While statements on the human costs of war typically focus on persons killed, wounded or arrested, everyone is embedded in a network of people who love and care for them. If we widen our focus from directly affected individuals to indirectly affected friends and families, we can begin to gauge the wider implications of war and terror. Such implications are eminently practical. For example, having a close friend or relative arrested, detained or killed probably influences one's likelihood of joining a resistance movement (Weinberg et al. 2003). When civilians are killed in the crossfire, their family is likely to react with resistance. That is, just as Hercules' famous opponent grew two new heads for every one severed, arresting, detaining and killing (potential) opponents can create new opponents. Similarly, people may be much less likely to support a war if they are directly connected to the casualties. These points raise an obvious empirical question: *how many people know somebody who has been a casualty or target of the United States' war on terror?*

We do not have the data needed for a direct answer to this question. We can, however, generate good estimates based on typical network sizes and counts of the numbers of people killed or detained. Known as the "network scale-up" problem in studies of social networks, this has been studied extensively by social scientists (Bernard, Killworth, Johnsen, Shelley, and McCarty 2001; McCarty, Killworth, Bernard, Johnsen, and Shelley 2000; Johnsen, Bernard, Killworth, Shelley, and McCarty 1995; Killworth, Johnsen, McCarty, Shelley, and Bernard 1998).

For these estimates we need to know the number of people involved in an anti-terror "event" and the average number of people a typical person knows. Typical network size is difficult to gauge since it depends on what we mean by "know." If you only consider people you regularly talk with face-to-face, estimates can be quite small. If you extend size to people who mutually know each other's names, estimates fall somewhere in the few hundreds. If you extend this further to people you have ever interacted with, estimates range into the thousands (Bernard et al. 2001).

Here I use 2 types of estimates that bound the range of intimacy implied by different meanings of "know." The first is an estimate of extended family size. In most cultures, it is reasonable to assume that having a close relative killed would be more likely to generate action than simply knowing the name of a person killed. Here I use a Western model of extended family consisting of the types of relations with names: cousins, parents, grandparents, uncles, in-laws, children, nieces and nephews. The size of the extended kin network will be larger in cultures with more fine-grained kinship systems and depends crucially on the fertility rate. I provide low and high extended family size estimates[1] of 26 and 49 to account for these differences.

[1]If you assume every woman has 2 children (current non-extended family size of 4), the archetypical extended family size would be 26; if you assume 3 children (non-extended family size of 5), size goes to 49 if you assume 4 it goes to 80 (see Palmer, Steadman, and Coe 2006). This ignores married aunts and uncles (my mother's brother's wife, for example), though I do include the spouses of siblings (on both sides). This is somewhat arbitrary but reflects a sense that the spouses of age-similar relatives are likely more familiar than those of one's parent's generation. Kinship size would be smaller if you restricted attention to the father's line, which might be more salient in some settings. Excluding kin connected to ego only through the mother or spouse yields extended patrilineal kinship sizes of 15 if fertility were 2, 27 if it were 3 and 43 if it were 4. Network sketches for archetypical families are available from the author. Current US fertility rates suggest about 2.09 children per woman, in Afghanistan the rate is 6.69, in Iraq it is 4.18, though I use

The second class of estimates is based on mutual acquaintance networks – the people whose names you know who also know your name – and recent survey work puts the mean number of people an average American knows at about 290 (std. dev. = 232) (Bernard et al. 2001). There are few international estimates, though two estimates for Mexico suggest a size between 223 (Mexico City) and 192 (Oaxaca) (Bernard et al. 2003). While individual variance is large, we can think of this as an upper bound for "weak tie" networks. To bound this estimate for people in Iraq and Afghanistan, I use the US estimate of 290 as a high value and the 192 from Oaxaca as a low value. White and Houseman (2002) estimate that strong-tie kinship networks in the Middle East can be even more extensive than these estimates.

The second count needed is the number of people involved in an anti-terror event. The classes of events that interest us here are people killed during US action in Iraq and Afghanistan and those held as enemy combatants. Numbers for non-US casualties and detainees are not officially recorded. I use counts taken from various sources on July 30, 2006, listed below in Table 1. Given the difficulty with knowing true values, I use the lowest plausible estimates to be conservative. So, for example, while some have estimated as many as 80,000 people detained by US forces or up to 100,000 civilians killed (Roberts et al. 2004), I use much lower estimates commonly cited in the media. US casualties are from Department of Defense sources.

