab Emirates and Oman (Figure 2). The profiles of the eight countries were collected and briefly organized (Table 1), comprising information on area, population, religion, language, political system, economy, as well as military affairs.

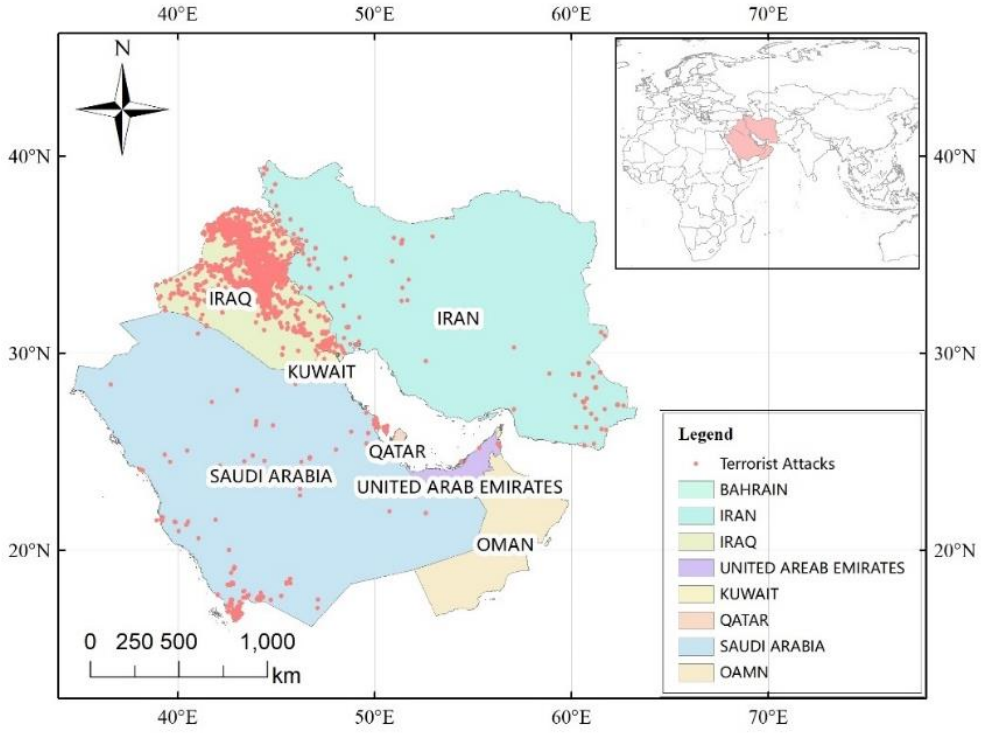


Figure 2. Terrorist Incidents Based on Geographic Location of Gulf States in 2001-2020

Table 1. The basic situation of eight Gulf states

Country Name	United Arab Emirates	Oman	Bahrain	Kuwait	Iraq	Iran	Qatar	Saudi Arabia
Area	83,600 sq.km	309,500 sq.km	780 sq.km	17,818 sq.km	438,300 sq.km	1,645,000 sq.km	11,521 sq.km	2,250,000 sq.km
Population	10.17 million	5.08 million	1.5 million	4.824 million	43.35 million	85.02 million	2.97 million	32.18 million
Religion	Mostly Islamic	Islam is state religion	Mostly Islamic	Islam is state religion	Mostly Islamic	Islam is state religion	Mostly Islamic	Islam is state religion
Language	Arabic; General English	Arabic; General English	Arabic; General English	Arabic	Arabic; Kurdish	Persian	Arabic; General English	Arabic
Political System	The highest authority: The Federal Supreme Council	Hereditary monarchies; Political parties are prohibited	Hereditary monarchies; Political parties are prohibited	Hereditary monarchical emirates	Federalism; More than 200 political parties and entities	Theocratic political system; Presidential cabinet system	Hereditary monarchies; Political parties are prohibited	Hereditary monarchies; Political parties are prohibited
Economy in 2022	GDP per capita: $47,700,000; GDP growth rate: 8.9%	GDP per capita: $19,000; GDP growth rate: 4.3%	GDP per capita: $23,500,000; GDP growth rate: 4.9%	GDP per capita: $39,000; GDP growth rate: 7.6%	GDP per capita: $5,021; GDP growth rate: 8.3%	GDP per capita: $4,388; GDP growth rate: 4%	GDP per capita: $81,800,000; GDP growth rate: 4%	GDP per capita: $34,400,000; GDP growth rate: 8.7%
Military Affairs	Voluntary military service system; Total military strength: 56,500	Compulsory military service system; Total military strength: 43,500	Voluntary military service system; Total military strength: 11,800	Compulsory military service system; Total military strength: 23,000	Recruitment system; Total military strength: 778,000	Compulsory military service system; Total military strength: 1.27 million	Voluntary military service system; Total military strength: 12,000	Voluntary military service in peacetime and compulsory military service in wartime; Total military strength: 230,000

Dataset

The datasets utilized in this study include the GTD, which covers records of terrorist attacks in the Gulf States region from 2001 to 2020 (the latest available data is updated to June 2021). GTD is an open-source database operated by the National Center for Terrorism at the University of Maryland and the Consortium for the Study and Research of Terrorism. It is widely recognized as the most comprehensive and sophisticated database on terrorism worldwide. The database incorporates data from reports published by authoritative media organizations. It includes information on the time and location of terrorist attacks, targets, attackers, and the number of people killed, injured and so on. Statistics show that there were 28,264 attacks in the Gulf States from 2001 to 2020. To ensure accuracy, data records with incomplete latitude and longitude information were excluded, ultimately 28,091 terrorist attacks in the Gulf states region were involved in this study.

This study selects eight socio-economic indicators as related factors (Table 2), based on the relevant studies mentioned in the introduction section and using the World Bank database as a reference. These indicators are:

- Per capita GDP (constant 2015 dollars);
- Unemployment rate (the ratio of the total number of unemployed to the total number of labor force);
- Net migration (net migration is the total number of net migrants during the period, i.e., the total number of migrants who migrated abroad minus the number of migrants who migrated into the country each year, including both permanent and non-permanent residents. The number of net migrants in that year is then divided by the country's population in that year);
- Adolescent fertility rate (the number of births per 1,000 15~19-year-old females);
- Military strength (armed forces personnel as a percentage of the total labor force);
- Urban population (the percentage of the urban population compared to the total population);
- Agricultural land (per capita agricultural land refers to land used for short-term cropping, short-term pasture for mowing or grazing, vegetable gardens for supplying the market, and gardens for own use, as defined by the Food and Agriculture Organization of the United Nations (FAO). Recreational land resulting from the conversion of farming practices is not included);
- Commodity trade (as a percentage of GDP).

