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A statistical analysis of Iraq body counts

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Abstract The Iraq conflict is one of the most outrageous and unprovoked aggressions unleashed by the West. Here, we provide a statistical analysis of the number of civilians deaths resulting from the US-led invasion. For this purpose, we propose several new discrete distributions. The distributions are fitted to the data on the number of deaths by maximum likelihood. Variables like province, cause of death and time are taken as covariates. Useful predictions are given on the number of deaths.

Keywords Discrete distributions · Number of deaths · Predictions

1 Introduction

The invasion of Iraq led by US forces began on 20 March 2003. Other countries also sent forces to Iraq, including the UK, South Korea, Italy, Poland, Australia, Georgia, Ukraine, Netherlands, and Spain.

Much of the evidence for Iraq war was based on weapons of mass destruction (including Yellowcake uranium, Poison gas and biological weapons), connections to anthrax attacks and connections to the 11 September attacks. As often the case in the West, most of this evidence was fabricated and found to have no substance. The Iraq conflict has led to over one million deaths, including deaths of over 100,000 civilians.

US led forces also committed numerous human right abuses during the conflict, including Abu Ghraib torture and prisoner abuse, Haditha killings of 24 civilians, white phosphorus use, gang-rape and murder of a 14-year-old girl and the murder of her family in Mahmoudiyah, the torture and killing of prisoner of war, Iraqi Air Force commander, Abed Hamed Mowhoush, the killing of Baha Mousa, Mukaradeeb wedding party massacre of 42 civilians, and Blackwater Baghdad shootings.

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There has been considerable academic interest in the Iraq conflict and its effect. Most of the academic papers published focus on issues relating to the military personnel, the perpetrators of the unjustified, bloody, and criminal invasion. For example, Nason and Bailey (2008) propose an approach for estimating intensity of deaths of coalition personnel. We question the morality of these and other authors. In our opinion, these authors and their research are as criminal as the invasion itself.

There have been very few papers investigating civilian deaths from the Iraq conflict. The only one we are aware of is Lewis et al. (2012). The main conclusion of this paper is: "Our results indicate that self-excitation makes up as much as 37-50 percent of all violent events and that self-excitation lasts at most between two and six weeks, depending upon the district in question". It is not clear to us what practical implication that this conclusion has.

The aim of this paper to provide a statistical analysis of civilian deaths from the Iraq conflict. This paper appears to be the first of its kind with respect to the Iraq conflict.

The contents of this paper are organized as follows. The data on the number of civilian deaths are described in Sect. 2. A range of discrete distributions for modeling the data is listed in Sect. 3. Many of these distributions are new. Statistical modeling of the data is described in Sect. 4. Some conclusions of this modeling exercise are noted in Sect. 5.

2 Data

The data for this paper was extracted from http://www.iraqbodycount.org/, a website giving civilian deaths of the Iraq conflict since 2003. We extracted the maximum number of civilians killed biyearly in each of the 18 provinces of Iraq (Baghdad, Anbar, Babylon, Basrah, Dahuk, Diyala, Erbil, Kerbala, Missan, Muthanna, Najaf, Ninewa, Qadissiya, Salah al-Din, Sulaymaniyah, Tameem, Thi-Qar, Wassit) by US-led coalition only or US-led coalition including Iraqi forces using explosives, air attacks, gunfire or suicide attacks.

The number of civilians killed was also given weekly, monthly, quarterly and yearly. But the weekly, monthly and quarterly data exhibited significant serial correlation. The biyearly data did not show significant serial correlations. The yearly data were thought to be too few for statistical analysis.

The website http://www.iraqbodycount.org/ also reported civilian deaths due to Iraqi state forces without coalition, anti-government/occupation forces and others. We did not consider these data since the purpose here is to investigate the effect of Western aggression in Iraq.

Figure 1 shows the distribution of the number of deaths versus the provinces. The number of deaths appears largest for Anbar in terms of median and variability. It appears smallest for Dahuk, Erbil and Tameem in terms of median and variability.

Figure 2 shows the distribution of the number of deaths versus the cause. The number of deaths appears largest due to gunfire, second largest due to air attacks, third largest due to explosives and smallest due to suicide attacks.

Both Figs. 1 and 2 suggest that the number of deaths appears larger at least in terms of variability when the perpetrators are US-led coalition with Iraqi forces (as opposed to US-led coalition only).

3 Models

The data are counts. So, discrete distributions are needed to model them. Unfortunately, most if not all of the discrete distributions available in the literature have limited applicability

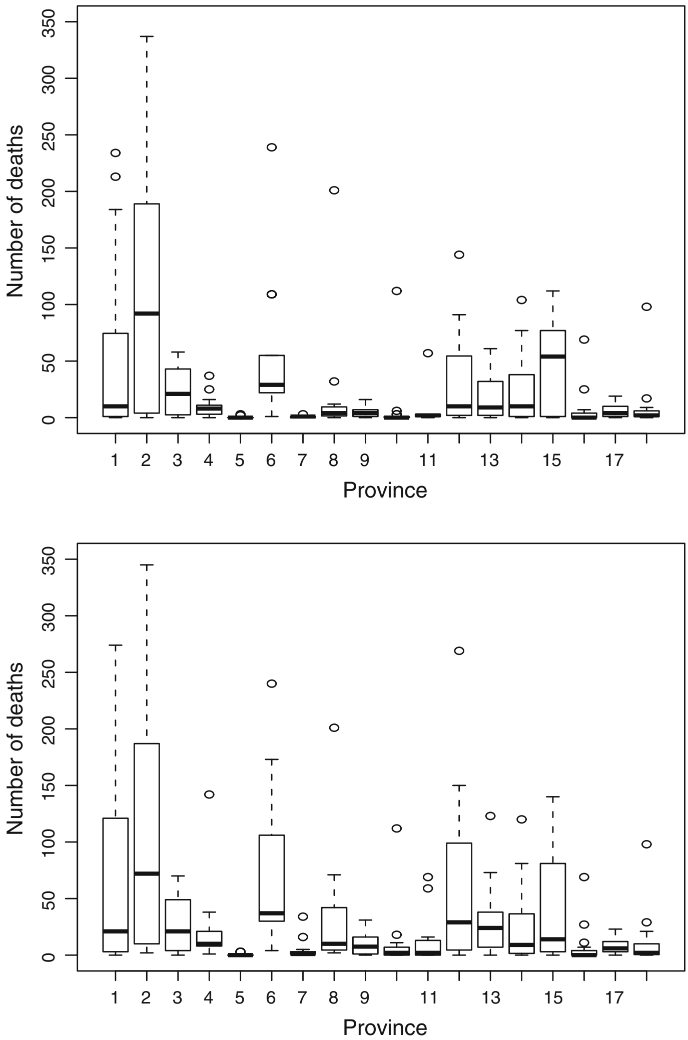

Fig. 1 Boxplots of the number of civilian deaths versus province for deaths caused by US-coalition only (*top*) and for deaths caused by US-coalition including Iraqi forces (*bottom*)

(Johnson et al. 1992). Here, we list a range of discrete distributions that can be used to model the data. Of the 20 discrete distributions listed, the first 10 are known ones. The remaining 10 discrete distributions (generalized discrete Pareto, discrete Fréchet, discrete lognormal, discrete F, discrete inverse gamma, discrete inverse Gaussian, discrete Birnbaum Saunders, discrete half t, discrete half Cauchy, and discrete half logistic) are new.

