Murder and Medicine

The Lethality of Criminal Assault 1960-1999

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Despite the proliferation of increasingly dangerous weapons and the very large increase in rates of serious criminal assault, since 1960, the lethality of such assault in the United States has dropped dramatically. This paradox has barely been studied and needs to be examined using national time-series data. Starting from the basic view that homicides are aggravated assaults with the outcome of the victim's death, we assembled evidence from national data sources to show that the principal explanation of the downward trend in lethality involves parallel developments in medical technology and related medical support services that have suppressed the homicide rate compared to what it would be had such progress not been made. We argue that research into the causes and deterrability of homicide would benefit from a "lethality perspective" that focuses on serious assaults, only a small proportion of which end in death.

According to Vital Statistics, the gold standard of U.S. natality and mortality measurement since 1931, the U.S. homicide rate has not strayed more than 51% from its level of 9.2 per 100,000 population (National Center for Health Statistics [NCHS], 2000). By 1998, the Vital Statistics rate stood at 6.8, 26% lower than the 1931 level. In

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similar fashion, since the start of the FBI's national Uniform Crime Report (UCR) data series in 1931, the U.S. homicide rate as measured by UCR has not strayed more than 45% from its baseline level of 8.2 per 100,000 population. By 1998, the published rate stood at 6.3, 25% below its 1931 baseline. In comparison, by 1998, the UCR aggravated assault rate was about 700% higher than its 1931 baseline (Federal Bureau of Investigation, 1931-1997). UCR data show increases in rates of other violent crimes similar to those for aggravated assault. It is homicide that has, paradoxically, barely changed.[1]

Although nearly so, the paradox has not gone entirely unnoticed. Over the years, a handful of criminologists have noticed the disparity between homicide and aggravated assault trends and speculated on its potential importance (e.g., Blumstein, 2000; Lattimore, Trudeau, Riley, Leiter, & Edwards, 1997; Morris & Hawkins, 1970; Wilson, 1985; Wolfgang, 1958), but there is no systematic published national-level research on the topic. Considering the theoretical and policy-related importance of the issues surrounding it, we think the trend needs to be examined using data that are national in scope and as broad in time span as possible, and placed squarely on the national agenda for discussion, policy debate, and long-term research. In the present research, we go on to examine this paradoxical trend in criminal lethality, using recently available U.S. data on weapons use in assaults and homicides from 1964 to 1999 and countywide assault and homicide data from 1960 to 1997.

Although not explicitly concerned with describing or explaining national historical trends involving the aggravated assault/homicide paradox, previous criminological research that examines the link between medical resources and homicide, particularly Doerner's work (1983, 1988; Doerner & Speir, 1986), provides a critical building block in our analysis (see also Barlow &

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Barlow, 1988; Giacopassi, Sparger, & Stein, 1992; Long-Onnen & Cheatwood, 1992). Relying on this research, we think the best starting point in explaining the homicide paradox involves the observation of parallel, dramatic developments in medical technology and related support services,[2] developments that may have functionally, and equally dramatically, suppressed the homicide rate compared to what it would be had such progress not been made. If so, this success has ironically masked the perception that America continues to face extraordinarily high levels of criminal violence. Compared to 1960, the year our analysis begins, we estimate that without these developments in medical technology there would have been between 45,000 and 70,000 homicides annually the past 5 years instead of an actual 15,000 to 20,000.

The General Impact of Innovations in Trauma Care

Since World War II, and particularly since the Vietnam War of the 1960s and 1970s, much has been published in medical journals concerning the development of emergency and trauma medicine as clinical specialties (Rosen & Anderson, 1998; Trunkey, 2000), with a particular emphasis on the differential mortality of trauma patients. Many of these studies document a dramatic overall decrease in trauma mortality over the second half of the 20th century (DeVivo, Krause, & Lammertse, 1999; Norwood, Fernandez, & England, 1995; O'Keefe, Jurkovich, Copass, & Maier, 1999; Roberts, Campbell, Hollis, & Yates, 1996; Ruchholtz et al., 1998; Sampalis, Lavoie, Williams, Mulder, & Kalina, 1993). Controlling for severity of injury, these studies show annual mortality drops ranging from 3% to more than 16%. Despite the greater difficulties of acuity-matching in penetrating trauma, such investigations have demonstrated that technological and other medical improvements (LeBlang & Dolich, 2000) have led to substantial mortality reduction (Ferrada & Birolini, 1999; Murray, Berne, & Asensio, 1998; Parks, Chrysos, & Diamond, 1999) among patients with penetrating trauma. There is thus a highly compelling base of medical evidence to justify the hypothesis that dramatic improvements in the reduction of trauma-induced mortality in general have likely also characterized a parallel reduction in criminally induced trauma mortality.

Such evidence looks at a variety of factors affecting trauma mortality in general, including level of emergency medical care on scene, Basic Life Support (BLS) versus Advanced (ALS) training of EMS personnel, police, and firemen; helicopter versus ambulance transport; the trauma-care level and patient volume of the receiving hospital; urban setting versus rural setting; penetrating versus blunt trauma; the availability of on-site versus on-call surgeons; and so on. Injuries in these mortality studies are not necessarily produced by violent assault but include the results of accidents as well. Some studies document the impact of mortality on trauma centers and prehospital time (Norwood et al., 1995; O'Keefe et al., 1999; Pepe & Eckstein, 1998; Sampalis et al., 1993). Others focus on urban/rural differences in mortality from trauma (Esposito, Sanddal, Hansen, & Reynolds, 1995; Rutledge et al., 1992; Sampalis et al., 1997). And some follow general trends in trauma mortality in larger areas and/or over longer periods of time (Nardi et al., 1994; Roberts et al., 1996; Ruchholtz et al., 1998). In an important comparison to the present research, using cross-sectional time-series analysis and multivariate Poisson and negative binomial regression techniques, Nathens, Jurkovich, Cummings, Rivera, and Maier (2000) assess the impact of regionally organized trauma care systems on motor vehicle crash (MVC) mortality in the United States from 1979 through 1995.[3]

The Impact of Medical Advances on Homicide and Aggravated Assault

Prior to this medical research, several criminologists proposed that postwar medical advances were likely to suppress the homicide rate (Hawkins, 1983; Morris & Hawkins, 1970; Rose, 1979; Wilson, 1985; Wolfgang, 1958). In his 1958 study of homicide in Philadelphia in the early 1950s, Wolfgang noted that in both Philadelphia and the entire United States, the homicide rate showed an overall decrease since its UCR-measured starting points in the early 1930s to the early 1950s. In explaining this trend, Wolfgang cited a bundle of medical/technological breakthroughs: (a) the ability to communicate quickly with the police via telephone and radio shortly after a potentially lethal attack, (b) the related ability to provide rapid transportation to a hospital after such an attack, and (c) newly enhanced levels of in-hospital care, such as the ability to stop infection through the administration of penicillin and other "modern wonder drugs."[4]

In identifying a southern "culture of violence" that might be used to account for the South's traditional regional leadership in homicide rates, Gastil (1971) observed in passing that statewide variance in physician rates and in hospital bed rates was inversely associated with variance in homicide rates. Doerner (1983) undertook the first study to focus explicitly on medical resources—including hospital beds, nurses, surgeries, and emergency room visits—as key determinants of statewide differences in homicide rates. The results were mixed. Using as independent variables countywide measures of structural poverty (Loftin & Hill, 1974) and medical resources, Doerner and Speir (1986) extended Doerner's 1983 study by looking at homicide in Florida's 67 counties from 1968 to 1972. As their main dependent variable, Doerner and Speir used a new variable they constructed called *percent lethality*, or simply the ratio of recorded homicide cases to the number of recorded homicide and aggravated assaults. The results of this study added support to Doerner's theory that heightened levels of available medical care were associated with lower levels of homicide.

In 1988, Doerner refined the measurement of medical resources into more detailed components. The main dependent variable was again percent lethality. Limited to Florida counties for the period 1982 to 1986, the findings supported Doerner's earlier research. Especially noteworthy were the strong findings on the vital role of pre-hospital variables, most notably emergency transportation, in distributing lethality.[5] Although primarily limited to cross-sectional analyses of Florida counties for a few short multiyear intervals, the results of Doerner's research clearly support the present hypothesis that heightened levels of available medical care are associated with the paradoxically large increases in aggravated assault and virtually level trends in homicide observed for the United States during the second half of the 20th century.