In addition, considering the differences in each country's population, economy, etc., the Terrorist incident rate is defined as the number of terrorist attacks in a given year divided by the population of that country in the same year.

Table 2. Basic information on related socio-economic indicators to terrorist attacks

Index	Socio-economic variable	Abbreviation
x_1	Per capita GDP ($)	PCG
x_2	Unemployment rate (%)	UR
x_3	Net migration (%)	NM
x_4	Adolescent fertility rate (persons/1000)	AFR
x_5	Military strength (%)	MS
x_6	Urban population (%)	UP
x_7	Agricultural land (hectares)	AL
x_8	Commodity trade (%)	CT
y	Terrorist incident rate (cases/million people)	TIR

METHODOLOGY

The Correlation Analysis Method

Correlation analysis is a straightforward and accessible analytical method for measuring how quantitative data are related to each other, and it is commonly used to determine the degree of correlation between variables. To

calculate the strength of correlation between two different factors, a correlation coefficient is introduced below, that is the Spearman Correlation Coefficient (R_S), as shown in Eq. (1). The Spearman's Rank Correlation Coefficient (R_S) offers greater flexibility compared to the Pearson Correlation Coefficient (R_p), which is typically limited to describing linear relationships assuming a normal distribution. R_S is often used to assess the ranking of relationships, particularly in scenarios where variables possess ordinal properties, do not follow a normal distribution, or when the distribution type is unknown. The flexibility arises from its less restrictive data requirements. Current research often focuses on investigating ordinal relationships between variables, specifically examining whether an increase in one variable is accompanied by an increase in another. Therefore, the formula for calculating Spearman's correlation coefficient is chosen based on research needs. To calculate the Spearman's rank correlation coefficient (R_S), define two data sequences, $\{x_i\}$ and $\{y_i\}$, of equal length, where n is the number of data points in each sequence. Assign rank values (denoted as $\{p_i\}$ and $\{q_i\}$) to each data point in $\{x_i\}$ and $\{y_i\}$ respectively, based on their position from smallest to largest. Then, for each corresponding data point in the two sequences, calculate the difference $\{d_i\}$ between their rank values. Note that variables with the same value should be assigned the same rank, and in case of ties, the average rank is commonly used. The variables $\overline{p}$ and $\overline{q}$ are denoted as the mean ranks, respectively.

$$R_s = \frac{\sum_{i=1}^{n}(p_i - \bar{p})(q_i - \bar{q})}{\sqrt{\sum_{i=1}^{n}(p_i - \bar{p})^2}\sqrt{\sum_{i=1}^{n}(q_i - \bar{q})^2}} = 1 - \frac{6 * \sum_{i=1}^{n} d_i^2}{n\,(n^2 - 1)} \quad (1)$$

R_s is an index that quantifies the strength of correlation in the range of [-1, 1]. The closer the value of R_s is to either 1 or -1, the stronger the correlation. R_s >0 indicates a positive correlation, while R_s <0 indicates a negative correlation.

When performing correlation analysis, significance level tests are routinely conducted to assess whether the observed correlation is statistically meaningful. This means that the correlation is unlikely to be due to random factors. In statistics, the p-value is used to assess the probability of the sample data appearing under the null hypothesis, thus testing the statistical significance of an effect. The Spearman's rank correlation coefficient, for example, can be used to measure the strength and direction of the relationship between two variables, and the resulting correlation coefficient can then be used in a hypothesis test to calculate a p-value. Generally speaking, the smaller the p-value, the more significant the correlation is, indicating that the observed effect is less likely to be due to random error. To visually communicate the significance of these results, asterisks (*) are often used as markers. Specifically, a single asterisk (*) is used when the p-value for the correlation is less than 0.05, indicating statistically significant correlation. Two asterisks (**) are used for p-values less than 0.01, emphasizing the reliability of the correlation. Three asterisks (***) are reserved for p-values less than 0.001, which usually serve as highly convincing evidence of a strong and reliable correlation between the two variables.

The Grey Relation Analysis Method

Grey Relation Analysis (GRA) is a statistical method for multifactor analysis. It determines the degree of closeness between the series of the reference data and the series of several comparison data, by comparing the geometric similarity of their curves and calculating the degree of correlation between the curves. The more similar the curves are, the greater the correlation between the corresponding sequences will be, and vice versa. The reference sequence is usually the sequence that represents the overall development trend of the system, while the comparison sequence requires analysis. Set $x'_0 = \{x'_0(k)|k = 1, 2, 3, \ldots, n\}$ as the reference series, $x'_i = \{x'_i(k)|k = 1, 2, 3, \ldots, n\}$ $(i = 1, 2, 3, \ldots, \mathrm{m})$ as the comparison series. As the factors hold varying physical significance, the series data may not always share the same order of magnitude. This can impede comparison and make it difficult to draw accurate conclusions. To address this, it is necessary to convert all sequences to the same order of magnitude. This is typically achieved by dividing each element in the sequence by the average (as shown in Eq. (2)) or first element of the sequence (as shown in Eq. (3)). The grey correlation coefficient between the reference sequence and the comparison sequence is calculated using Eq. (4). Here, $x_i(k)$ denotes the k-th element of the i-th sequence, and $x_0(k)$ represents the k-th element of the reference sequence. The grey correlation degree of the i-th sequence r_{0i} is the average value of all grey correlation coefficients between it and the reference sequence (as shown in Eq. (5)). The rank of the i-th sequence is determined by comparing its grey correlation degree with other sequences. The resolution coefficient, ρ, should be determined based on the specific background and requirements and is in the range of (0,1). The default value of ρ is always set to be 0.5. r_{0i} denotes the gray correlation of x_0 with x_i. The closer to 1 the value of r_{0i} is, the better the correlation is.