The list of 20 distributions includes both light- and heavy-tailed distributions. The Poisson, geometric, logarithmic, Yule, discrete gamma, discrete Weibull, discrete half normal, discrete lognormal, discrete inverse Gaussian, discrete Birnbaum Saunders and discrete half logistic distributions have light tails. The discrete inverse Weibull, Zeta, discrete Burr, generalized discrete Pareto, discrete Fréchet, discrete F, discrete inverse gamma, discrete half t, and discrete half Cauchy distributions have heavy tails.

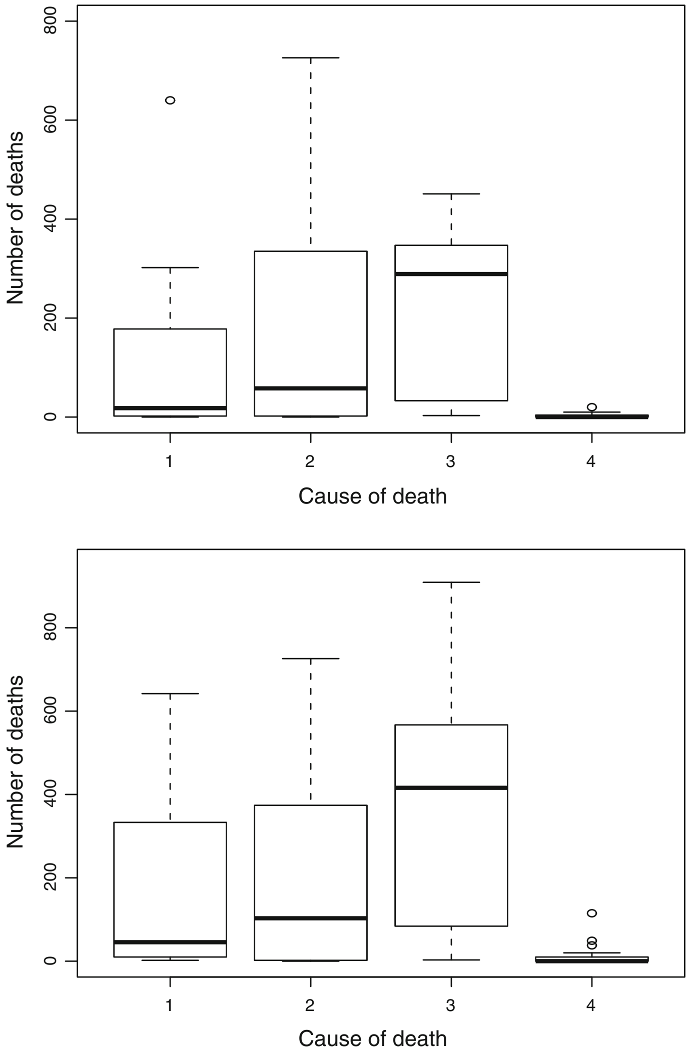

Fig. 2 Boxplots of the number of civilian deaths versus cause of death for deaths caused by US-coalition only (*top*) and for deaths caused by US-coalition including Iraqi forces (*bottom*)

3.1 Poisson distribution

This distribution is well known and has its probability mass function (pmf) specified by

$$p(x) = \frac{\lambda^x \exp(-\lambda)}{x!},$$

for $\lambda > 0$, the rate parameter, and $x = 0, 1, \ldots$

3.2 Geometric distribution

This distribution is well known and has its pmf specified by

$$p(x) = p(1-p)^x,$$

for $0 < p < 1$, the probability parameter, and $x = 0, 1, \ldots$

3.3 Logarithmic distribution

This distribution due to Fisher et al. (1943) has its pmf specified by

$$p(x) = -\frac{p^x}{x \log(1-p)},$$

for $0 < p < 1$, the probability parameter, and $x = 1, 2, \ldots$

3.4 Yule distribution

This distribution due to Yule (1925) has its pmf specified by

$$p(x) = \rho B(x, \rho + 1),$$

for $\rho > 0$, the shape parameter, and $x = 1, 2, \ldots,$ where $B(a, b) = \int_0^1 t^{a-1}(1-t)^{b-1} dt$ denotes the beta function.

3.5 Discrete gamma distribution

This distribution due to Yang (1994) has its pmf specified by

$$p(x) = \frac{\gamma(\xi, \sigma(x+1))}{\Gamma(\xi)} - \frac{\gamma(\xi, \sigma x)}{\Gamma(\xi)},$$

for $\sigma > 0$, the scale parameter, $\xi > 0$, the shape parameter, and $x = 0, 1, \ldots,$ where $\gamma(a, x) = \int_0^x t^{a-1} \exp(-t) dt$ denotes the incomplete gamma function and $\Gamma(a) = \int_0^\infty t^{a-1} \exp(-t) dt$ denotes the gamma function.

3.6 Discrete Weibull distribution

This distribution due to Nakagawa and Osaki (1975) has its pmf specified by

$$p(x) = q^{x^\theta} - q^{(x+1)^\theta},$$

for $0 < q < 1$, $\theta > 0$ and $x = 0, 1, \ldots$ Here, both q and θ are shape parameters.

3.7 Discrete inverse Weibull distribution

This distribution due to Jazi et al. (2010) has its pmf specified by

$$p(x) = \begin{cases} q, & \text{if x=1,} \\ q^{x^{-\theta}} - q^{(x-1)^{-\theta}}, & \text{if x = 2,3,\ldots,} \end{cases}$$

for $0 < q < 1$ and $\theta > 0$. Here, both q and θ are shape parameters.

3.8 Zeta distribution

This is a known distribution with its pmf specified by

$$p(x) = \frac{x^{-s}}{\zeta(s)},$$

for $s > 1$, the shape parameter, and $x = 1, 2, \ldots,$ where

$$\zeta(s) = \sum_{n=1}^{\infty} n^{-s},$$

denotes the Riemann zeta function.

3.9 Discrete half normal distribution

This distribution due to Gómez-Déni (2012) has its pmf specified by

$$p(x) = 2\Phi\left(\frac{x+1}{\sigma}\right) - 2\Phi\left(\frac{x}{\sigma}\right),$$

for $\sigma > 0$, the scale parameter, and $x = 0, 1, \ldots,$ where $\Phi(\cdot)$ denotes the cumulative distribution function of a standard normal random variable.

3.10 Discrete Burr distribution

This distribution due to Krishna and Pundir (2009) has its pmf specified by

$$p(x) = \frac{1}{[1 + x^a]^b} - \frac{1}{[1 + (x+1)^a]^b},$$

for $a > 0$, $b > 0$ and $x = 0, 1, \ldots$ Here, both a and b are shape parameters.