In line with these findings, although limited to just one locale for just 1 year, Barlow and Barlow (1988) looked at emergency response times for aggravated assault and homicide cases in St. Louis in 1982. They observed a 4% mortality rate among patients who arrived at a hospital within 20 minutes of their injury, compared to a 20% mortality rate for patients arriving more than 20 minutes later. Moreover, this held true regardless of type of weapon or number of wounds.

Although also limited to one locale, one of the more persuasive pieces of research on the medical care/lethality link to date is Giacopassi et al.'s (1992) retrospective study of homicide in Memphis at three points in time: 1935, 1960, and 1985. Several variables identified as potentially important by Doerner (1983) were examined by Giacopassi et al.: percent lethality, percent of homicide victims dead on arrival at hospital (DOA), and survival time of non-DOA victims. More or less consistent with national UCR data, from 1935 to 1985, lethality in Memphis dropped from 11.4% to 3.2%. It is interesting that the percentage of all homicide victims DOA rose from 52.4% to 74.4%. This increase might have been caused by an underlying trend toward more severe injury and thus a narrower time frame for obtaining medical help before death. On the other hand, if we assume that trauma care greatly improved during this time across all victims of criminal injury, we should actually expect to see a mean increase in duration (survival time) as the years go by. This means that in a homicide-only dataset, such as Giacoppasi et al.'s, an increase in percent DOA (with an accompanying decrease in the survival time of all the non-DOAs) simply, although counterintuitively, suggests an unobserved but increasing proportion of assault victims saved from death who "reside elsewhere," that is, in an unobserved aggravated assault dataset.[6]

The most geographically extensive, but again historically rather limited, research on the medical/lethality link to date has been by Long-Onnen and Cheatwood (1992). Using all 306 counties in five contiguous Eastern states—Delaware, Maryland, Pennsylvania, Virginia, and West Virginia—the authors aggregated homicides and aggravated assaults over the period 1980 to 1985 to form the dependent variable: Doerner and Speir's percent lethality. Relying on a variety of 1980 U.S. Census data on countywide medical resources and demographic/"structural poverty" variables, Long-Onnen and Cheatwood found significant medical resource effects on lethality.

On a related topic, Hanke and Gundlach (1995) examined racial differences in access to emergency medical care and how that might affect life or death outcomes for victims of assault. Using datasets derived from homicide cases in Alabama from 1929 to 1985, Hanke and Gundlach argued that victims of Black offenders, themselves likely to be Black, received a lower level of care and were more apt to die than White victims. This leads to the rather provocative conclusion that if there is a markedly higher mortality rate among Black assault victims, it would produce a markedly inflated observation of Black versus White homicide victim and offender rates.

Beside these criminological studies, additional medical research exists on the specific distribution and nature of personal assaults. It has focused on estimating the population parameters of criminal injury by weapon type, population- and hospital-based survival rates by gunshot wounds and stabbings, and self- versus other-inflicted assault. The National Center for Injury Prevention at the CDC and the Center for Injury Control, both in Atlanta, have taken the lead in this regard (see Annest & Mercy, 1998; Annest, Mercy, Gibson, & Ryan, 1995; Cherry, Annest, Mercy, Kresnow, & Pollock, 1998; Ikeda, Gorwitz, James, Powell, & Mercy, 1997; Mercy, Ikeda, & Powell, 1998; Sinauer, Annest, & Mercy, 1996; see also Kellermann, Somes, Rivera, Lee, & Banton, 1998). For example, Beaman, Annest, Mercy, Kresnow, and Pollock (2000) estimated that in the United States in the period 1992 to 1995, an average of more than 132,000 people per year suffered gunshot wounds that led to death or treatment in an emergency department. They observed an overall age-adjusted case fatality rate (CFR) for this population of 31.7% (95% confidence interval, 27.7% to 35.6%), but a CFR of only 11.3% for the subset reaching the emergency department alive (see also Rhee et al., 1998). In light of Hanke and Gundlach's assertion (1995), it is worth noting that these researchers report a 50% higher CFR for White victims of violent assault than Black victims (29.5% vs. 19.2%). Although such findings speak to the likelihood that medical advances have indeed suppressed the homicide rate as we propose, they do not explicitly assess the linkage.

Analysis Plan

We start with the view that homicides (defined as murders + nonnegligent manslaughters) are neither no more, nor no less, than aggravated assaults with the outcome of the victim's death (see, particularly, Zimring, 1968; see also Cook, 1991; Morris & Hawkins, 1970; Pittman & Handy, 1964; Polsby, 1995). Factors that affect whether an aggravated assault victim lives or dies necessarily have a critical impact on the recorded homicide. Such factors include the following:

Weaponry: from fists and feet, to clubs, bottles, knives, and handguns to automatic assault weapons, through caliber, muzzle velocity, and rate of fire.

Injury Characteristics: seriousness of injury (body location, blunt or penetrating trauma, etc.).

Victim (Host) Characteristics: from the health of the individual victim, through health and trauma-resilient demographic covariates, such as age and gender.

Health Care Delivery: from the likelihood of witness and discovery of injury, to ability to call first arrival (EMS) specialists, their training, to time to 1st Arrival and equipment, to time to stabilize and triage, to emergency department (ED)/hospital/trauma center facility delivery, to facility personnel, expertise, and medical equipment.

From this viewpoint, an increasing aggravated assault rate would not necessarily lead directly to an increasing homicide rate. Weaponry over time could change from generally less to generally more deadly, or vice-versa. Collinear with weaponry, seriousness of injury would be expected to vary. Victim, or host, characteristics could also vary systematically by time and place. For example, a shift toward younger victims would signal a greater mean victim ability to resist trauma-induced lethality and a minimizing of other comorbid factors collinear with age.

A principal source of such variation in the lethality of violent assault also involves the delivery of health care. In modern America, such factors would include the general proliferation (and occasional loss) of hospitals over the years, time to first arrival and facility delivery by geographic area (urban/rural), regional development of trauma centers, by level and system coordination, and quality of care and equipment varying by local counties, including level of road infrastructure and traffic density.

Our analysis starts with an overall look at changes in the lethality of criminal assault in the United States from 1960 to 1999. We then assess the possible link between these changes and changes in weaponry. Finally, using national countywide data on the presence of physicians, hospitals, trauma centers, and membership in regionalized trauma care systems, we explore the link between lethality and the presence of medical resources. The analyses will show that, on a nationwide scale, there has been a continuous drop in lethality since 1960 and this drop is primarily attributable to developments in trauma care. A number of the alternative explanations of the decline in lethality will be examined and found to have, at best, a modest influence. Before presenting these analyses, we identify our data sources, define and evaluate our measures, and describe the statistical model we employed to estimate change and variation in the lethality rate.

Data Sources

A number of UCR and other data sources were used in our analyses. The first dataset used contains annual UCR national-level rates of homicides and aggravated assaults known to the police from 1960 to 1999. The second UCR dataset used contains annual national-level counts of homicides and aggravated assaults known to the police from 1964 to 1999, broken down into four weapons types: firearm, knife/cutting implement, body (hands, fists, feet), and other (including blunt instruments, but also explosives, fire, poison, etc.).

The third dataset contains annual UCR police-agency–based counts of aggravated assaults and homicides aggregated to the county-level for the years 1960 to 1997 (Chilton & Weber, 2000). These data are used in our concluding analyses of the countywide relationship between lethality and medical resources for two time periods, 1976-1980 and 1994-1997. Unlike the first two UCR datasets, this dataset involves counts of arrests, not offenses known to the police. In the concluding analyses, two multiyear samples of this UCR dataset were merged with data from the NCHS (1979) and the U.S. Bureau of the Census (1994) on county-specific medical resources, population, and geographic size. Data on the presence of county trauma centers (Sheps Rural Studies Center, 2000) and on the county's status as part of a larger state/regional trauma system (Bazzoli & Madura, 1993) were added. Independent of any trend data, these detailed, local medical data allow for additional evaluation of the validity of the present measure of lethality.