$$x_i(k) = \frac{x'_i(k)}{\frac{1}{m}\sum_{k=1}^{m} x'_i(k)} \quad (2)$$

$$x_i(k) = \frac{x_i'(k)}{x_i'(1)} \tag{3}$$

$$\xi_i(k) = \frac{\min_i \min_k |x_0(k) - x_i(k)| + \rho \max_i \max_k |x_0(k) - x_i(k)|}{|x_0(k) - x_i(k)| + \rho \max_i \max_k |x_0(k) - x_i(k)|} \tag{4}$$

$$r_{0i} = \frac{1}{m} \sum_{k=1}^{m} \xi_i(k) \tag{5}$$

RESULTS

Time Evolution Characteristics of Terrorist Attacks

Between 2001 and 2020, the eight Gulf states experienced a total of 28,091 terrorist attacks, averaging 1,405 attacks per year. The number of deaths totaled 81,979, averaging 7,037 deaths per year, and the number of injuries totaled 140,744, averaging 4,099 injuries per year. Figure 3 illustrates the temporal evolution of terrorist attacks in all the eight Gulf states. Since the 21st century, the terrorist situation in the Gulf countries has shown significant fluctuations. The number of terrorist attacks, deaths, and injuries has exhibited a trend of growth followed by a decrease, reaching its peak in 2014. These trends are relatively consistent, with two significant turning points in 2007 and 2014. Fatalities resulting from terrorist attacks in 2020 decreased by 36.63% from the previous year to 531, marking the fourth consecutive year of decline since 2016. This decline is closely linked to an improvement in the intense conflict in Iraq.

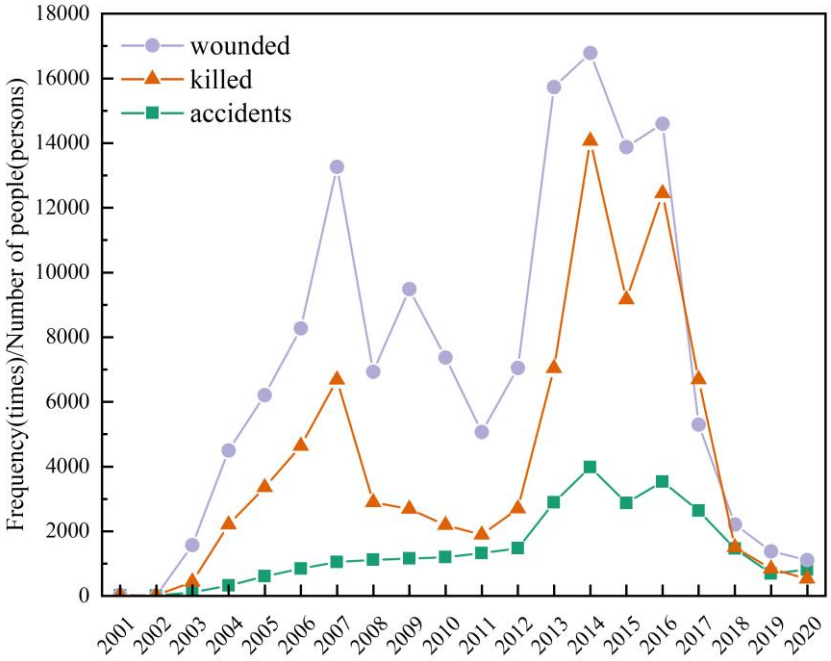


Figure 3. Interdecadal characteristics of terrorist attacks in the eight Gulf states

Out of the 28,091 terrorist attacks, the number of casualties from 841 terrorist attacks was unrecorded by GTD and therefore unknown. The remaining 27,250 terrorist attacks were further analyzed. Figure 4 shows the distribution of deaths in these attacks. Of all incidents, 64.39% resulted in fatalities in 17,545 cases, indicating that terrorist attacks are a considerable cause of casualties, despite the fact that the majority of terrorist attacks result in only a few fatalities.

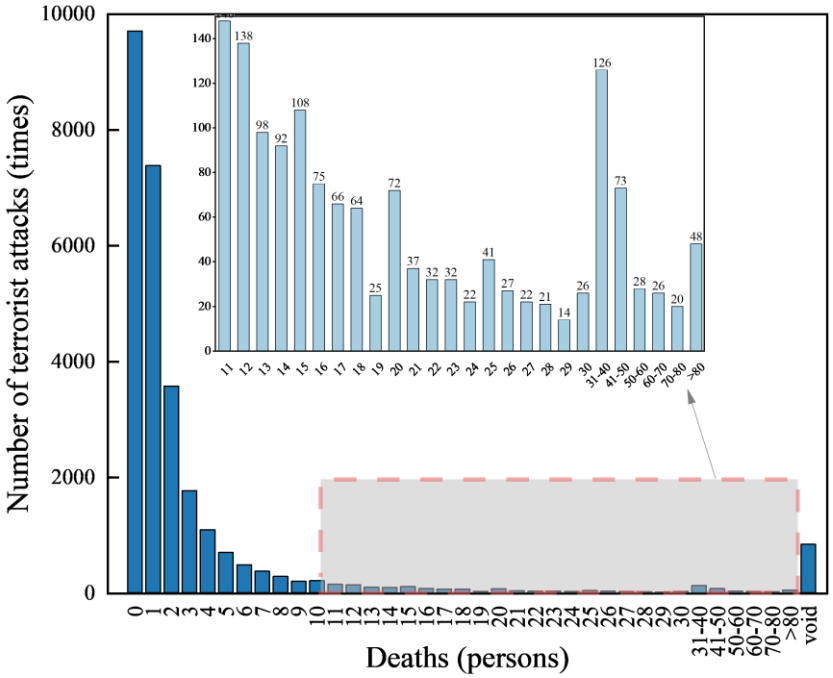
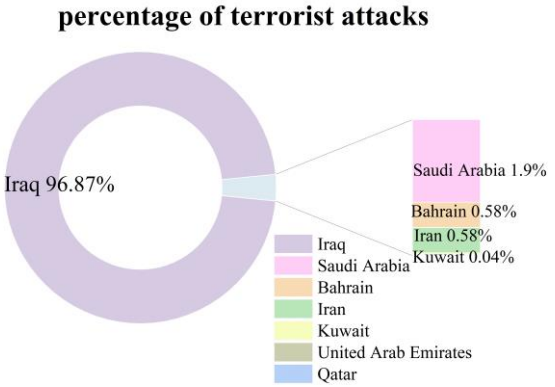