3.11 Generalized discrete Pareto distribution

This distribution is new and has its pmf specified by

$$p(x) = \left[1 + \frac{\xi x}{\sigma}\right]^{-1/\xi} - \left[1 + \frac{\xi(x+1)}{\sigma}\right]^{-1/\xi},$$

for $\sigma > 0$, the scale parameter, $-\infty < \xi < \infty$, the shape parameter, and $x = 0, 1, \ldots$

3.12 Discrete Fréchet distribution

This distribution is new and has its pmf specified by

$$p(x) = \exp\left[-\left(\frac{\sigma}{x+1}\right)^{\xi}\right] - \exp\left[-\left(\frac{\sigma}{x}\right)^{\xi}\right],$$

for $\sigma > 0$, the scale parameter, $\xi > 0$, the shape parameter, and $x = 0, 1, \ldots$

3.13 Discrete lognormal distribution

This distribution is new and has its pmf specified by

$$p(x) = \Phi\left(\frac{\log(x+1) - \mu}{\sigma}\right) - \Phi\left(\frac{\log x - \mu}{\sigma}\right),$$

for $\sigma > 0$, the scale parameter, $-\infty < \mu < \infty$, the location parameter, and $x = 0, 1, \ldots$

3.14 Discrete F distribution

This distribution is new and has its pmf specified by

$$p(x) = I_{\nu_1(x+1)/[\nu_1(x+1)+\nu_2]}\left(\frac{\nu_1}{2}, \frac{\nu_2}{2}\right) - I_{\nu_1 x/[\nu_1 x+\nu_2]}\left(\frac{\nu_1}{2}, \frac{\nu_2}{2}\right),$$

for $\nu_1 > 0$, the first degree of freedom parameter, $\nu_2 > 0$, the second degree of freedom parameter, and $x = 0, 1, \ldots,$ where $I_x(a, b) = \int_0^x t^{a-1}(1-t)^{b-1}dt/B(a, b)$ denotes the incomplete beta function ratio.

3.15 Discrete inverse gamma distribution

This distribution is new and has its pmf specified by

$$p(x) = \frac{\Gamma(\xi, \sigma/(x+1))}{\Gamma(\xi)} - \frac{\Gamma(\xi, \sigma/x)}{\Gamma(\xi)},$$

for $\sigma > 0$, the scale parameter, $\xi > 0$, the shape parameter, and $x = 0, 1, \ldots,$ where $\Gamma(a, x) = \int_x^\infty t^{a-1}\exp(-t)dt$ denotes the complementary incomplete gamma function.

3.16 Discrete inverse Gaussian distribution

This distribution is new and has its pmf specified by

$$p(x) = \Phi\left(\sqrt{\frac{\xi}{x+1}}\left(\frac{x+1}{\sigma} - 1\right)\right) + \exp\left(\frac{2\xi}{\sigma}\right)\Phi\left(-\sqrt{\frac{\xi}{x+1}}\left(\frac{x+1}{\sigma} + 1\right)\right)$$
$$-\Phi\left(\sqrt{\frac{\xi}{x}}\left(\frac{x}{\sigma} - 1\right)\right) - \exp\left(\frac{2\xi}{\sigma}\right)\Phi\left(-\sqrt{\frac{\xi}{x}}\left(\frac{x}{\sigma} + 1\right)\right),$$

for $\sigma > 0$, the scale parameter, $\xi > 0$, the shape parameter, and $x = 0, 1, \ldots$

3.17 Discrete Birnbaum Saunders distribution

This distribution is new and has its pmf specified by

$$p(x) = \Phi\left(\frac{1}{\xi}\left(\sqrt{\frac{x+1}{\sigma}} - \sqrt{\frac{\sigma}{x+1}}\right)\right) - \Phi\left(\frac{1}{\xi}\left(\sqrt{\frac{x}{\sigma}} - \sqrt{\frac{\sigma}{x}}\right)\right),$$

for $\sigma > 0$, the scale parameter, $\xi > 0$, the shape parameter, and $x = 0, 1, \ldots$

3.18 Discrete half t distribution

This distribution is new and has its pmf specified by

$$p(x) = \frac{2(x+1)\Gamma((\nu+1)/2)}{\sqrt{\pi\nu}\,\Gamma(\nu/2)}\,{}_2F_1\left(\frac{1}{2}, \frac{\nu+1}{2}; \frac{3}{2}; -\frac{(x+1)^2}{\nu}\right)$$
$$-\frac{2x\Gamma((\nu+1)/2)}{\sqrt{\pi\nu}\,\Gamma(\nu/2)}\,{}_2F_1\left(\frac{1}{2}, \frac{\nu+1}{2}; \frac{3}{2}; -\frac{x^2}{\nu}\right),$$

for $\nu > 0$, the degree of freedom parameter, and $x = 0, 1, \ldots,$ where

$${}_2F_1(a, b; c; x) = \sum_{k=0}^{\infty} \frac{(a)_k(b)_k}{(c)_k}\frac{x^k}{k!},$$

denotes the Gauss hypergeometric function, where $(f)_k = f(f+1)\cdots(f+k-1)$ denotes the ascending factorial.

3.19 Discrete half Cauchy distribution

This distribution is new and has its pmf specified by

$$p(x) = \frac{2}{\pi}\arctan\left(\frac{x+1}{\sigma}\right) - \frac{2}{\pi}\arctan\left(\frac{x}{\sigma}\right),$$

for $\sigma > 0$, the scale parameter, and $x = 0,\ 1, \ldots$

3.20 Discrete half logistic distribution

This distribution is new and has its pmf specified by

$$p(x) = 2\left[1 + \exp\left(-\frac{x+1}{\sigma}\right)\right]^{-1} - 2\left[1 + \exp\left(-\frac{x}{\sigma}\right)\right]^{-1},$$

for $\sigma > 0$, the scale parameter, and $x = 0,\ 1, \ldots$

Note that we have simply listed the pmf for each of the 20 discrete distributions, including the 10 new ones. We have not attempted to derive structural properties like moments or procedures for maximum likelihood estimation. These are not needed in subsequent sections. A detailed study of mathematical properties of the 10 new distributions is a possible future work.

4 Results

Section 4.1 determines the best of the 20 distributions in Sect. 3 to model number of civilian deaths. Section 4.2 investigates the effect of province on the number of deaths. Section 4.3 investigates the effect of cause on the number of deaths. Section 4.4 investigates the effect of time on the number of deaths. Section 4.5 provides some useful predictions on the number of deaths.

4.1 Best fitting model

The first step is to see which of the 20 distributions in Sect. 3 gives the best fit for the data. We fitted all of the distributions to the data by ignoring the groupings into provinces and the groupings into causes of death. The parameter estimates, standard errors, loglikelihood values, values of Akaike information criterion (1974) and values of Bayesian information criterion (Schwarz 1978) are shown in Table 1 when the perpetrators are US-led coalition only. The parameter estimates, standard errors, loglikelihood values, values of AIC and values of BIC are shown in Table 2 when the perpetrators are US-led coalition with Iraqi forces. The method of maximum likelihood was used for fitting. The standard errors were computed by inverting the observed information matrices.