The final numbers we need are relevant population sizes. It is well known that networks have a small-world structure that take us to many parts of the world quickly (Killworth, Bernard and McCarty 1984; Watts 1999) and that the US war on terror is broad. Since my primary interest is to think about the widest social implications of anti-terror activity, I treat the relevant population as those living in a selection of Middle Eastern countries using a 2005 estimate for total population of 574M (M=Million), though I provide more limited estimates focused just on those living in Iraq and Afghanistan (53M) as well.[2] For estimates of Americans that know US casualties, I use 280M as the population estimate.

Table 1. Event counts & Sources

Event	Count	Source
People Killed by US led forces	39,460	http://www.iraqbodycount.net/
People detained as enemy combatants	30,000	http://www.humanrightsfirst.org/us_law/PDF/behind-the-wire-033005.pdf
US Soldiers killed in Iraq & Afghanistan	2,888	http://www.dod.gov/news/casualty.pdf (06.28.2006)
US Soldiers wounded in Iraq & Afghanistan	19,994	http://www.dod.gov/news/casualty.pdf (06.28.2006)

a smaller total family size estimate of 3 children as an upper bound to account for higher mortality in Iraq and Afghanistan, which will leave fewer living members of the extended kinship network.

[2] The population data come from Microsoft MapPoint 2006. The countries used are: Afghanistan , Bahrain, Egypt, Iran, Iraq, Jordan, Kuwait, Lebanon, Libya, Oman, Pakistan, Qatar, Saudi Arabia, Syria, Tunisia, Turkey, United Arab Emirates, Yemen. As it turns out, the total population size is a minor factor due to the relatively local nature of the networks.

Since all of the numbers used to make this estimate are difficult to know, rapidly changing and subject to different interpretations (what counts as family, for example), I provide a Java network scale-up calculator so that interested readers can estimate these figures based on assumptions they judge as more reasonable.[3] Similarly, to reflect the estimation uncertainty, I express values below as orders of magnitude (M=million, T=thousand).

The formulas for estimating the number of people who know at least one person in the event have been worked out previously, and I use the one provided in Killworth et al. (1998).[4] A little reorganization of their equation 2 gives us the following estimation equation:

$$p_r = 1 - (1 - \frac{e}{t})^c$$

where p_r is the proportion of the total population *(t)* who know somebody involved in the event whose number is given by *e*, and *c* is the average number of people a person knows. The number of people who know at least 1 person in the event class is thus $p_r t$. Applying the network scale-up formula provides the estimates given in Table 2 for the number of people who know somebody in the given event type.

Table 2. The number of people in the population who know …

	Selected Middle Eastern Countries				Iraq & Afghanistan			
Event	Family		Acquaintances		Family		Acquaintances	
	Low (26)	High (49)	Low (192)	High (290)	Low (26)	High (49)	Low (192)	High (290)
someone killed by US Forces:*	1.0M	1.9M	7.5M	11.3M	1.0M	1.9M	7.1M	10.3M
someone detained as an enemy combatant:*	779T	1.5M	5.7M	8.6M	775T	1.5M	5.5M	8.0M
	American							
a US Soldier killed**	75T	141T	554T	836T				
a US Soldier wounded**	519T	978T	3.8M	5.7M				

* These estimates use a Middle East population base (574M)
**These estimates use a US population base (280M).

The model suggests that between 1.0 and 1.9 million people in the Middle East have lost at least 1 family member due to US activities and just slightly fewer have at

[3] The calculator can be downloaded from the *Structure and Dynamics* webpage as supplemental material (at http://repositories.cdlib.org/cgi/viewcontent.cgi?filename=3&article=1052&context=imbs/socdyn/sdeas&type=additional) for this paper. Special thanks to Colin Odden for programming the calculator.

[4] My own simulation work shows that this formula provides very accurate estimates in complex networks given correct measures of network size and event counts, even though the mathematical foundation for these formulas assume people are randomly selected into events. Thus, even if we assume (a) strong clustering in the underlying network and (b) strong autocorrelation between members of the events (i.e. if I'm detained my contacts have a higher probability of being detained as well), the formulas provide excellent estimates. In principle, these estimates will be high proportional to the non-independence of involvement in the event. These simulations are available as SAS code on request.

least one family member held as an enemy combatant. These estimates do not differ much if you look just within Iraq or Afghanistan (because networks tend to be local). If we expand to mutual acquaintances, between 7.5 and 11.3 million people in the Middle East and 7.1 to 10.3 million people in Iraq and Afghanistan know somebody who has been killed as a result of US actions in the war on terror. An additional 5.7 to 8.6 million people know somebody who has been detained as an enemy combatant.