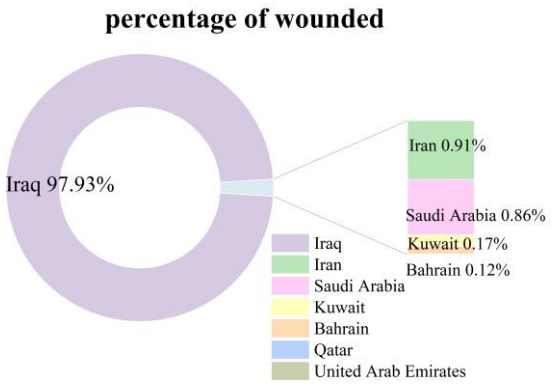
Figure 4. Characteristic analysis of casualties resulting from different terrorist attacks in the eight Gulf states

Regional Distribution Characteristics of Terrorist Attacks

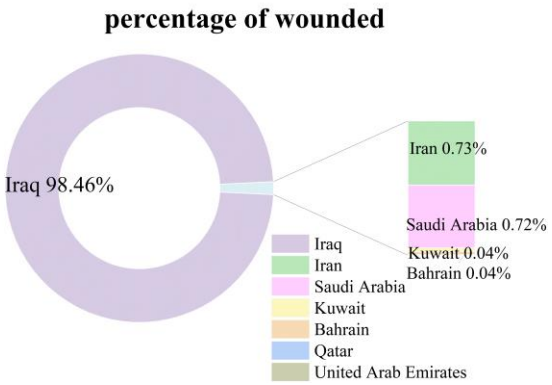
This study examines the geographical distribution of terrorist attacks in the Gulf states between 2001 and 2020, using latitude and longitude data from GTD. The analysis reveals that the majority of terrorist incidents in the Gulf states during the 21st century occurred in Iraq and Iran. The number of deaths in Iraq has reached 80,719, accounting for 98.46% of the total. Additionally, 137,830 people have been injured, accounting for 97.93%. Furthermore, there have been 27,212 terrorist attacks, accounting for 96.87% (Figure 5). These statistics confirm that Iraq is a high-risk area for terrorist incidents in the Gulf region. This phenomenon may be related to the war in Iraq that began in 2003 and the establishment of the terrorist organization ISIS in 2014.



(a) Quantitative characteristics of terrorist attacks in different countries



(b) Quantitative characteristics of the injuries in terrorist attacks in different countries



(c) Quantitative characteristics of the casualties in terrorist attacks in different countries

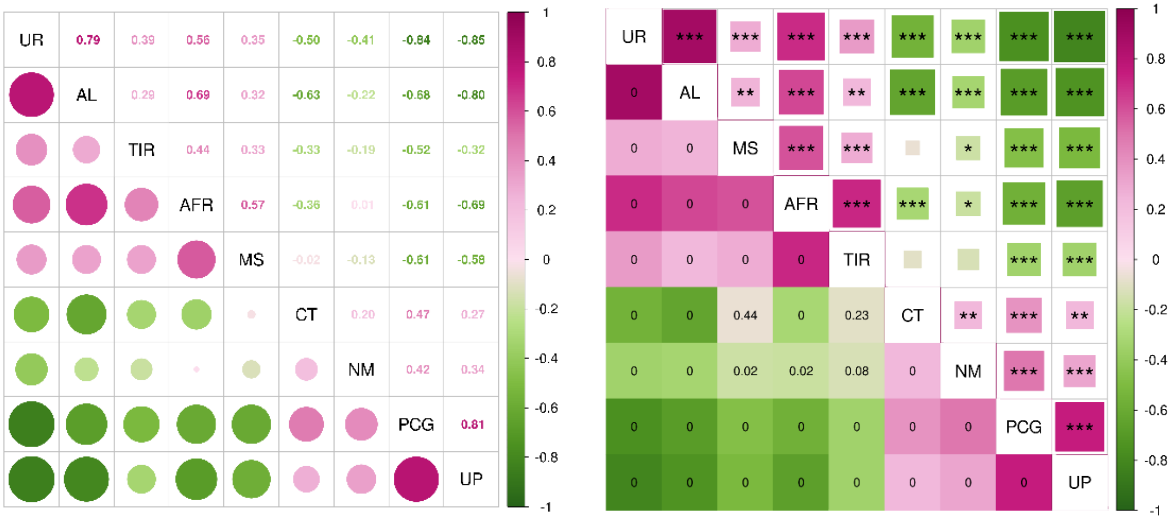
Figure 5. Regional distribution characteristics of terrorist attacks in the eight Gulf states

Correlation Analysis

Terrorism often arises from confluence of factors, such as social instability, political conflict, economic hardship and religious, racial or ethnic differences. These factors may lead to an increase in social tensions, social discontent, and extremist thinking, thus providing a breeding ground for terrorism. At the same time, the occurrence of terrorism will further aggravate social unrest and trigger a series of political, economic and livelihood problems. It can be seen that the terrorist attacks and socio-economic factors are often causal and interdependent, which is quite complex and not yet be confirmed in this field. In this paper, the causal analysis of terrorist attacks has been temporarily shelved in favor of a mainly correlational analysis. From the perspective of direct correlation, we have analyzed which factors might be highly correlated with terrorist attacks, and a more in-depth analysis is planned for the future. A Spearman correlation analysis of terrorist attacks in the Gulf States from 2001 to 2020 explores the relationships between the various elements listed in Table 2 above, as shown in Figure 6.