Among the one-parameter models, the logarithmic distribution gives the smallest loglikelihood value, the smallest AIC value and the smallest BIC value when the perpetrators are US-led coalition only. The discrete half Cauchy distribution gives the smallest loglikelihood

Table 1 Fitted models when the perpetrators are US-led coalition only

Distributions	Parameter estimates (SE)	$-\log L$	AIC	BIC
Poisson	$\widehat{\lambda} = 789\,(7)$	15,797.9	31,597.8	31,598.7
Geometric	$\widehat{p} = 1.266 \times 10^{-3}\,(3.213 \times 10^{-4})$	138.1	278.2	279.1
Logarithmic	$\widehat{p} = 9.999 \times 10^{-1}\,(1.000 \times 10^{-14})$	133.6	269.1	270.0
Yule	$\widehat{\rho} = 1.832 \times 10^{-1}\,(4.414 \times 10^{-2})$	141.3	284.5	285.4
Discrete gamma	$\widehat{\sigma} = 1,852.5\,(837.1)$, $\widehat{\xi} = 4.262 \times 10^{-1}\,(1.156 \times 10^{-1})$	131.7	267.4	269.2
Discrete Weibull	$\widehat{q} = 9.684 \times 10^{-1}\,(2.221 \times 10^{-2})$, $\widehat{\theta} = 5.616 \times 10^{-1}\,(9.798 \times 10^{-2})$	130.9	265.7	267.5
Discrete inverse Weibull	$\widehat{q} = 5.059 \times 10^{-4}\,(2.508 \times 10^{-3})$, $\widehat{\theta} = 5.006 \times 10^{-1}\,(1.260 \times 10^{-1})$	132.0	268.0	269.7
Zeta	$\widehat{s} = 1.176\,(4.169 \times 10^{-2})$	141.6	285.2	286.0
Discrete Burr	$\widehat{a} = 6.490\,(1.562 \times 10^{-1})$, $\widehat{b} = 2.995 \times 10^{-2}\,(3.539 \times 10^{-1})$	140.1	284.1	285.9
Generalized discrete Pareto	$\widehat{\sigma} = 197.0\,(136.8)$, $\widehat{\xi} = 1.049\,(6.981 \times 10^{-1})$	132.0	268.0	269.7
Discrete Fréchet	$\widehat{\sigma} = 60.9\,(29.6)$, $\widehat{\xi} = 5.157 \times 10^{-1}\,(9.275 \times 10^{-2})$	132.1	268.2	270.0
Discrete half normal	$\widehat{\sigma} = 997.4\,(218.2)$	158.4	318.8	319.7
Discrete lognormal	$\widehat{\mu} = 5.143\,(4.769 \times 10^{-1})$, $\widehat{\sigma} = 2.023\,(3.374 \times 10^{-1})$	130.8	265.6	267.4
Discrete F	$\widehat{\nu_1} = 11,697.9\,(1,945.0)$, $\widehat{\nu_2} = 3.585 \times 10^{-1}\,(9.102 \times 10^{-2})$	144.3	292.7	294.5
Discrete inverse gamma	$\widehat{\sigma} = 8.199 \times 10^{-2}\,(3.821 \times 10^{-2})$, $\widehat{\xi} = 3.892 \times 10^{-1}\,(1.048 \times 10^{-1})$	132.9	269.9	271.7
Discrete inverse Gaussian	$\widehat{\sigma} = 789.5\,(919.1)$, $\widehat{\xi} = 32.7\,(10.9)$	133.0	270.1	271.9
Discrete Birnbaum Saunders	$\widehat{\sigma} = 146.0\,(49.4)$, $\widehat{\xi} = 2.8\,(0.5)$	129.5	263.1	264.9
Discrete half t	$\widehat{\nu} = 1.631 \times 10^{-1}\,(4.048 \times 10^{-2})$	144.8	291.7	292.6
Discrete Cauchy	$\widehat{\sigma} = 999.0\,(542.0)$	140.4	282.8	283.7
Discrete half logistic	$\widehat{\sigma} = 619.3\,(133.4)$	142.1	286.2	287.1

value, the smallest AIC value and the smallest BIC value when the perpetrators are US-led coalition with Iraqi forces.

Among the two-parameter models, the discrete Birnbaum Saunders distribution gives the smallest loglikelihood value, the smallest AIC value and the smallest BIC value when the perpetrators are both US-led coalition only and US-led coalition with Iraqi forces.

Overall, the discrete Birnbaum Saunders distribution gives the smallest loglikelihood value, the smallest AIC value and the smallest BIC value when the perpetrators are both US-led coalition only and US-led coalition with Iraqi forces. This distribution is one of the newly proposed distributions in Sect. 3.

Table 2 Fitted models when the perpetrators are US-led coalition with Iraqi forces

Distributions	Parameter estimates (SE)	$-\log L$	AIC	BIC
Poisson	$\widehat{\lambda} = 933.7\,(7.2)$	14,347.7	28,697.4	28,698.3
Geometric	$\widehat{p} = 1.070 \times 10^{-3}\,(2.751 \times 10^{-4})$	141.1	284.2	285.1
Logarithmic	$\widehat{p} = 9.999 \times 10^{-1}\,(1.000 \times 10^{-14})$	147.9	297.8	298.6
Yule	$\widehat{\rho} = 1.600 \times 10^{-1}\,(3.840 \times 10^{-2})$	157.6	317.1	318.0
Discrete gamma	$\widehat{\sigma} = 1,429.0\,(580.2)$, $\widehat{\xi} = 6.537 \times 10^{-1}\,(1.846 \times 10^{-1})$	139.8	283.7	285.4
Discrete Weibull	$\widehat{q} = 9.921 \times 10^{-1}\,(6.208 \times 10^{-3})$, $\widehat{\theta} = 7.330 \times 10^{-1}\,(1.068 \times 10^{-1})$	139.1	282.2	284.0
Discrete inverse Weibull	$\widehat{q} = 1.030 \times 10^{-7}\,(2.923 \times 10^{-6})$, $\widehat{\theta} = 4.886 \times 10^{-1}\,(1.895 \times 10^{-2})$	141.2	286.3	288.1
Zeta	$\widehat{s} = 1.155\,(3.663 \times 10^{-2})$	157.9	317.7	318.6
Discrete Burr	$\widehat{a} = 3.987\,(6.994 \times 10^{-1})$, $\widehat{b} = 4.246 \times 10^{-2}\,(9.391 \times 10^{-1})$	156.3	316.6	318.3
Generalized discrete Pareto	$\widehat{\sigma} = 472.9\,(197.9)$, $\widehat{\xi} = 5.230 \times 10^{-1}\,(3.672 \times 10^{-1})$	138.3	280.6	282.3
Discrete Fréchet	$\widehat{\sigma} = 185.2\,(57.3)$, $\widehat{\xi} = 8.068 \times 10^{-1}\,(1.478 \times 10^{-1})$	138.1	280.2	282.0
Discrete half normal	$\widehat{\sigma} = 1,883.0\,(313.4)$	148.8	299.6	300.5
Discrete lognormal	$\widehat{\mu} = 5.906\,(3.270 \times 10^{-1})$, $\widehat{\sigma} = 1.387\,(2.313 \times 10^{-1})$	137.7	279.5	281.3
Discrete F	$\widehat{\nu_1} = 11,661.6\,(2,054.1)$, $\widehat{\nu_2} = 3.112 \times 10^{-1}\,(7.837 \times 10^{-2})$	160.3	324.6	326.4
Discrete inverse gamma	$\widehat{\sigma} = 8.253 \times 10^{-3}\,(3.413 \times 10^{-3})$, $\widehat{\xi} = 7.410 \times 10^{-1}\,(2.160 \times 10^{-1})$	138.3	280.6	282.3
Discrete inverse Gaussian	$\widehat{\sigma} = 934.2\,(478.4)$, $\widehat{\xi} = 198.2\,(66.1)$	137.4	278.8	280.6
Discrete Birnbaum Saunders	$\widehat{\sigma} = 397.0\,(113.3)$, $\widehat{\xi} = 1.7\,(0.3)$	137.3	278.6	280.3
Discrete half t	$\widehat{\nu} = 1.435 \times 10^{-1}\,(3.538 \times 10^{-2})$	160.7	323.3	324.2
Discrete Cauchy	$\widehat{\sigma} = 391.9\,(143.6)$	138.8	279.7	280.6
Discrete half logistic	$\widehat{\sigma} = 709.4\,(149.0)$	143.9	289.7	290.6