Measure of Lethality and Its Validity

Lethality is defined as the ratio of homicides (murders + non-negligent manslaughters) to homicides plus aggravated assaults identified in annual UCR data. There is little question about the validity of the UCR-derived homicide count, the sole term in the numerator of the measure and, along with the aggravated assault count, the second term in the lethality denominator. Although the UCR offenses known-based national homicide rate falls consistently about 5% below the gold standard Vital Statistics (NCHS) rate in the period examined, the correlation of the UCR offenses known-based national homicide rate with the Vital Statistics homicide rate is extremely high (r = .9947). Thus, while compared to the Vital Statistics homicide count, the UCR offenses known count leads to a systemic 5% or so underestimate of criminal lethality,[7] the difference is more or less constant across time and, for the purpose of symmetry, does not seriously vitiate the use of UCR counts.

A more complicated set of issues concerns the use of aggravated assaults as a historically unbiased measure of life-threatening, criminally induced injury. Although used in this way in a major, recent National Institute of Justice (NIJ) exploration of homicides in eight cities from the mid-1980s to the early-1990s (Lattimore et al., 1997), the shortcomings inherent in UCR aggravated assault data are well known (see Abt Associates, 1984; Biderman & Lynch, 1991; Blumstein, 2000; Maltz, 1999). These shortcomings basically concern variation in citizens' perceptions and reporting of violent acts—especially among acquaintances, friends, and intimates—as criminal assaults rather than as civil problems, as well as substantial long-term and jurisdictional de facto discretion in the police use of the aggravated assault category to record known assaults ranging from criminal threats of injury with weapons, to assaults producing very minor injuries, to assaults producing potentially lethal trauma (Allen, 1986).

If there were no historically significant changes in this "noisy" mix and in its historical reporting and recording, we would simply be left with a situation of more or less constant measurement overestimation orthogonal to observed increases in serious, assault-induced injury. Whether such changes in the noisy mix have or have not actually occurred is currently an unresolved empirical matter. But there are reasons to think such changes may have occurred. For example, it has been argued that over the years of this study period, general public tolerance for violence as a routine part of civil life has decreased (Rosenfeld, 2000; Zimring & Hawkins, 1997), thus leading to the citizen reporting and/or police recording of (a) an ever-more complete UCR census of actual criminal assaults with or without injury and (b) an ever-more "diluted" level of truly serious injury in that census. Since the first Minneapolis Spousal Assault experimental results were published in 1984 (Sherman & Berk, 1984), a matter of particular concern in this regard has been the question of whether the police have increasingly treated domestic violence incidents as criminal matters, thus both differentially accreting the aggravated assault arrest count over time—if not also the "offenses known count"—and possibly diluting its aggregate seriousness (Blumstein, 2000; Garner, Hickman, Simpson, Allen, & Woods, 1999).

There is no question that serious, criminally induced trauma would be best measured by medically trained personnel using validated injury scales such as ISS to rate seriousness of injury. Absent such data, however—but based on the strong and compelling findings in the general medical literature that clearly document recent drops in trauma mortality—the best question at this point may not be whether aggravated assaults known to the police are a problem-free proxy of serious criminal injury, but rather, "are there currently better alternatives?"

The one alternative we know of, reaching back to only 1973—and then experiencing years of development and change—involves the use of National Crime Survey (NCS/NCVS) data based on victims' self-reports of crime, including aggravated assaults. Because lethality based on NCS/NCVS aggravated assaults during the first dozen or so years of the victim survey's development (1973-1985) correlate negatively ($r = -.15$) with lethality based on UCR aggravated assaults known to the police, using such estimates would clearly produce different lethality results than those observed using UCR estimates.[8] In that NCS/NCVS too suffers from an inability to clearly distinguish life threatening from minor injury, and in the absence of a simple, direct, and valid measure of serious criminal injury—a gold-standard against which we could assess their relative virtues—no UCR or NCVS proxy measure can be judged as fault free. Although a full-blown discussion of any such discrepancy is outside the scope of this article, for present purposes, we stress several major points in justifying our present choice of the UCR measure.

One, despite its many uses in measuring crimes unknown to the police, NCS/NCVS has been widely recognized as having continuously undersampled high-risk-for-crime groups, ranging from the Black underclass, to families that recompose and/or move frequently, to prisoners, to the homeless, and to other hard-to-reach populations. For example, in a study of 26 U.S. cities, O'Brien (1983) found that whereas urban percentage African American is positively correlated at .47 with UCR assault rates and .43 for UCR rape rates, it is negatively correlated at –.45 with NCVS assault rates and –.26 with NCVS rape rates. Slightly weaker but parallel findings occur when percentage poor was used by O'Brien instead of percentage African American (see also Reiss and Roth's extensive 1993 critical review for the National Research Council).

Two, NCS/NCVS incident underestimation is likely to have been generally exacerbated for violent crimes, including aggravated assault, and particularly so with respect to repeated or series violence by nonstrangers (counted as one victim incident in NCVS; NIJ, 1996). For example, a 1998 NIJ/CDC national study estimated 2.9 times as many 1995 attempted and completed rape victimizations for victims 18 and older compared to the NCVS finding for victims 12 and older (about 987,000 vs. about 340,000 incidents) and 3.8 times as many 1995 physical assaults (both estimates include weapons threats) as the 1995 NCVS finding for victims 12 and older (about 13,800,000 vs. about 3,600,000). This undercount of violent victimization is especially critical because it appears to underestimate—even more severely—assaults that have a high potential for lethal outcomes. Cook (1985, 1991), for example, concluded that NCS/NCVS underestimates the number of gunshot victims known to the police by a factor of three.

Three, a modest (and rare) opportunity to assess construct validity in comparing an NCVS-based measure of lethality to a parallel UCR measure is provided using recently available public data from national samples of U.S. hospital emergency departments started in 1992 (NCHS, 1992 to 1999). Using an independent, third measure of criminal aggravated assault counts (injury requiring a hospital visit or stay) produces a third annual lethality measure that is negatively correlated with the parallel NCVS-based annual lethality measure (–.58), on one hand thus challenging the validity of the NCVS measure and, on the other—since this third measure is strongly positively correlated with it (r = .91)—offering our UCR-based measure of lethality some external validation. This is fully in line with Reiss's (1985) early observation concerning possible NCVS/UCR divergence to the effect that "the more serious the crime in terms of injury to the victims . . . the more likely . . . [it is] to become a police case report" (p. 167).[9]

Statistical Analysis

Generally, homicide is a rare event in a county, and its monthly or annual countywide distributions are best characterized as overdispersed Poissons. Under that circumstance, ordinary least squares analysis of homicide rates is inappropriate. In examining count distributions undoubtedly similar to those for motor vehicle crash deaths, we used negative binomial regression with robust standard errors in estimating the impact of year and other predictors on lethality. Explicitly, this meant specifying the raw homicide count as dependent in the regressions, with the natural log of the lethality denominator (homicides + aggravated assaults) as an offset in the calculations. In the concluding analysis incorporating medical variables as predictors, we also used negative binomial regression but clustered on county to obtain robust standard errors. Statistical analyses were produced using Stata 6.0 software (Stata Corporation, College Station, Texas).

Analysis I: National Drops in Lethality 1960-1999

Figure 1 shows aggregate U.S. homicide rate (HR), aggravated assault rate (AR), and lethality rate (LR) trends for 1960 to 1999 based on annual UCR national-level rates of homicides and aggravated assaults known to the police. The homicide series varies from a low of 4.6 in 1962 and 1963 to a high of 10.2 in 1980. From 1960 to 1999, it increases from 5.1 to 5.7—a rise of 12%. Assault rates vary from a low of 85.7 in 1961 to a high of 441.8 in 1992. For the entire period, they increase from 86.1 to 336.1—a rise of 290%. This means an almost undisturbed drop in lethality during the 40-year period. It is worth noting that the second of the two periods