Upon careful observation of the color legend on the right side of Figure 6(a), a clear visual correlation between color and the intensity of correlation can be established. A gradual shift in color from dark to light red corresponds to a decrease in the numerical value from near 1 to 0, indicating a gradual weakening of the positive correlation. Conversely, the transition from deep green to lighter shades corresponds to a decrease in the numerical value from near -1 to 0, signifying a gradual weakening of negative correlation. The figure displays the correlation coefficients between the variables. The right triangular matrix displays the correlation coefficients among various variables, providing precise numerical values regarding their degrees of association. The left triangular part employs the size of the circle as a visual aid, where a larger circle area represents stronger correlation, thus enhancing the visualization of correlation strength. Simultaneously, the circle's color aligns with the legend, emphasizing the correlation's positive and negative directions. Figure 6(b) displays the correlation analysis's significance level. The combination of p-values and asterisks (*) enables quick identification of statistically significant correlations. A value of 0 on the graph corresponds to a p-value less than 0.01, indicating high statistical significance. Similar to Figure 6(a), the colors, size, and depth of the graphs continue to indicate the strength of the correlations. In this figure, they are also integrated with the significance level, providing a more comprehensive analytical perspective.

Figure 6(a) demonstrates a positive correlation between TIR and the influencing factors of UR, AL, AFR, and MS, while a negative correlation exists between TIR and CT, NM, PCG, and UP. Figure 6(b) reveals that the p-values for the correlations between terrorist attacks and the socio-economic factors are less than 0.01, with the exception of NM. Consequently, the majority of the socio-economic factors, excluding net migration, exhibit significant relationships with terrorist attacks based on the presented data.



(a) Spearman correlation coefficient (b) Significance level and p-value

Figure 6. Correlation analysis between terrorist attacks and different socio-economic factors

Correlation between TIR and PCG, CT, UR

Specifically, the frequency of terrorist incidents exhibits a significant negative correlation with per capita GDP (PCG) and commercial trade as a percentage of GDP (CT), with correlation coefficients of -0.52 and -0.33, respectively. While a significant positive correlation with the unemployment rate (UR) was observed, with 0.39. It is widely acknowledged that a decrease in the number of terrorist incidents in a region is associated with increased stability and economic development, and vice versa. GDP per capita commonly serves as a key measure of a region's economic prosperity. A high GDP per capita indicates that, on average, people in the region enjoy greater economic resources and benefits, leading to improved quality of life and a more stable social environment. Conversely, lower GDP per capita generally implies economic hardship and poverty, which may lead to an increase in social tensions and discontent, subsequently elevating the risk of terrorist incidents. Therefore, it is not difficult to understand that GDP per capita (PCG) could serve as a reliable index to characterize the intensity of terrorist attacks. Similarly, the healthy development of commercial trade is usually associated with economic dynamism and international cooperation. A vibrant and thriving business environment encourages increased employment opportunities, raises income levels, and stimulates economic development. In contrast, regions with underdeveloped or restricted trade are often at risk of economic decline and social instability. High unemployment, severe poverty, and economic underdevelopment may lead to conflict and provide fertile ground for terrorism.

Correlation between TIR and UP, AL

The correlation coefficient value of -0.32 indicates a highly significant negative correlation between the frequency of terrorist attacks and the ratio of urban population to total population (UP). Additionally, there is an extremely significant positive correlation of 0.29 between the frequency of terrorist attacks and the number of hectares of arable land per capita (AL). This result implies that higher urbanization tends to lead to a lower incidence of terrorist attacks. It is well known that the UP ratio and AL per capita are important indicators of urbanization, which is usually accompanied by economic development, social progress, and improved infrastructure. On the one hand, urban areas usually offer a higher standard of living and greater employment opportunities than rural areas, potentially reducing economic pressures and social grievances that can contribute to the risk of terrorist incidents. Moreover, urban areas tend to have more social communication, promoting interaction among people and strengthening social ties and community participation. These stronger social ties help to build harmonious social relations and increase social stability, thus reducing the nurturing environment for terrorism. On the other hand, terrorist attacks can significantly impede the normal development and urbanization of cities, including a country's overall urbanization level. In conclusion, this outcome aligns with people's perceptions.

Correlation between TIR and MS

A correlation coefficient value of 0.33 indicates a significant positive correlation between the number of terrorist attacks and military strength (MS), measured as the proportion of active military members in the labor force.

According to World Bank data, the countries with the highest percentage of armed forces personnel in their labor force from 2001 to 2020 are predominantly located in Asia and Africa, including Eritrea, the Democratic People's Republic of Korea, and Jordan. It is worth noting that most of these countries are developing nations with limited economic growth. Their economic development primarily rely on agriculture, industry, or resource exploitation. They often exhibit geopolitical complexity, with border disputes or conflicts with neighboring countries. As a result, these countries tend to have stronger militaries, which does not necessarily translate into better control of terrorism. In fact, the outlook for terrorism in these countries is not optimistic. On the contrary, a stronger military sometimes leads to greater instability in the country, increasing the risk of terrorism.

Correlation between TIR and AFR

Frequency of terrorist attacks shows an extremely significant positive correlation with the adolescent fertility rate (AFR), denoted by the number of births per 1,000 females aged 15-19, with a value of the correlation coefficient of 0.44. AFR varies across countries and regions, and is influenced by various factors, such as sociocultural attitudes, economic conditions, education level, and access to sex education and contraception. Based on 2021 World Bank data, the adolescent fertility indicator ranks African countries such as Niger, Mozambique, and Somalia at the top. Notably, these countries also face significant challenges from terrorism. On one hand, the frequent occurrence of terrorist incidents may trigger social unrest and affect the normal life and studies of adolescents, thus impacting their academic performance and future development. On the other hand, an increase in the fertility rate during adolescence may lead to greater socio-economic pressures, including education and management of troubled youth, and youth social participation. The risk of terrorist attacks may increase due to extremist religious thoughts that can arise from low levels of education, neglect of duty, and engaging in inappropriate business during adolescence.

Grey Relation Analysis

Table 3 illustrates a close and strong correlation between TIR and multiple socio-economic indicators through the application of gray correlation analysis. These findings align with the previous correlation analysis. The top three most significant factors are the adolescent fertility rate (AFR), agricultural land per capita (AL), and unemployment rate (UR), exhibiting gray correlation coefficients of 0.9013, 0.8913, and 0.8892, respectively. Notably, the relationship between terrorist attacks and the AFR is particularly strong, highlighting AFR as the most highly correlated factor.