4.2 Effect of provinces

We investigate the effect of provinces on the number of deaths. The discrete Birnbaum Saunders distribution has two parameters: the shape parameter, ξ, and the scale parameter, σ. We fitted the following models:

Model 1: ξ is the same for each province, σ is the same for each province;
Model 2: ξ is the same for each province, σ is different for each province;
Model 3: ξ is different for each province, σ is the same for each province;
Model 4: ξ is different for each province, σ is different for each province.

We obtained the values of $-\log L = 869.0, 825.6, 834.9$ and 783.5 for Models 1–4, respectively, when the perpetrators are US-led coalition only. The values of $-\log L = 1131.3, 1066.9, 1091.0$ and 997.3 were obtained for Models 1–4, respectively, when the perpetrators are US-led coalition with Iraqi forces. It follows by the standard likelihood ratio test that both the shape and scale parameters are different for each province.

4.3 Effect of causes of death

We investigate the effect of the cause of death (explosives, air attacks, gunfire or suicide attacks) on the number of deaths. We fitted the following models:

Model 1: ξ is the same for each cause, σ is the same for each cause;
Model 2: ξ is the same for each cause, σ is different for each cause;
Model 3: ξ is different for each cause, σ is the same for each cause;
Model 4: ξ is different for each cause, σ is different for each cause.

We obtained the values of $-\log L = 285.5, 284.1, 284.7$ and 271.4 for Models 1–4, respectively, when the perpetrators are US-led coalition only. The values of $-\log L = 359.5, 355.8, 358.0$ and 324.5 were obtained for Models 1–4, respectively, when the perpetrators are US-led coalition with Iraqi forces. It follows by the standard likelihood ratio test that both the shape and scale parameters are different for each cause.

4.4 Effect of time

We seek how the number of deaths varies with respect to time. Scatter plots of the data not shown here suggest that the predominant pattern is a decrease in the number of deaths with respect to time. A decrease can be represented by several mathematical forms. A simplest form is a linear one. We fitted the following models:

Model 1: $\sigma = \exp(a)$, $\xi = \exp(b)$;
Model 2: $\sigma = \exp(a)$, $\xi = \exp(b + c \times \text{time})$;
Model 3: $\sigma = \exp(a + c \times \text{time})$, $\xi = \exp(b)$;
Model 4: $\sigma = \exp(a + c \times \text{time})$, $\xi = \exp(b + c \times \text{time})$;
Model 5: $\sigma = \exp(a + b \times \text{time})$, $\xi = \exp(a + c \times \text{time})$;
Model 6: $\sigma = \exp(a + b \times \text{time})$, $\xi = \exp(c + d \times \text{time})$.

Time is in the units of a 6-month period. The exponentiation is used because both the scale and shape parameters are positive by definition. Model 1 supposes that both parameters are independent of time. Model 2 supposes that the shape parameter varies linearly with respect to time but the scale parameter remains independent. Model 3 supposes that the scale parameter varies linearly with respect to time but the shape parameter remains independent. Model 4 supposes that both parameters vary linearly with respect to time but with the same slope. Model 5 supposes that both parameters vary linearly with respect to time but with the same intercept. Model 6 supposes that both parameters vary linearly with respect to time with no restrictions on slope or intercept.

We fitted Models 1–6 to data from each province and to data corresponding to each cause of death when the perpetrators are US-led coalition only or US-led coalition with Iraqi forces. The best fitting models as determined by the likelihood ratio test are shown in Tables 3, 4, 5 and 6.

The number of deaths in Baghdad, Anbar, Babylon, Basrah, Diyala, Ninewa, Tameem and Thi-Qar shows a decreasing trend (the slope parameter for σ is significantly negative).

Table 3 Best fitting models by province when the perpetrators are US-led coalition only

Provinces	Models	Parameter estimates (SE)
Baghdad	3	$\widehat{a} = 8.851\ (1.082)$, $\widehat{b} = 1.300\ (1.983 \times 10^{-1})$, $\widehat{c} = -6.834 \times 10^{-1}\ (1.002 \times 10^{-1})$
Anbar	3	$\widehat{a} = 7.763\ (7.299 \times 10^{-1})$, $\widehat{b} = 9.013 \times 10^{-1}\ (1.870 \times 10^{-1})$, $\widehat{c} = -6.126 \times 10^{-1}\ (6.802 \times 10^{-2})$
Babylon	3	$\widehat{a} = 4.032\ (8.052 \times 10^{-1})$, $\widehat{b} = 1.112\ (1.808 \times 10^{-1})$, $\widehat{c} = -3.055 \times 10^{-1}\ (6.031 \times 10^{-2})$
Basrah	3	$\widehat{a} = 5.362\ (1.052)$, $\widehat{b} = 1.099\ (1.736 \times 10^{-1})$, $\widehat{c} = -4.678 \times 10^{-1}\ (7.980 \times 10^{-2})$
Dahuk	3	$\widehat{a} = -6.488\ (1.105)$, $\widehat{b} = 6.262 \times 10^{-1}\ (2.085 \times 10^{-1})$, $\widehat{c} = 3.925 \times 10^{-1}\ (1.110 \times 10^{-1})$
Diyala	3	$\widehat{a} = 4.815\ (6.234 \times 10^{-1})$, $\widehat{b} = 3.420 \times 10^{-1}\ (1.769 \times 10^{-1})$, $\widehat{c} = -2.268 \times 10^{-1}\ (6.205 \times 10^{-2})$
Erbil	1	$\widehat{a} = -2.171\ (3.979 \times 10^{-1})$, $\widehat{b} = 1.081\ (2.056 \times 10^{-1})$
Kerbala	6	$\widehat{a} = 5.258\ (5.127 \times 10^{-1})$, $\widehat{b} = -7.623 \times 10^{-1}\ (1.002 \times 10^{-1})$, $\widehat{c} = -5.504 \times 10^{-1}\ (4.165 \times 10^{-1})$, $\widehat{d} = 1.831 \times 10^{-1}\ (6.314 \times 10^{-2})$
Missan	1	$\widehat{a} = -1.384\ (3.366 \times 10^{-1})$, $\widehat{b} = 1.537\ (1.670 \times 10^{-1})$
Muthanna	1	$\widehat{a} = -6.177 \times 10^{-1}\ (4.538 \times 10^{-1})$, $\widehat{b} = 1.891\ (2.140 \times 10^{-1})$
Najaf	4	$\widehat{a} = -9.147 \times 10^{-2}\ (4.651 \times 10^{-1})$, $\widehat{b} = 2.834\ (3.198 \times 10^{-1})$, $\widehat{c} = -1.801 \times 10^{-1}\ (3.512 \times 10^{-2})$
Ninewa	3	$\widehat{a} = 3.855\ (4.445 \times 10^{-1})$, $\widehat{b} = 1.076 \times 10^{-1}\ (1.829 \times 10^{-1})$, $\widehat{c} = -1.201 \times 10^{-1}\ (5.171 \times 10^{-2})$
Qadissiya	1	$\widehat{a} = -8.641 \times 10^{-1}\ (4.117 \times 10^{-1})$, $\widehat{b} = 1.692\ (1.955 \times 10^{-1})$
Salah al-Din	2	$\widehat{a} = 4.017\ (1.396 \times 10^{-1})$, $\widehat{b} = -1.665\ (3.281 \times 10^{-1})$, $\widehat{c} = 2.177 \times 10^{-1}\ (3.605 \times 10^{-2})$
Sulaymaniyah	1	$\widehat{a} = -2.264 \times 10^{-1}\ (6.068 \times 10^{-1})$, $\widehat{b} = 2.168\ (2.983 \times 10^{-1})$
Tameem	6	$\widehat{a} = 3.962\ (4.865 \times 10^{-1})$, $\widehat{b} = -3.938 \times 10^{-1}\ (5.747 \times 10^{-2})$, $\widehat{c} = -4.011 \times 10^{-1}\ (4.053 \times 10^{-1})$, $\widehat{d} = 1.343 \times 10^{-1}\ (3.906 \times 10^{-2})$
Thi-Qar	4	$\widehat{a} = 5.790 \times 10^{-2}\ (4.619 \times 10^{-1})$, $\widehat{b} = 3.020\ (3.104 \times 10^{-1})$, $\widehat{c} = -2.011 \times 10^{-1}\ (3.282 \times 10^{-2})$
Wassit	3	$\widehat{a} = 1.248\ (7.884 \times 10^{-1})$, $\widehat{b} = 1.558\ (1.851 \times 10^{-1})$, $\widehat{c} = -2.209 \times 10^{-1}\ (8.403 \times 10^{-2})$