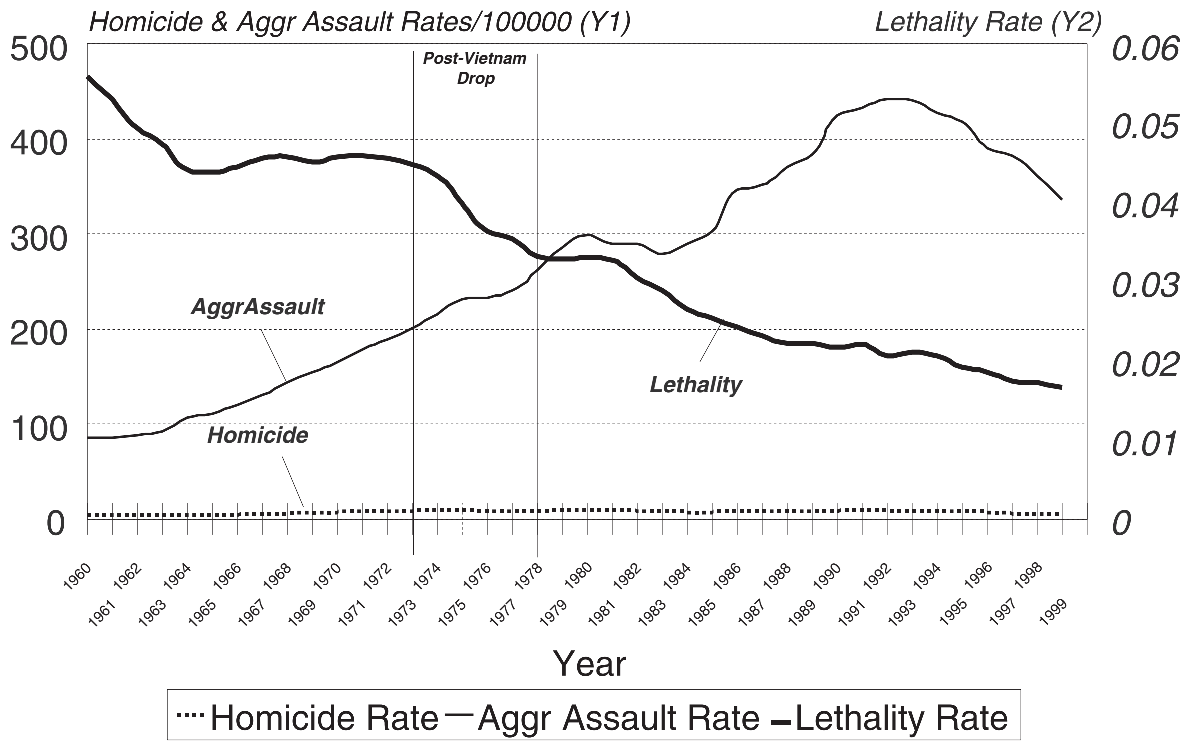

Figure 1: Homicide Rate (HR), Aggravated Assault Rate (AR), and Lethality Rate (LR): Annual National-Level Uniform Crime Report Offenses Known Data 1960-1999

SOURCE: Sourcebook of Criminal Justice Statistics, 2001.

NOTE: HR = (homicides + nonnegligent manslaughters) per 100,000 population; AR = aggravated assaults per 100,000; LR = HR/(HR + AR).

of greatest lethality drops, 1960-1965 and 1973-1978, occurs on the heels of the American involvement in Vietnam, quite likely the kind of postwar period of great gain in trauma care identified by medical historians (Rosen & Anderson, 1998; Trunkey, 2000).

There were 916,380 aggravated assaults and 15,533 homicides in 1999. If the aggregate 1960 lethality level (.056) described these data, we would have instead observed about 880,000 aggravated assaults and about 52,000 homicides—or about 3.4 times the 15,500 or so actually observed. To put this finding in context, it would be useful to look at parallel national findings on trauma mortality from a different cause of injury.

In recent years, the number of annual deaths from motor vehicle crashes in the nation has typically run two to three times the number of deaths from homicides, with severe trauma the overwhelmingly clear cause in both cases. Figure 2 indicates that strikingly similar processes may have occurred in lowering the motor vehicle crash death rate in just about the same proportions (66% for criminal lethality and 67% for motor vehicle crash lethality) during the period 1960 to 1995 (National Safety Council, 1997; see also Forde & Giacoppasi, 1999). Because some medical researchers have argued that the MVC mortality rate is an inverse function of population density (Bentham, 1986; Brodsky & Hakkert, 1983; Clark & Cushing, 1999; Maio, Burney, Lazzara, & Takla, 1990), it is worth noting that, by increasing the chances of life-threatening injuries being witnessed and reported, overall increases in population density over time could help explain the drop in MVC lethality (and possibly the drop in criminal lethality).

The national lethality trend in Figure 1 is not governed simply by drops in large metropolitan areas. Figure 3 shows the trend for four different FBI-identified population groups stratified by level of urbanization. The stratified trends connect mean annual lethality rates. For the entire period, lethality in each stratum drops by more than 50%: from .074 to .021 in rural counties, .050 to .011 in small cities, .044 to .018 in large cities, and .043 to .020 in very large cities (with more than 250,000 population).

As would be expected based on the general medical findings on trauma mortality, rural counties consistently show the highest level of lethality. But Figure 3 also suggests that there is a nonlinear relationship between urbanization level and criminal lethality. In the largest or Group I cities, lethality is quite high. It

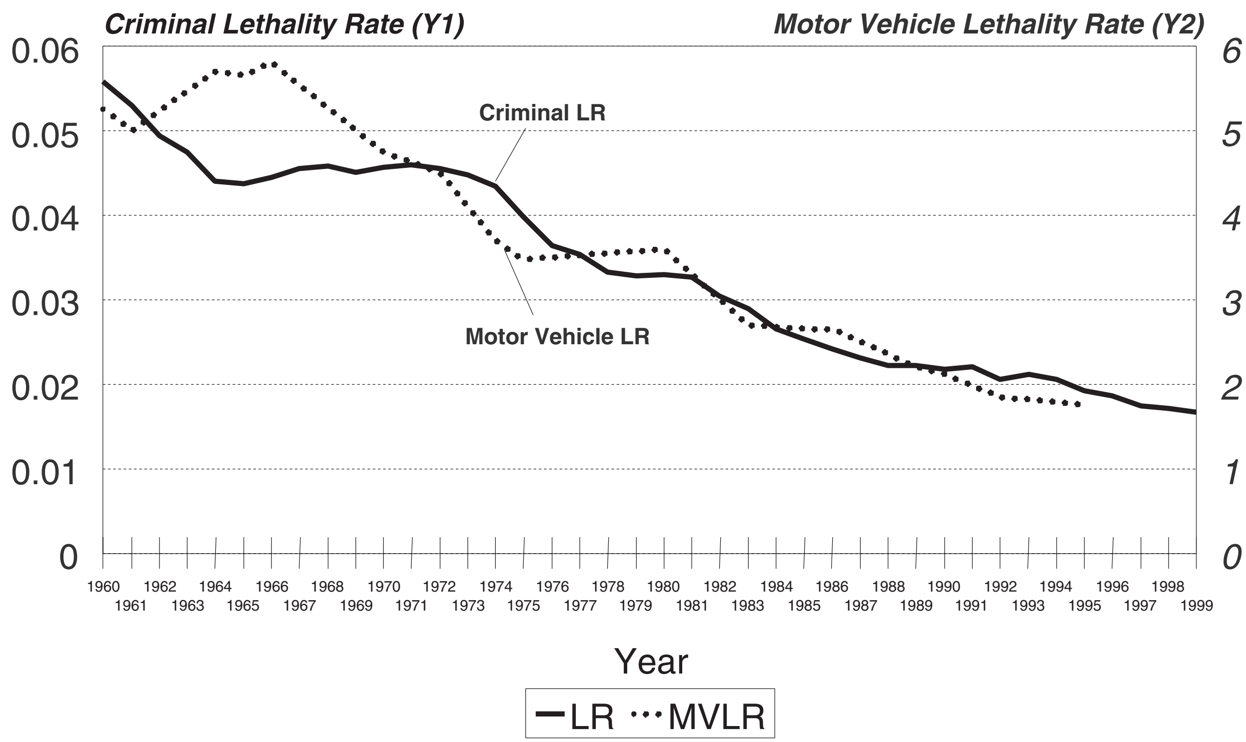

Figure 2: Criminal Lethality Rate (LR) and MV Lethality Rate (MVLR): Uniform Crime Report Data 1960-1999 and National Safety Council Data 1960-1995

NOTE: LR = homicides/(aggravated assault + homicides); MVLR = MV traffic injury deaths per 100,000 vehicle miles.