Table 3. Gray correlation analysis between TIR and different factors

Factor	Grey correlation coefficient	Rank
AFR	0.9013	1
AL	0.8913	2
UR	0.8892	3
MS	0.8876	4
CT	0.8720	5
PCG	0.8621	6
UP	0.8693	7
NM	0.8521	8

Comparing the data on adolescent fertility rates in the eight Gulf region countries (Figure 7), it is clear that Iraq has a significantly higher fertility rate than the other countries. Given the significant number of terrorist attacks that have taken place in Iraq between 2001 and 2020, there is a strong likelihood of a correlation between these attacks and the fertility of adolescents. This underscores the urgency of prioritizing educational opportunities, well-being, and human rights for adolescents in terrorist incident-prone areas. Furthermore, in Iraq, the literacy rate of young women aged 15-24 was below the world average until 2016, indicating that their right to education for this group is not fully guaranteed. Additionally, World Bank data reveals that in 2004, there were only 0.006 community health workers per 1,000 people in Iraq, equivalent to just 6 community health workers per 1,000,000 people. This statistics highlights the extreme inadequacy of community health services, which could pose a serious threat to the health and well-being of children and adolescents. From a global perspective, it is noteworthy that in

certain countries or regions, such as Gaza, Kenya, and Haiti, adolescents and their families face life-threatening crises due to political unrest, civil strife, violence, extreme poverty, and natural disasters. These crises encompass displacement, infectious diseases, and malnutrition. In contrast, the deadly threat posed by terrorist attacks on adolescents has not received sufficient attention. The paper suggests a potential association between terrorist attacks and the human rights of adolescents, which deserves further exploration.

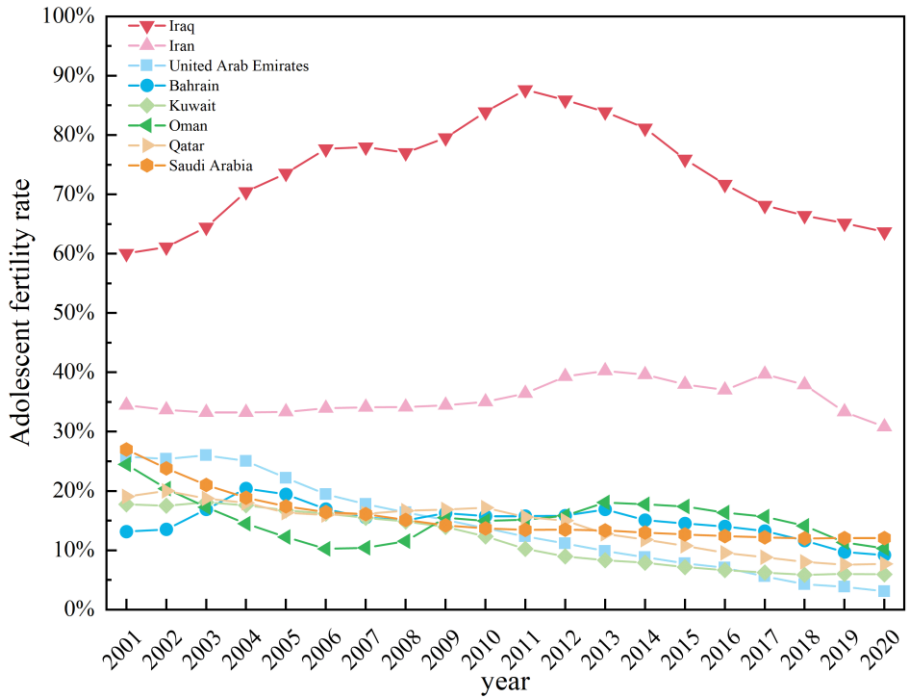
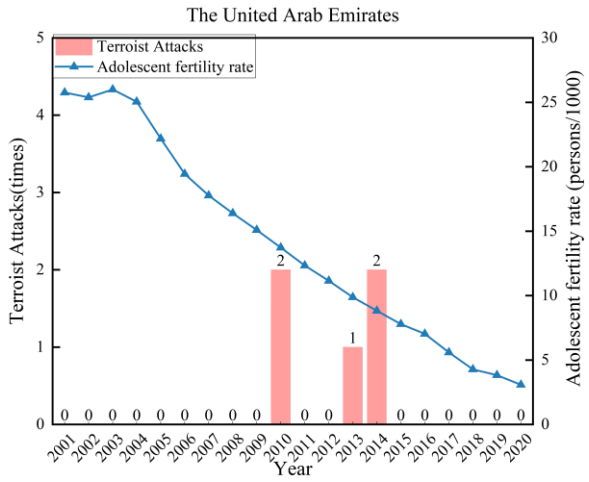


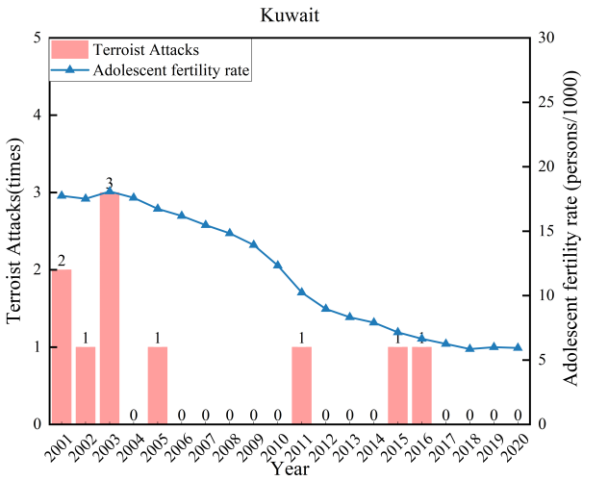
Figure 7. Comparison of adolescent fertility rates among the eight Gulf States

The downward trend in adolescent fertility rates over the years not only reflects the increasing emphasis on personal development and life choices but also demonstrates the deepening commitment to human rights protection. Figure 8(a)-(d) reveals that the United Arab Emirates, Kuwait, Oman and Qatar all experienced relatively few terrorist attacks between 2001 and 2020, with none exceeding 10 and an AFR of less than 30%. These countries also showed a steady downward trend. To some extent, this illustrates the significant advancements these nations have made in upholding social stability and security amidst globalization, which assures individuals the opportunity to pursue higher-quality lives and personal growth. Within this relatively stable and secure social environment, individuals are able to make more autonomous and responsible choices in areas such as childbirth, education, and career, which is a tangible manifestation of human rights protection. Upon further examination of Figures 8(e)&(f), it becomes evident that the sustained occurrence or sudden increase in terrorist attacks, as observed in Iran and Bahrain, can potentially slow down or even reverse the downward trend in adolescent fertility rates. The situation in Saudi Arabia (Figure 8(g)) corroborates this observation.