The number of deaths in Dahuk and Salah al-Din shows an increasing trend (the slope parameter for σ is significantly positive). The number of deaths in Erbil, Missan, Qadissiya and Sulaymaniyah does not appear to show significant changes (neither of the slope parameters are significantly different from zero).

For Kerbala, Najaf and Wassit, the number of deaths shows a decreasing trend when the perpetrators are US-led coalition only and does not appear to show significant changes when the perpetrators are US-led coalition with Iraqi forces.

Table 4 Best fitting models by province when the perpetrators are US-led coalition with Iraqi forces

Provinces	Models	Parameter estimates (SE)
Baghdad	3	$\widehat{a} = 6.317\,(4.294 \times 10^{-1})$, $\widehat{b} = 2.060 \times 10^{-1}\,(1.716 \times 10^{-1})$, $\widehat{c} = -2.055 \times 10^{-1}\,(4.757 \times 10^{-2})$
Anbar	6	$\widehat{a} = 7.200\,(4.947 \times 10^{-1})$, $\widehat{b} = -3.680 \times 10^{-1}\,(3.715 \times 10^{-2})$, $\widehat{c} = 6.290 \times 10^{-1}\,(3.267 \times 10^{-1})$, $\widehat{d} = -7.388 \times 10^{-2}\,(2.953 \times 10^{-2})$
Babylon	3	$\widehat{a} = 3.874\,(9.210 \times 10^{-1})$, $\widehat{b} = 1.216\,(1.902 \times 10^{-1})$, $\widehat{c} = -2.829 \times 10^{-1}\,(6.447 \times 10^{-2})$
Basrah	3	$\widehat{a} = 5.927\,(8.606 \times 10^{-1})$, $\widehat{b} = 1.028\,(1.788 \times 10^{-1})$, $\widehat{c} = -4.353 \times 10^{-1}\,(7.152 \times 10^{-2})$
Dahuk	3	$\widehat{a} = -6.488\,(1.105)$, $\widehat{b} = 6.262 \times 10^{-1}\,(2.085 \times 10^{-1})$, $\widehat{c} = 3.925 \times 10^{-1}\,(1.110 \times 10^{-1})$
Diyala	3	$\widehat{a} = 4.505\,(5.057 \times 10^{-1})$, $\widehat{b} = 2.088 \times 10^{-1}\,(1.667 \times 10^{-1})$, $\widehat{c} = -1.301 \times 10^{-1}\,(4.647 \times 10^{-2})$
Erbil	1	$\widehat{a} = -1.878\,(4.153 \times 10^{-1})$, $\widehat{b} = 1.191\,(2.096 \times 10^{-1})$
Kerbala	1	$\widehat{a} = 2.818\,(3.587 \times 10^{-1})$, $\widehat{b} = 4.777 \times 10^{-1}\,(2.140 \times 10^{-1})$
Missan	1	$\widehat{a} = -1.029\,(3.630 \times 10^{-1})$, $\widehat{b} = 1.648\,(1.773 \times 10^{-1})$
Muthanna	3	$\widehat{a} = 1.278\,(9.371 \times 10^{-1})$, $\widehat{b} = 1.410\,(1.849 \times 10^{-1})$, $\widehat{c} = -2.572 \times 10^{-1}\,(9.890 \times 10^{-2})$
Najaf	1	$\widehat{a} = 4.347 \times 10^{-1}\,(4.822 \times 10^{-1})$, $\widehat{b} = 2.144\,(2.175 \times 10^{-1})$
Ninewa	6	$\widehat{a} = 4.545\,(3.914 \times 10^{-1})$, $\widehat{b} = -8.946 \times 10^{-2}\,(2.491 \times 10^{-2})$, $\widehat{c} = 1.110\,(3.731 \times 10^{-1})$, $\widehat{d} = -1.722 \times 10^{-1}\,(3.507 \times 10^{-2})$
Qadissiya	1	$\widehat{a} = -8.285 \times 10^{-1}\,(3.718 \times 10^{-1})$, $\widehat{b} = 1.743\,(1.786 \times 10^{-1})$
Salah al-Din	2	$\widehat{a} = 4.066\,(1.484 \times 10^{-1})$, $\widehat{b} = -1.472\,(3.254 \times 10^{-1})$, $\widehat{c} = 1.791 \times 10^{-1}\,(2.989 \times 10^{-2})$
Sulaymaniyah	1	$\widehat{a} = -6.637 \times 10^{-1}\,(4.001 \times 10^{-1})$, $\widehat{b} = 1.910\,(1.912 \times 10^{-1})$
Tameem	6	$\widehat{a} = 3.950\,(3.390 \times 10^{-1})$, $\widehat{b} = -3.165 \times 10^{-1}\,(4.706 \times 10^{-2})$, $\widehat{c} = -7.922 \times 10^{-1}\,(3.391 \times 10^{-1})$, $\widehat{d} = 1.404 \times 10^{-1}\,(3.190 \times 10^{-2})$
Thi-Qar	4	$\widehat{a} = -3.346 \times 10^{-2}\,(3.844 \times 10^{-1})$, $\widehat{b} = 2.913\,(2.951 \times 10^{-1})$, $\widehat{c} = -1.178 \times 10^{-1}\,(2.611 \times 10^{-2})$
Wassit	1	$\widehat{a} = -3.116 \times 10^{-1}\,(4.001 \times 10^{-1})$, $\widehat{b} = 1.803\,(1.844 \times 10^{-1})$