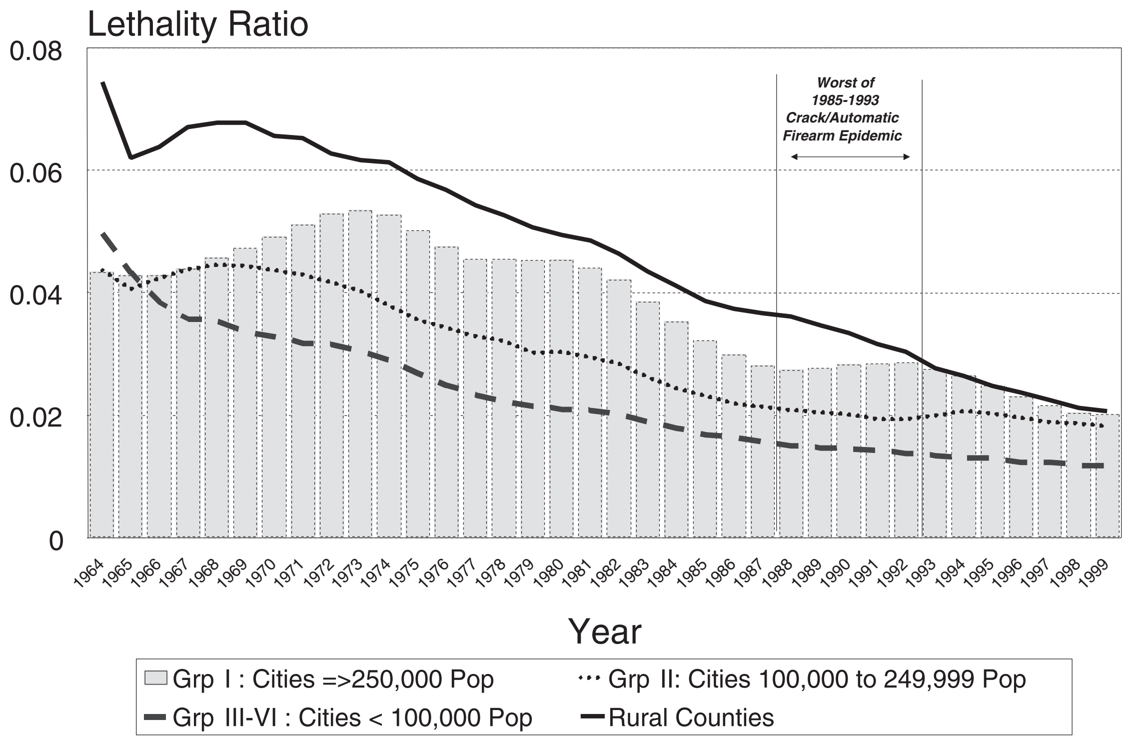

Figure 3: Lethality by Year and Level of Urbanization: Annual Uniform Crime Report Population Group-Level Data 1964-1999 and 3-Year Moving Averages (Uniform Crime Reports, 1960 to 1999)

decreases by about 21% across the period as we move from Group I to smaller Group II cities. Moving from Group II to small or Group III-VI cities produces an additional drop in lethality of 24%. But, across the period, at the mean, rural county lethality runs about 100% higher than at the small-city level. Although we cannot assess the hypothesis, we suspect this has to do with the net outcome of two trends: (a) level of urbanization is parabolically related to the use of deadly weaponry in aggravated assaults, with proportions of highly deadly pistol usage dropping off by dwindling city size but increasingly replaced by growing proportional use of long guns (rifles and shotguns) in rural areas, and (b) level of urbanization is directly related to the greater availability of and proximity to medical resources.[10]

By 1999, three important changes have occurred. Figure 3 shows the first and second: (a) each population stratum shows a mean lethality rate about one half to one quarter of its 1964 baseline, and (b) there is an ever decreasing gap between rural and city lethality levels. Although we do not currently have good enough historical medical data to assess the hypothesis, as shall be argued for in the last of our analyses, we think a likely explanation of this involves the differential proliferation of medical resources into U.S. rural areas during the period.

The third important change cannot be seen in Figure 3; there has been a general shift in the U.S. population away from rural counties toward a greater concentration in suburban and urban counties. Clearly, changes in both the component structural and in the compositional population (input mix) parameters of the aggregate national LR have occurred and contributed to lowering the homicide rate.

Finally, Figure 3 shows two increases in lethality for the largest or Group I cities, the first from 1966 to 1973 and the second from 1988 to 1992. U.S. Bureau of Justice Statistics (2000) data on weapons use in criminal assault confirm that both periods were marked by substantial increases in the proportions of assaults (aggravated assaults + homicides) involving firearms. We cannot break these data out simultaneously by urbanization level and weaponry mix, but we do know that the second period, 1988 to 1992, marked the worst of the crack cocaine/automatic firearm epidemic lasting from 1985 to 1993—largely an inner–large-city problem (Blumstein, 2000). In our view, these peripheral findings add weight to the validity of the present measure of criminal lethality rather than tending to invalidate it.[11] In coinciding with Lattimore et al.'s (1997) findings on lethality in eight cities cited earlier for approximately the same time period, we suspect that with respect to the overall lethality trends examined, they are limited in their apparent anomalousness to metropolitan areas during the "crack epidemic" just described.

Analysis 2: National Drops in Lethality and Weaponry 1964-1999

A major rival explanation of the observed overall lethality drop in the period examined is provided by the "ever diluting aggravated assault mix" hypothesis discussed earlier, that is, a growing proportion are of assaults of a minor nature. The best way to assess this would involve examining the seriousness of aggravated assault injuries over time. Absent this alternative, this rival explanation might be indirectly assessed by examining the question of simultaneous changes in the underlying lethality of the mix of weapons used in aggravated assaults.

If this rival explanation is correct, we should expect to see very little change in the lethality per se of specific weapons types over time, but marked increases in the proportionality of less lethal weaponry in criminal assaults.[12] In considering these rival explanations, however, we need to be precognizant of critical findings from the Centers for Disease Control and Center for Injury Control studies cited earlier: (a) Trauma from gunshot wounds is by far the most likely of all criminally induced trauma to be lethal, and (b) the great bulk of criminally induced mortality is from firearms. Thus, any overall net change in lethality would therefore be far more sensitive to changes one way or the other in the firearm component of the distribution.

To estimate net weapons-specific lethality drops for the period more precisely, we turned to regression analysis. Table 1.1 displays results from the negative binomial regression of homicides on year by weapon type. In this approach, the logs of weapon-specific denominators (homicides + assaults) are offsets and thus serve as lethality denominators. Robust standard errors are used. The table shows similar drops in lethality overall and by weapon type: The drops for the generally blunt weapons cate-

TABLE 1
Declines in Lethality By Weapon Type 1964-1999

1.1 Regression of Lethality on Years by Weapon Type for 1964-1999

	Coefficient	SE	t	P > |t|	*[95% Conf. Interval]*		*Wald χ^2 (1)*	P > |F|
Firearms	–.0302	.0012	–25.54	.000	–.0324	–.0278	652.35	.000
Knives	–.0273	.0029	–9.44	.000	–.0329	–.02163	89.06	.000
Other	–.0347	.0014	–25.40	.000	–.0374	–.0320	645.05	.000
Body	–.0448	.0012	–37.01	.000	–.0472	–.0424	1,369.70	.000
Overall	–.0338	.0014	–24.03	.000	–.0366	–.0310	577.53	.000

1.2 Breakdown of Yearly Assaults[a] & Lethality by Weaponry for 1964-1999

	Mean Homicides	*Mean Aggr. Assaults*	*Total*	*Mean % of Yearly Total*	*Mean Yearly Lethality*
Firearms	10,876.17	137,213.1	148,089.3	23.58%	.0846
Knives	3,021.89	130,951.2	133,973.1	23.42%	.0241
Other	1,785.36	183,955.1	185,740.4	27.83%	.0118
Body	1,329.75	159,607.8	160,937.5	25.16%	.0104
Overall	17,013.17	611,727.2	628,740.3	100.00%	.0315

1.3 Breakdown of Monthly Assaults[a] & Lethality by Weaponry for 1964 & 1999

	a. *1964 %* *Assaults*	*b.* *1964* *Lethality*	*c.* *1999 %* *Assaults*	*d.* *Unadjusted* *1999 Lethality*	*e.* *Weapons* *Proportion Shift*	*f.* *Lethality* *Drop*	*g.* *Adjusted 1999* *Lethality Components*[b]
Firearms	16.92%	.1551	18.73%	.0539	10.70%	–65.21%	.0091
Knives	39.26%	.0292	17.93%	.0113	–54.33%	–61.34%	.0044
Other	22.39%	.0213	34.66%	.0058	54.80%	–66.83%	.00131
Body	21.44%	.0223	28.68%	.0043	33.77%	–80.52%	.0009
Overall	100.00%	.0472	100.00%	.0154	Overall lethality drop:	–67.41%	.0158
					Adjusted lethality drop:	–66.56%	
					Drop due to weapons shift:	–.84%	
					% of overall drop due to lethality drop:	98.75%	
					% of overall drop due to weapons shift:	1.25%	

a. Assaults = Homicides + Aggr. Assaults.
b. g = a × d.

gories "Other" and "Body" are estimated at about 3.5% to 4.5% per year ($p < .001$), whereas the generally more deadly penetrating weapons categories of knives and firearms show drops of about 2.5% to 3.0% per year ($p < .001$).