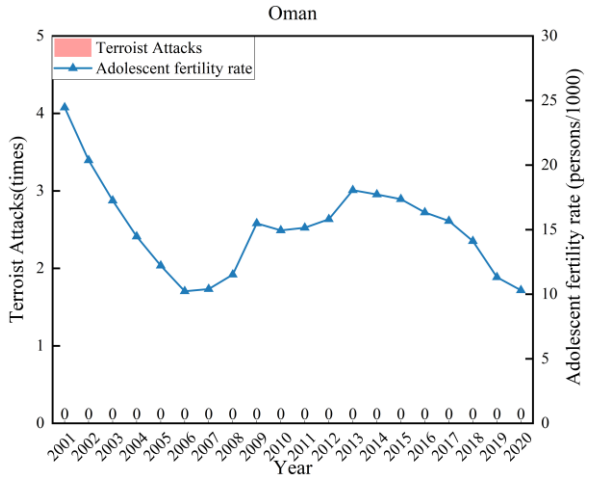
It is particularly noteworthy that the impact of terrorist attacks on AFR may manifest indirectly through various dimensions. Following a terrorist attack, members of society may be inclined to encourage earlier marriage and childbirth among adolescents due to a sense of insecurity. Economic recession may force adolescents into the labor market earlier, thus affecting their fertility plans. Restrictions on education and cultural activities may limit adolescents' educational and social opportunities, indirectly influencing their fertility decisions. Additionally, terrorist attacks may adversely affect the reproductive health of adolescents by compromising the provision of medical services. In the case of Iraq (Figure 8(h)), the average annual number of terrorist attacks in the country is as high as 1,360.6 in 2001-2020, and the AFR has remained above 60% over the 20 year. Specifically, between 2001 and 2012, as terrorist attacks escalated, the adolescent fertility rate also rose consistently. However, from 2017 to 2020, as the situation stabilized, the fertility rate began to decline. This phenomenon underscores the significant impact of heightened terrorist activity on social instability and public panic, ultimately driving up fertility rates. Conversely, when terrorist attacks are effectively contained or social stability is restored, fertility rates may respond by decreasing. This relationship highlights the crucial role of social stability and a secure environment in promoting responsible reproductive behavior, further emphasizing the close linkage between human rights protection and social development.



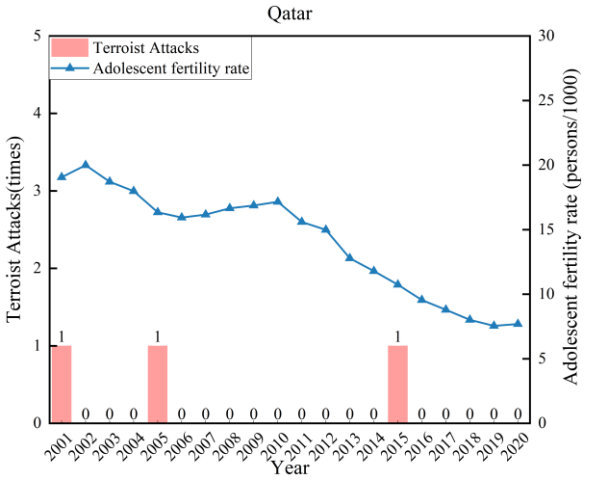
(a) The tendency of Terrorist Attacks and AFR in the United Arab Emirates



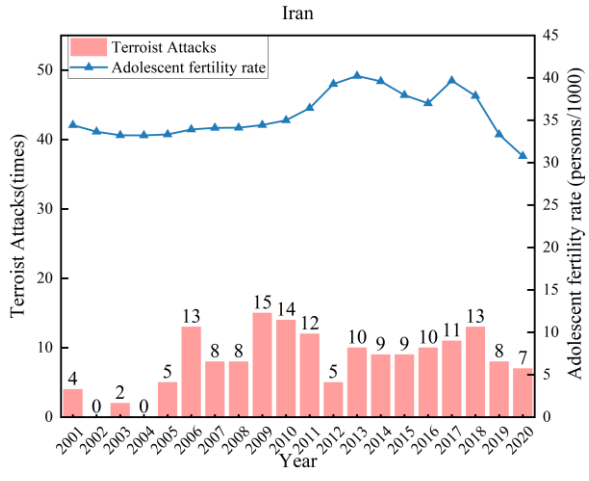
(b) The tendency of Terrorist Attacks and AFR in Kuwait



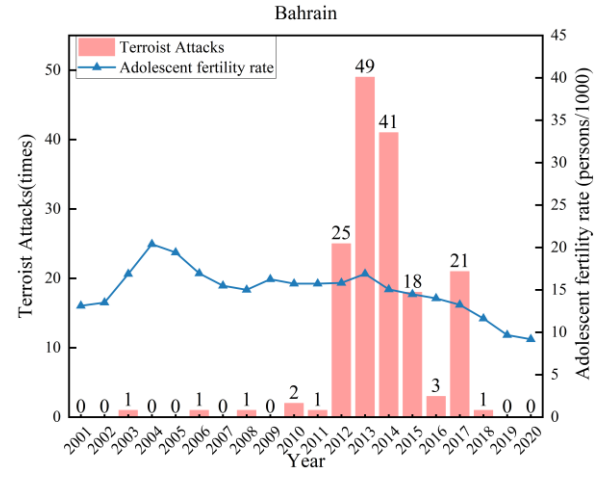
(c) The tendency of Terrorist Attacks and AFR in Oman