Table 5 Best fitting models by cause of death when the perpetrators are US-led coalition only

Provinces	Models	Parameter estimates (SE)
Explosives	6	$\widehat{a} = 6.159\,(6.858 \times 10^{-1})$, $\widehat{b} = -4.559 \times 10^{-1}\,(7.101 \times 10^{-1})$, $\widehat{c} = 4.288 \times 10^{-1}\,(3.716 \times 10^{-1})$, $\widehat{d} = 9.107 \times 10^{-2}\,(3.704 \times 10^{-2})$
Air attacks	3	$\widehat{a} = 5.134\,(1.382)$, $\widehat{b} = 1.817\,(2.109 \times 10^{-1})$, $\widehat{c} = -4.029 \times 10^{-1}\,(1.132 \times 10^{-1})$
Gunfire	3	$\widehat{a} = 7.432\,(4.230 \times 10^{-1})$, $\widehat{b} = -1.418 \times 10^{-2}\,(1.667 \times 10^{-1})$, $\widehat{c} = -3.225 \times 10^{-1}\,(3.963 \times 10^{-2})$
Suicide attacks	1	$\widehat{a} = -1.070\,(5.223 \times 10^{-1})$, $\widehat{b} = 1.762\,(2.619 \times 10^{-1})$

Table 6 Best fitting models by cause of death when the perpetrators are US-led coalition with Iraqi forces

Provinces	Models	Parameter estimates (SE)
Explosives	3	$\widehat{a} = 5.666\,(6.081 \times 10^{-1})$, $\widehat{b} = 5.767 \times 10^{-1}\,(1.726 \times 10^{-1})$, $\widehat{c} = -1.953 \times 10^{-1}\,(6.260 \times 10^{-2})$
Air attacks	3	$\widehat{a} = 5.099\,(1.510)$, $\widehat{b} = 1.883\,(2.212 \times 10^{-1})$, $\widehat{c} = -3.920 \times 10^{-1}\,(1.249 \times 10^{-1})$
Gunfire	3	$\widehat{a} = 6.892\,(3.317 \times 10^{-1})$, $\widehat{b} = -3.124 \times 10^{-1}\,(1.667 \times 10^{-1})$, $\widehat{c} = -1.478 \times 10^{-1}\,(3.106 \times 10^{-2})$
Suicide attacks	1	$\widehat{a} = -9.451 \times 10^{-1}\,(3.651 \times 10^{-1})$, $\widehat{b} = 1.787\,(1.796 \times 10^{-1})$

For Muthanna, the number of deaths shows a decreasing trend when the perpetrators are US-led coalition with Iraqi forces and does not appear to show significant changes when the perpetrators are US-led coalition only.

The number of deaths due to explosives, air attacks and gunfire shows a decreasing trend (the slope parameter for σ is significantly negative). The number of deaths due to suicide attacks does not appear to show significant changes (neither of the slope parameters are significantly different from zero).

4.5 Predictions

Using the best fitting models in Sect. 4.4, one can give useful predictions on the number of deaths into the future. Tables 7, 8, 9 and 10 give predictions up to and including the second six-month period of 2015. The numbers given in these tables are the median, 95th- and the 99th percentile of the number of deaths.

The number of deaths perpetrated by US-led coalition with Iraqi forces is generally higher than that perpetrated by US-led coalition only. The number of deaths predicted for Salah al-Din appears unusually high.

5 Conclusions

We have provided a statistical analysis of the number of civilians deaths from the Iraq conflict. Some of the main conclusions are: (i) the discrete Birnbaum Saunders distribution gives the best possible fit to the number of deaths, (ii) the distribution of the number of deaths differs significantly among the 18 provinces, (iii) the distribution of the number of deaths differs significantly among the four causes, (iv) the number of deaths in Baghdad, Anbar, Babylon, Basrah, Diyala, Ninewa, Tameem and Thi-Qar shows a decreasing trend, (v) the number of deaths in Dahuk and Salah al-Din shows an increasing trend, (vi) the number of deaths in Erbil, Missan, Qadissiya and Sulaymaniyah does not appear to show significant changes, (vii) the number of deaths due to explosives, air attacks and gunfire shows a decreasing trend, and (viii) the number of deaths due to suicide attacks does not appear to show significant changes.

Table 7 Predictions by province of number of deaths perpetrated by US-led coalition only

Year	Baghdad	Anbar	Babylon	Basrah	Dahuk	Diyala	Erbil	Kerbala	Missan	Muthanna	Najaf	Ninewa	Qadissiya	Salah al-Din	Sulaymaniyah	Tameem	Thi-Qar	Wassit
2008	– – –	– – –	– – –	– – –	– – –	– – –	– – –	0 2 3	– – –	1 65 129	– – –	– – –	– – –	– – –	– – –	– – –	– – –	– – –
2009	– – –	– – –	– – –	– – –	0 3 5	– – –	0 3 6	0 1 2	– – –	1 65 129	0 1 1	– – –	– – –	– – –	– – –	– – –	0 1 1	– – –
2009	– – –	– – –	– – –	– – –	0 4 8	– – –	0 3 6	0 1 1	– – –	1 65 129	0 1 1	– – –	– – –	– – –	1 167 331	– – –	0 0 1	– – –
2010	– – –	– – –	– – –	– – –	1 6 11	– – –	0 3 6	0 0 1	– – –	1 65 129	0 0 1	– – –	0 34 68	56 3797 7485	1 167 331	– – –	0 0 0	– – –
2010	– – –	– – –	– – –	– – –	1 9 17	– – –	0 3 6	0 0 1	– – –	1 65 129	0 0 0	7 36 59	0 34 68	56 5809 11509	1 167 331	– – –	0 0 0	– – –
2011	0 2 5	0 1 2	– – –	– – –	1 14 25	3 19 33	0 3 6	0 0 0	– – –	1 65 129	0 0 0	6 32 53	0 34 68	56 8918 17728	1 167 331	– – –	0 0 0	0 5 10
2011	0 1 2	0 1 1	– – –	0 1 2	2 20 37	2 15 26	0 3 6	0 0 0	– – –	1 65 129	0 0 0	5 28 47	0 34 68	56 13723 27340	1 167 331	– – –	0 0 0	0 4 8
2012	0 1 1	0 0 1	0 5 9	0 1 1	3 30 55	2 12 21	0 3 6	0 0 0	0 15 30	1 65 129	0 0 0	5 25 41	0 34 68	56 21150 42196	1 167 331	0 6 12	0 0 0	0 3 7
2012	0 0 1	0 0 0	0 3 7	0 0 1	4 44 82	1 10 17	0 3 6	0 0 0	0 15 30	1 65 129	0 0 0	4 22 37	0 34 68	56 32629 65158	1 167 331	0 5 10	0 0 0	0 3 5
2013	0 0 0	0 0 0	0 2 5	0 0 1	6 66 121	1 8 13	0 3 6	0 0 0	0 15 30	1 65 129	0 0 0	4 20 33	0 34 68	56 50371 100647	1 167 331	0 5 9	0 0 0	0 2 4
2013	0 0 0	0 0 0	0 2 4	0 0 0	9 97 179	1 6 11	0 3 6	0 0 0	0 15 30	1 65 129	0 0 0	3 17 29	0 34 68	56 77793 155499	1 167 331	0 4 8	0 0 0	0 2 3
2014	0 0 0	0 0 0	0 1 3	0 0 0	13 144 265	1 5 8	0 3 6	0 0 0	0 15 30	1 65 129	0 0 0	3 15 26	0 34 68	56 120176 240277	1 167 331	0 4 7	0 0 0	0 1 3
2014	0 0 0	0 0 0	0 1 2	0 0 0	19 214 392	1 4 7	0 3 6	0 0 0	0 15 30	1 65 129	0 0 0	3 14 23	0 34 68	56 185683 371311	1 167 331	0 3 6	0 0 0	0 1 2
2015	0 0 0	0 0 0	0 1 1	0 0 0	28 316 581	0 3 5	0 3 6	0 0 0	0 15 30	1 65 129	0 0 0	2 12 20	0 34 68	56 286931 573836	1 167 331	0 3 6	0 0 0	0 1 2
2015	0 0 0	0 0 0	0 1 1	0 0 0	41 468 860	0 2 4	0 3 6	0 0 0	0 15 30	1 65 129	0 0 0	2 11 18	0 34 68	56 443418 886858	1 167 331	0 2 5	0 0 0	0 1 1