The costs to American families are also larger than many might appreciate: the 2,888 US service members killed in Iraq and Afghanistan leave behind between 75,000 and 141,000 family members and about 800,000 friends and acquaintances. Between 519,000 and 800,000 thousand people have a wounded family member while about 5.7 million Americans know a wounded soldier.

We typically think of the cost of war in terms of the people killed or injured. But when people die, they leave behind close friends and family who love them. Those left behind grieve; and surely some will turn this grief to anger and revenge, suggesting that for each person we kill or arrest we probably generate new opponents. Social network analysis can help us identify the magnitude of these social multiplier effects, though future work would benefit from more precise estimates of size of local networks in more countries as well as direct research on how being connected to casualties affects the likelihood of joining a resistance movement or supporting military action. A network perspective rests on the social embeddedness of actors, highlighting how each are connected to a wider web of friends and loved ones. As we consider the *social* costs of war, we should thus consider both those affected directly as well as those indirectly reached through friends and family.

References

Bernard, H. Russell, Peter D. Killworth, Eugene C. Johnsen, Gene A. Shelley, and Christopher McCarty. 2001. “Estimating the Ripple Effect of a Disaster.” *Connections* 24(2):30-34. http://www.insna.org/Connections-Web/Volume24-2/242-Bernard.pdf

Bernard, H. Russell, Chris McCarty, Peter D. Killworth, Gene A. Shelley, and Eugene C. Johnsen. 2003. “Comparing Personal Network Size and Content in Mexico and the U.S.” Sunbelt Social Networks Conference Presentation, Cancún, Quintana Roo, México, February 12-16, 2003.

Johnsen, Eugene C., H. Russell Bernard, Peter D. Killworth, Gene A. Shelley, and Christopher McCarty. 1995. “A Social Network Approach to Corroborating the Number of AIDS/HIV+ Victims in the US.” *Social Networks* 17:167-87.

Killworth, Peter D., H. Russell Bernard, and Christopher McCarty. 1984. “Measuring Patterns of Acquaintance.” *Current Anthropology* 25:381-397.

Killworth, Peter D., Eugene C. Johnsen, Christopher McCarty, Gene A. Shelley, and H. Russell Bernard. 1998. “A Social Network Approach to Estimating Seroprevalence in the United States.” *Social Networks* 20(1):23-50.

McCarty, Christopher, Peter D. Killworth, H. Russell Bernard, Eugene C. Johnsen, and Gene A. Shelley. 2000. “Comparing Two Methods for Estimating Network Size.” *Human Organization* 60:28-39.

Microsoft MapPoint. 2006. http://www.microsoft.com/mappoint.

Palmer, Craig T., Lyle B. Steadman, and Kathryn Coe. 2006. "More Kin: An Effect of the Tradition of Marriage." *Structure and Dynamics* 1(2):250-266. http://repositories.cdlib.org/imbs/socdyn/sdeas/vol1/iss2/art4/

Roberts, Les, Riyadh Lafta, Richard Garfield, Jamal Khudhairi, and Gilbert Burnham. 2004. "Mortality Before and After the 2003 Invasion of Iraq: Cluster Sample Survey. *The Lancet* 364(9448):1857-64. http://linkinghub.elsevier.com/retrieve/pii/S0140673604174412. http://dx.doi.org/10.1016/S0140-6736(04)17441-2

Watts, Duncan J. 1999. *Small Worlds: The Dynamics of Networks Between Order and Randomness*. Princeton: Princeton University Press.

Weinberg, Leonard, Ami Pedahzur, and Daphna Canetti-Nisim. 2003. "The Social and Religious Characteristics of Suicide Bombers and their Victims." *Terrorism and Political Violence*. 15:139-153.

White, Douglas R., and Michael Houseman. 2002. "The Navigability of Strong Ties: Small Worlds, Tie Strength and Network Topology." *Complexity* 8(1):72-81. Networks and Complexity Special Issue. http://repositories.cdlib.org/hcs/DRW2002A