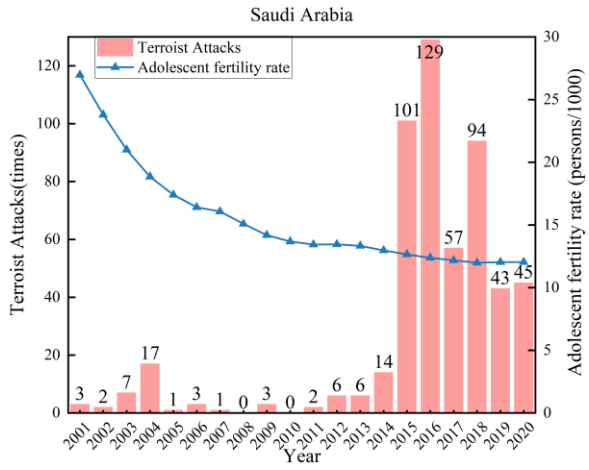
(d) The tendency of Terrorist Attacks and AFR in Qatar



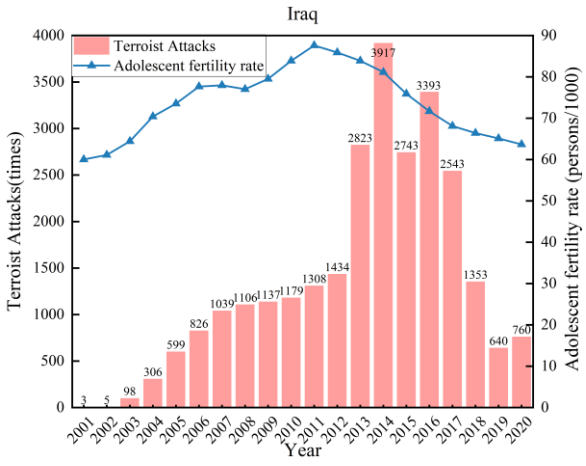
(e) The tendency of Terrorist Attacks and AFR in Iran



(f) The tendency of Terrorist Attacks and AFR in Bahrain



(g) The tendency of Terrorist Attacks and AFR in Saudi Arabia



(h) The tendency of Terrorist Attacks and AFR in Iraq

Figure 8. The tendency of Terrorist Attacks and AFR in Qatar in the eight Gulf States

LIMITATIONS AND FUTURE WORK

Firstly, this study aims to provide a correlation analysis between terrorist attacks and other socio-economic indicators, rather than causal analysis. The authors acknowledge that while causal analysis is more valuable, it is also more challenging to prove statistically whether a certain factor is the cause of terrorist attacks or a result of terrorist attacks. In addition, the mediators behind the changes in adolescent fertility, on which the article ultimately focuses, have not been thoroughly analyzed. In Figure 8, an attempt was made to illustrate the positive correlation between terrorist attacks and adolescent fertility rates through the analysis of individual countries, and qualitatively explored the underlying potential factors. However, this representation may have somewhat diminished the comparative effectiveness among countries. To enhance the depth and accuracy of the analysis, future research could delve deeper into two key directions: (1) whether differences in terrorist attack rates can serve as indicators of disparities in adolescent fertility rates among different countries, requiring comprehensive analysis and comparison of cross-national data; (2) how fluctuations in terrorist attack rates within a single country affect its domestic birth rate, which necessitates detailed national-level data support.

Secondly, as a case study, the authors only selected the Gulf states for analysis, consisting of eight countries. The authors believe that the threat of terrorism is becoming a serious international concern and requires a more comprehensive and larger-scale analysis. Moreover, the findings of this paper, which are based solely on the Gulf states, may not be applicable to other countries and regions globally. Therefore, the authors plan to expand the scope of the study by including more countries and regions to gain a better understanding of the global risk on terrorist attacks. In the near future, we may even conduct a global-scale analysis to uncover more universal and inspiring findings.

CONCLUSIONS

This paper presents a thorough analysis of terrorist attacks in Gulf states using the GTD database. The case study encompasses totally eight countries: Bahrain, Iran, Iraq, Kuwait, Qatar, Saudi Arabia, United Arab Emirates and Oman. As a preliminary exploratory study, Spearman's correlation analysis and Gray correlation analysis methods were employed to explore the correlation between terrorist attacks and potential socio-economic factors. The socio-economic factors considered in this paper include per capita GDP, unemployment rate, net migration, adolescent fertility rate, military strength, urban population, agricultural land, and commodity trade.

It was observed that:

(1) Between 2001 and 2020, the terrorism situation in the Gulf states experienced continuous fluctuation. From 2001 to 2010, the fluctuations in the terrorism situation in the Gulf states were relatively smooth. Although there were some major incidents, such as the wars in Iraq in 2003 and Lebanon in 2006, which heightened regional tensions, the overall trend was not significantly upward. From 2010 onwards, there was a fluctuating growth trend in terrorism in the Gulf states. Iraq bore the brunt of terrorist attacks. Since 2016, this trend has gradually weakened and the number of terrorist attacks decreased. However, terrorism remains a significant security risk that negatively affects economic development, overseas investments, and the well-being of the population.

(2) Terrorism in the Gulf states is a complex phenomenon resulting from multiple factors. This war-ravaged region has become a breeding ground for terrorism, further aggravating the fragile security situation in the Gulf states. The study concludes that the unemployment rate, arable land ratio, military strength and teenage fertility rate have significant positive correlations with terrorist attacks, while the urban population ratio, GDP per capita and commodity trade have significant negative correlations. These factors are interrelated and pose a significant threat to the security and stability of the Gulf and the Middle East region.

(3) Children residing in regions experiencing a high frequency of terrorist attacks often face immense difficulties in fully exercising their rights to education and. The prevalent insecurity and terrorist activities in these areas pose a profound danger to the survival and development of children and adolescents, effectively barring them from enjoying their fundamental rights to the fullest extent. Consequently, it is incumbent upon the international community and each individual nation to prioritize the survival and sustainable development of children and adolescents, implementing effective measures to safeguard their rights and welfare.

Future studies are expected to delve deeper into causal analyses of terrorist attacks and conduct comprehensive global-scale investigations. This paper proposes that the Gulf States expeditiously forge a consensus on regional security, vigorously facilitate security cooperation, and boost investments in safeguarding the welfare of children and adolescents. Additionally, the concerted effort of the entire international community is imperative to collectively tackle the humanitarian challenges posed by terrorism, attain sustainable regional and global security, and enhance the protection and development opportunities for all children and adolescents worldwide.

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