Table 1.2 shows percentage distribution and lethality by weapon type of all potentially lethal assaults (aggravated assaults + homicides) during the whole period. Knife/cutting weapon assaults represent the smallest (23.4%) and "Other" assaults the largest (27.8%) proportions of assaults. Firearm assaults are by far the most lethal form of assault (lethality ratio [LR] = .0846) and, by almost an order of magnitude, bodily (or personal) assaults (LR = .010) the least lethal.

Table 1.3 shows weapons-specific percentage distributions and lethality levels at the beginning and at the end of the period. From 1964 to 1999, there is an overall drop in lethality of 67.4%, with weapons-specific drops ranging from 61.3% (knives) to 80.5% (body).

During this time, whereas there is nearly a 400% increase in all assaults by all weapons between 1964 (167,431 total assaults) and 1999 (813,802 total assaults), there is clearly a marked change in the proportional composition of the weaponry mix: The firearm component increases by 11% (from 16.9% to 18.7%) and the knife component actually decreases by 54% (dropping from 39.3% to 17.3%), whereas bodily and "other" weapon assaults increase by 34% and 55%, respectively (see Table 1.3). Examining this same change by looking instead at across-time changes within weapon types is instructive. From this perspective, from 1964 to 1999, the bodily assault and the "Other" (primarily blunt) weapon assault count show very large increases of 550% (233,381 assaults in 1999 vs. 35,894 assaults in 1964) and 652% (282,091 vs. 37,489 assaults), respectively, whereas the firearm assault count increases by only 438% (152,456 vs. 28,322) and the knife assault count by a meager 122% (145,874 vs. 65,726).

These findings suggest that, indeed, the overall increase in the aggregate aggravated rate over the 40-year period has been differentially padded by assaults with less lethal weapons (and consequently less serious injury) and, as such, the observed overall drop in lethality based on the weaponry aggregate results at least in part from either an increase in actual but relatively non–life-threatening assaults (brawls) and/or the increased reporting/

recording of such hitherto unreported/unrecorded incidents as criminal aggravated assaults. In short, these data appear to support the rival hypothesis that aggravated assaults have increasingly captured relatively mild—or at least less potentially lethal—assaults and artificially deflated historical levels of lethality.

But, although it is true that an increasingly large proportion of aggravated assaults have less lethal potential, two observations severely weaken the threat the rival hypothesis poses to the lethality hypothesis. The first is that Table 1.1 shows significant drops in lethality for all weapon types, from firearm assaults to bodily assaults—that is, from the most lethal to the least lethal weapons. The second observation develops the first and is tied to the CDC's implied admonition to pay particular attention to the firearm component; since 1964, in our data firearms account for between 55% and 70% of all homicides. Thus, whereas there has been a historically differential buildup of relatively nonlethal assaults within the aggravated assault total, limiting the analysis to firearm-only assaults (i.e., applying their lethality level of .155 in 1964 to the estimated firearm assault total of about 189,000 in 1999) would have led to almost double the number of homicides in 1999—from 15,500 total homicides from all causes to 29,300 homicides from firearms alone! In short, proportions of weapons assaults that are firearm related tend to govern the homicide outcome of all weapons assaults and, as medical success is attained in differentially minimizing the mortality of nonfirearm assault, so too will proportions of all assaults that are firearm-related increasingly govern the homicide outcome of assault.

To assess the "waning seriousness of assault" rival more specifically, we adjusted the overall lethality drop (67.4%; Table 1.3, column f) to reflect the underlying downward shift in weapon lethality. Unadjusted overall lethality in 1999 was .015396. Multiplying 1999 weapons-specific lethality levels by their 1964 proportions and then summing the resulting components yields a weapons-adjusted lethality level of .01579. This number is used to produce an adjusted or net lethality drop of 66.6% ((.04724-.01579)/(.04724)). The remainder of the unadjusted lethality drop, or .84% (67.6%-66.6%), can be attributed to that portion of the unadjusted lethality drop due to the dilution in weaponry. Thus, in all, 1.2% of the (unadjusted) overall lethality drop (67.4%/

66.6%) can be attributed to a shift in weaponry and the remaining 98.8% to a drop in lethality per se.

Several conclusions are in order. One, the findings reported in Tables 1.1-1.3 are consistent with the general lethality hypothesis and with more specific expectations based on medical research. There are significant drops in lethality for all categories of weaponry, with the largest drops in the blunt trauma categories and the smallest drops in the penetrating trauma categories. Insofar as knife and firearm assaults account for about 82% of all known homicides in this period—with firearms alone accounting for almost 64%—significant decreases in the lethality of the penetrating weapons categories appear to be extremely influential in suppressing the overall transformation of lethal to "ordinary" aggravated assaults. Two, only about 1% of the overall decrease in criminal lethality during the period can be attributed to compositional shifts in weaponry. Three, if the 1964 weaponry mix characterized the 1999 weapons-specific lethality level (overall .0154), there would have been about 45,000 homicides instead of the actual 15,500 observed—a severity-adjusted difference almost 3 times larger than the actual count. Adjusting homicide figures in this fashion for the highest-ever assault total in U.S. history—1993—would have produced about 67,000 homicides instead of the 23,500 or so actually observed.

Analysis 3: County-Level Lethality and Medical Resources 1976-1980 and 1994-1997

Assessment of the lethality/medical resource link at the national level is no substitute for assessment at the local level; what counts after a potentially lethal wound has been inflicted is proximity to actual medical resources, not the national level of medical care. This suggested the use of historical countywide detail on offenses known as well as on medical resources. Although, unfortunately, such criminal data were not currently available, an arrest-based alternative was, allowing for two separate multiyear analyses (1976-1980 and 1994-1997) of the criminal lethality/medical resource link.[13]

Developed by Chilton and Weber, the UCR data used in creating this dataset contain annual UCR police-agency–based counts of arrests (not offenses known to the police) for aggravated assault and homicide. The agency reports were aggregated first across months to get yearly totals and then across agencies to get county totals. Each year, in aggregating agency-year arrests to the county level, we did not include agencies that reported fewer than the full 12 months of that year. Agencies were excluded from the aggregate counts only for the years in which they reported fewer than 12 months of data. Applying this criterion produced a total of 75,274 annual countywide arrest totals for homicide and aggravated assaults.[14]

For the first period, 1976 to 1980, lethality data were merged with countywide medical resource data from a 1975 federal survey of all U.S. hospitals (NCHS, 1979), producing an *N* of 10,557 county-years. For the second period, 1994 to 1997, lethality data were merged with 1990-1994 U.S. Census data on countywide medical resources, population, and geographic size (U.S. Bureau of the Census, 1994), then with 1994 countywide data on the presence of trauma centers (Sheps Rural Studies Center, 2000) and with 1993 data on the county's status as part of a larger state/regional trauma system (Bazzoli & Madura, 1993). This yielded an *N* of 8,493 county-years.