Table 8 Predictions by province of number of deaths perpetrated by US-led coalition and Iraqi forces

Year	Baghdad	Anbar	Babylon	Basrah	Dahuk	Diyala	Erbil	Kerbala	Missan	Muthanna	Najaf	Ninewa	Qadissiya	Salah al-Din	Sulaymaniyah	Tameem	Thi-Qar	Wassit
2008	– – –	– – –	– – –	– – –	– – –	– – –	– – –	17 149 268	– – –	– – –	– – –	– – –	– – –	– – –	– – –	– – –	– – –	– – –
2009	– – –	– – –	– – –	– – –	0 3 5	– – –	0 5 9	17 149 268	– – –	– – –	2 307 612	– – –	– – –	– – –	– – –	– – –	– – –	– – –
2009	– – –	– – –	– – –	– – –	0 4 8	– – –	0 5 9	17 149 268	– – –	– – –	2 307 612	– – –	– – –	– – –	– – –	– – –	– – –	– – –
2010	– – –	– – –	– – –	– – –	1 6 11	– – –	0 5 9	17 149 268	– – –	– – –	2 307 612	– – –	– – –	– – –	– – –	– – –	– – –	– – –
2010	– – –	– – –	– – –	– – –	1 9 17	– – –	0 5 9	17 149 268	– – –	– – –	2 307 612	– – –	– – –	– – –	– – –	– – –	– – –	– – –
2011	– – –	– – –	– – –	– – –	1 14 25	– – –	0 5 9	17 149 268	– – –	0 2 4	2 307 612	– – –	– – –	– – –	– – –	– – –	– – –	– – –
2011	14 81 138	– – –	– – –	0 3 7	2 20 37	– – –	0 5 9	17 149 268	– – –	0 2 3	2 307 612	– – –	0 39 78	– – –	1 65 128	– – –	0 2 3	1 74 147
2012	11 66 112	1 3 3	0 7 14	0 2 4	3 30 55	8 45 77	0 5 9	17 149 268	0 27 53	0 1 3	2 307 612	17 21 22	0 39 78	58 7614 15113	1 65 128	0 15 29	0 1 2	1 74 147
2012	9 54 91	1 2 2	0 6 11	0 1 3	4 44 82	7 40 68	0 5 9	17 149 268	0 27 53	0 1 2	2 307 612	16 18 20	0 39 78	58 10842 21572	1 65 128	0 14 28	0 1 2	1 74 147
2013	7 44 74	1 1 1	0 4 8	0 1 2	6 66 121	6 35 60	0 5 9	17 149 268	0 27 53	0 1 2	2 307 612	14 16 17	0 39 78	58 15462 30812	1 65 128	0 14 27	0 1 1	1 74 147
2013	6 36 61	0 1 1	0 3 6	0 1 1	9 97 179	5 31 52	0 5 9	17 149 268	0 27 53	0 1 1	2 307 612	13 15 15	0 39 78	58 22070 44030	1 65 128	0 13 26	0 1 1	1 74 147
2014	5 29 49	0 0 1	0 2 5	0 0 1	13 144 265	5 27 46	0 5 9	17 149 268	0 27 53	0 0 1	2 307 612	12 13 14	0 39 78	58 31524 62941	1 65 128	0 13 25	0 0 1	1 74 147
2014	4 24 40	0 0 0	0 2 3	0 0 0	19 214 392	4 24 40	0 5 9	17 149 268	0 27 53	0 0 1	2 307 612	11 12 12	0 39 78	58 45050 89996	1 65 128	0 12 24	0 0 0	1 74 147
2015	3 19 33	0 0 0	0 1 3	0 0 0	28 316 581	3 21 35	0 5 9	17 149 268	0 27 53	0 0 1	2 307 612	10 11 11	0 39 78	58 64400 128703	1 65 128	0 12 24	0 0 0	1 74 147
2015	3 16 27	0 0 0	0 1 2	0 0 0	41 468 860	3 18 31	0 5 9	17 149 268	0 27 53	0 0 0	2 307 612	9 10 10	0 39 78	58 92083 184077	1 65 128	0 11 23	0 0 0	1 74 147

Table 9 Predictions by cause of number of deaths perpetrated by US-led coalition only

Years	Explosives	Air attacks	Gunfire	Suicide attacks
2009	– – –	– – –	– – –	0 32 64
2009	– – –	– – –	– – –	0 32 64
2010	– – –	– – –	– – –	0 32 64
2010	– – –	– – –	– – –	0 32 64
2011	– – –	– – –	– – –	0 32 64
2011	0 22 44	– – –	– – –	0 32 64
2012	0 17 33	0 8 17	4 16 26	0 32 64
2012	0 13 25	0 6 11	3 12 19	0 32 64
2013	0 10 19	0 4 7	2 9 14	0 32 64
2013	0 7 15	0 3 5	1 6 10	0 32 64
2014	0 6 11	0 2 3	1 4 7	0 32 64
2014	0 4 8	0 1 2	1 3 5	0 32 64
2015	0 3 6	0 1 1	1 2 4	0 32 64
2015	0 2 5	0 1 1	0 2 3	0 32 64

Table 10 Predictions by cause of number of deaths perpetrated by US-led coalition and Iraqi forces

Years	Explosives	Air attacks	Gunfire	Suicide attacks
2011	– – –	– – –	– – –	0 38 76
2011	9 90 164	– – –	– – –	0 38 76
2012	7 74 135	0 11 22	59 186 278	0 38 76
2012	6 61 111	0 8 15	51 160 240	0 38 76
2013	5 50 91	0 5 10	44 138 207	0 38 76
2013	4 41 75	0 3 7	38 119 179	0 38 76
2014	3 34 62	0 2 5	33 103 154	0 38 76
2014	3 28 51	0 2 3	28 89 133	0 38 76
2015	2 23 42	0 1 2	24 77 115	0 38 76
2015	2 19 34	0 1 1	21 66 99	0 38 76

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