Lethality was regressed against a number of countywide medical variables ranging from number of RNs to number of blood banks to annual number of surgeries. As might be expected among components of an integrated health care delivery system, preliminary analyses revealed substantial multicollinearity among the medical variables. Because our primary interest is not precise estimation of the effects of different medical resources, but to show that the lethality rate, at any given point in time, depends on the availability of medical resources, we included only those medical variables that are the most strongly related to lethality.[15]

The medical resource variables included in the 1976-1980 analysis are number of hospital admissions, number of hospitals that provide open-heart surgery, number of hospital-affiliated physicians, and number of hospital beds in the county. A dummy variable was used to indicate whether the county had no hospitals. It was coded 1 to indicate the presence of any hospital in the county. The 1994-1997 analysis includes a slightly different set of medical resource variables. Data on hospital admissions were not available, but we were able to add two indicators of the availability of trauma care in the county. One dummy variable represents the presence of a trauma center in the county; the other indicates whether the county participates in a statewide trauma care system. The number of physicians in Period 2 includes all physicians in the county and is not limited to hospital-affiliated physicians.

Arguably missing from the regression analyses are a number of potential control variables known to be related to the homicide rate, such as percentage Black, county is in the South, county is rural or urban, and resource deprivation (an index composed of several variables measuring income levels and income inequality, taken from Land, McCall, & Cohen, 1990).[16] But these variables are not included in the main analysis because they are known as predictors of homicide rather than lethality per se (that is, whether or not an aggravated assault eventuates in death).

Table 2 presents the results of the negative binomial regressions of lethality on county-level medical variables in the periods 1976-1980 and 1994-1997. Consistent with the medical literature associating higher levels of hospital volume with higher levels of trauma mortality, Table 2 shows a significant positive link between countywide volume of patient intake and higher levels of lethality in Period 1 (.68% increase per 1,000 admissions, $p < .001$). However, this effect appears to be fully offset by resources in the form of hospital beds (5.5% decrease per 1,000 beds, $p < .05$). For Period 2, the impact of hospital beds on lethality turns unexpectedly positive. In the absence of hospital admissions data, we believe the unexpected positive association between hospital beds and lethality for Period 2 is an artifact of the beds-alone measure having turned into a proxy for hospital admissions (volume).

For every physician affiliated with a county hospital in Period 1, there is a significant reduction in that county's lethality rate, estimated at 4.3% per 100 hospital-affiliated physicians ($p < .01$). In Period 2, the addition of 100 physicians to a county's population is associated with a much smaller drop of about 1.4% ($p = .05$), but countywide "number of doctors" is a different measure in this period. Because we are now considering their presence at large within a county, not their availability as a direct trauma care resource in hospitals and emergency departments per se (as we were in 1976-1980 period), the smaller effect should be expected.

For every open-heart surgery facility—a surrogate for high level of care (HLC) county hospitals in the period—there is a significant 1.5% reduction in that county's criminal lethality ($p <$

TABLE 2
Regression of Lethality on County-Level Medical Variables 1976-1980 and 1994-1997

	Coefficient	*Semi-Robust* SE	z	P > |z|		*[95% Conf.*	*Interval]*		
Period 1: 1976-1980								N Obs =	10,557
								N groups =	2,739
# hospital admissions	6.82e-06	1.10e-06	6.21	.000		4.67e-06	8.97e-06	Obs per group	
# hospitals w/ open heart surgery (HLC)	–.0153	.0028	–5.45	.000		–.0207	–.0098	min	1
# hospital-affiliated physicians	–.0004	.0002	–2.64	.008		–.0008	–.0001	avg	3.9
# hospital beds	–.0001	.0000	–2.16	.031		–.0001	–5.15e-06	max	5
Presence of any hospital (dummy)	–.1124	.0501	–2.24	.025		–.2106	–.0143	Wald $\chi^2(5)$ =	59.81
Presence of a trauma center (dummy)[a]	—	—	—	—		—	—		
Part of trauma care system (dummy)[a]	—	—	—	—		—	—		
Constant	–2.3678	.0466	–50.81	.000		–2.4591	–2.2764	Prob > χ^2 =	.0000
Period 2: 1994-1997								N Obs =	8,493
								N Groups =	2,559
# hospital admissions[b]	—	—	—	—		—	—	Obs per group	
# hospitals w/ open heart surgery (HLC)	–.0111	.0036	–3.06	.002		–.0181	–.0039	min	1
# physicians	–.0001	.0001	–1.96	.050		–.0003	–9.84E-08	avg	3.3
# hospital beds	.0002	.0001	4.64	.000		.0001	.0003	max	4
Presence of any hospital (dummy)	–.2367	.0615	–3.84	.000		–.3573	–.1160	Wald $\chi^2(5)$ =	61.26
Presence of a trauma center (dummy)	–.0704	.0489	–1.44	.149	ns	–.1662	.0253		
Part of trauma care system (dummy)	–.1563	.0376	–4.16	.000		–.2299	–.0826		
Constant	–2.8522	.0586	–48.65	.000		–2.9672	–2.7373	Prob > χ^2 =	.0000

a. Data not available for Period 1.
b. Data not available for Period 2.

.001). Assuming underlying across-period stability in the HLC array, for every HLC facility in the 1990s period there is a significant 1.2% drop in lethality (p = .001).

The impact of simply having a hospital in the county is also significant, lowering lethality by an estimated 11.2% each year in Period 1 (p < .05). For the 1990s period, that impact is greater still, decreasing county lethality by about 24% a year (p < .001). For the 1990s period, the impact of simply having any hospital in the county is still greater, in Period 2 decreasing county lethality by 24% a year (p < .001). It is worth stressing that in both periods, the presence of a hospital in a county had a much greater effect on lethality than the effect of the "high level of medical care surrogate." Although it may not be so in the future, as counties without hospitals disappear, in our study period a hospital within reach during the "golden hour" after potentially lethal injury may have been the paramount medical factor in lowering lethality, not whether the county's brand-new trauma center had the latest in medical technology.

For the 1990s period, the sample for which we have trauma center and system data, the countywide presence of a trauma center is associated with a reduction of 7.0% in lethality levels, but the finding is not significant (p = .149). This null finding is puzzling but not altogether surprising. As the medical literature shows, at a minimum, knowing a trauma center's startup date is important; for many years after implementation, individual centers may become "magnets" for trauma cases with high fatality rates, channeling and concentrating their distribution from previously broader, regional dispersions (Hammond & Breckenridge, 1999; Nathens et al., 2000; O'Keefe et al., 1999). In estimating trauma center effects, it would also be helpful to know which level of trauma care these trauma centers represent, and whether and how they are certified. We did not have these data.[17]

We did, however, have data bearing on an equally important national health care concern. That is, whether regional systematization of trauma care—including coordination of triage and interhospital transfers—is effective in reducing trauma mortality. The data in Table 2 strongly support this view. Being part of a regionalized trauma system reduces criminal lethality levels by an additional 16% (p < .000) over and above the drops associated with presence of a hospital.

Conclusion

In three analyses of lethality trends, over time, by type of weapon and across counties, we have garnered considerable support for the hypothesis that advances in emergency medical care have greatly and increasingly reduced the lethality of violent assaults, with observed annual drops in such lethality ranging from 2.5% to 4.5%. This finding is thoroughly consistent with general medical findings on trauma that, while rigorously controlling for severity of injury, find annual drops in trauma mortality ranging from 3% to more than 16% (see section on the General Impact of Innovations in Trauma Care).

As a proxy for serious, life-threatening injury, we have no doubt that aggravated assaults recorded by the police are a blunt instrument in general and one that may suffer from historical biases that inflate the observation of drops in criminal lethality. Almost certainly the entirety of the measured drop in criminal lethality between 1960 and 1999 is not due to progress in emergency medical care and technology alone. Increases in the rate of police personnel and resources available to record aggravated assault, along with other nonlethal crimes, have likely increased over time. As noted, although some may still call it medical progress, another portion of the drop may be accounted for by population shifts away from isolated medical resource-poor counties to resource-rich counties. And additional, although likely small, portions of the overall decrease in criminal lethality can be attributed to compositional shifts in weaponry (see Table 1)[18] and to drops in the age of victims.[19]

In observing essentially the same historical aggravated assault/homicide paradox as we observe, Blumstein (2000) speculated that since the mid 1980s there may have been a significant inclusion of a less lethal mix of domestic violence cases into the police count of aggravated assaults. This inclusion would also serve to inflate the lethality denominator during the last third of our 1960 to 1999 study period, leading in turn to attaching too much importance to the medical resource explanation of the lethality decline.

To some extent—because during most of the period (1964 to 1999) we were able to observe changes in the weaponry mix in criminal assault—we may already have accounted for domestic violence inflation by having adjusted for the drop in the overall lethality of the weapon mix. Additional evidence bearing on the question of inflation can be found in data captured by the new National Incident Based Reporting System, or NIBRS (NIJ, 1992). Detailed NIBRS data from nine states in 1995 were used in the FBI's recent study, "The Structure of Family Violence: An Analysis of Selected Incidents" (Federal Bureau of Investigation, 2000). In these data, family violence—part of a superset that contains the domestic violence speculated on by Blumstein—made up 23.8% of all aggravated assaults, with nonfamily violence making up the 76.2% remainder. Major injury was indeed reported more frequently in non–family-aggravated assaults than in family-aggravated assaults, but the difference was small (24.4% vs. 20.5%). In addition, insofar as family-aggravated assaults in 1995 still represented a relatively small proportion of all aggravated assaults (23.8%), the increasing inclusion of domestic aggravated assaults in all aggravated assaults from the mid 1980s to the end of the 1990s is not likely to have artificially diluted the lethality ratio by more than 5% to 10%.[20]

Following Allen's (1986) and Doerner and Speir's (1986) admonitions, the addition of controls for seriousness of injury in future lethality-related research would obviate many of the problems encountered in this research.[21] Ideally, such research would also measure fatality on a case-by-case basis, with proper adjustment for demographic (host) characteristics, would geocode the distance of the injury site from the nearest receiving health care facility, and along with temporal correlates of the process, would attempt to measure the quality and effectiveness of all medical hands and resources laid on the case from time of injury.

The "lethality perspective" suggests that research on homicide causation and prevention homicide might be facilitated by focusing on potentially lethal criminal actions rather than on completed homicides per se. The relative rarity of homicides, and the fact that they are made even more rare by medical intervention, may make homicide data alone a less reliable vehicle for studying etiology and prevention than the combination of homicides and assaults.

Adopting a lethality perspective raises many policy-relevant questions. For one, if there is unequal access to and/or use of medical treatment in the case of life-threatening injury, there is reason to wonder whether African Americans and other disadvantaged groups have not been significantly overrepresented in homicide rates, systematically differentiated not by lethal intent but by levels of their victims' medical care (see Hanke & Gundlach, 1995). For another, why limit the study of the impact of major social/gun control legislation—such as the Brady Bill (Ludwig & Cook, 2000) or extending the public right to carry concealed handguns (Loftin, McDowall, Wiersema, & Cottey, 1991; McDowall, Loftin, & Wiersema, 1995)—to homicide when the critical criterion should be the occurrence of potentially lethal assault with a firearm, not a victim's death (witness Brady's own survival)?

In sum, the lethality perspective would address these basic research and policy questions: (a) Rather than homicide, what are the factors directly shaping aggravated assault? and (b) Rather than homicide, do (new) laws, such as the Brady Bill, and threats of sanction, such as the death penalty or longer prison terms, directly deter aggravated assault? The ominous rise of semiautomatic weapon use in assaults in the last 20 years may signal an ever-decreasing opportunity to make and to observe additional inroads in the transformation of homicide into assault. At some point in contesting the outcome of criminal assault to the body, weaponry may yet trump medicine.

NOTES

1. Absolute rates of homicide and aggravated assaults in the United States have dropped significantly since 1994. The causes of the drop—possibly including accelerated rates of incarceration, community policing, an aging population, and an improved economy—have been vigorously disputed. Secular trends of similar magnitude can be seen in Uniform Crime Report (UCR) data prior to 1994. Our focus is on a broader period of time and, given our dependent variable (lethality of aggravated assaults), is independent of such fluctuations.

2. Essential here are basic developments in telecommunication services, from the simple proliferation of 911 emergency telephone dialing, radio dispatched communications between emergency service workers, to beeper services for MDs, to the use of cell phones by witnesses of accidents and assaults on isolated highways and streets. Developments in open heart, transplant surgery, emergency medicine, trauma centers and systems, and the training levels of prehospital trauma personnel are important examples of medical progress, as is the development and proliferation of such medical hardware as computerized tomographic scanners and portable defibrillators. By no means unimportant here is the simple historical proliferation of local and county hospitals throughout the nation.

3. Nathens et al. (2000) conclude that it takes about 10 years after initial trauma system implementation before the drop on motor vehicle crash mortality can be seen.

4. Wolfgang suggested that research exploring these probable contributing factors be conducted but never attempted such a study. Considering that one of the few recom-

mendations the President's Commission on Law Enforcement and Administration of Justice (1967) acted on was the proposed development of a nationwide "111" emergency phone number (later to become "911"), as a consultant to the commission Wolfgang arguably played a role in actually shaping the outcome to be studied (from conversation with Roland Chilton).

5. Relying on what appears to be ordinary least squares regression, Doerner reports significant medical variable effects (betas) on lethality for Basic Life Support Services ($\beta = -.53$), Helicopter Landing Site ($\beta = -.22$), Computerized Tomographic Scanner ($\beta = -.34$), and Percentage Population Health Shortage Area ($\beta = .29$). The countywide arrest data used in our concluding analysis on medical resources show an LR (lethality ratio) distribution in Florida counties from 1982 to 1986 similar to the national patterns for the period and throughout the 1960-1997 span overall. These patterns strongly point to the use of Poisson or negative binomial rather than simple ordinary least squares regression.

6. In a separate analysis of homicides in Chicago from 1982 to 1995 (Block, Block, & the Illinois Criminal Justice Information Authority, 1998), we observed similar trends for percentage DOA and survival time for each of the separate trauma categories: automatics, knives, clubs, and beatings.

7. Recent Vital Statistics changes in cause of death coding suggest that past homicide counts may actually have been too high.

8. Two additional comparisons are worth noting. One, the National institute of Justice's (NIJ's) Monitoring the Future project—which, like NCVS, suffers from relatively low capture of high-at-risk-for-crime populations—shows a generally increasing trend in reported assault with injury and armed robbery among high school seniors from 1980 to 1998. Over 19 years, the combined rate is correlated at .75 with UCR aggravated assaults, but at –.45 with NCVS aggravated assaults. Two, from 1986 through 1999, the parallel NCVS and UCR lethality measures are actually positively correlated at $r = .26$.

9. The problem of NCS/NCVS underestimation may have been further magnified by a trend toward telephone-based interviewing, changes in the nature of the proxy reporting of juvenile crime, and a severely shrinking national sample (see Atrostic, Bates, Burt, Silberstein, & Winters, 1999; Biderman & Lynch, 1991), as well as an approximately fourfold increase in national imprisonment rates since the survey's inception.

10. On one hand, the assumption that the case fatality rate (CFR) for long gun assaults is higher than the rate for handgun assaults is reasonable and is often made in related literature (cf. Kleck, 1991). Given actual variation in assault usage, however, such as distance from target, this is ultimately an empirical matter. We explored this question using a dataset produced by the merger of a Centers for Disease Control and Prevention (CDC) Firearm Injury dataset based on a national probability sample of hospital emergency room admissions for the years 1993 to 1997 (CDC, 2000) with national UCR Supplemental Homicide data (also just from firearms) for the same years (Fox, 2000). From the CDC subset, we dropped all injuries that were not coded as assault-based (e.g., accidental). Assuming they would be redundant with the firearm deaths in the UCR data, all firearm assaults ending in death in the CDC subset were dropped. Each of the two datasets merged contained information on the type of gun used in the assault or homicide (airgun assaults were eliminated). In logistic regression of mortality on long gun dummies (handguns were the excluded category), we again included age of victim and year of injury as controls. The only significant effects involved age of victim, which was positively related to mortality, as fully expected based on the medical literature, and the impact of shotguns, which, surprisingly, showed a lower CFR than handguns. The rifle dummy did not show significantly different effects on mortality than handguns ($N = 66{,}156$; weighted $N = 213{,}042$). These somewhat counterintuitive findings suggest that the upturn in lethality found for rural areas is more likely to reflect the absence of medical resources than the intrinsic lethality of long guns. Over the years, exsanguination (or, simply, "bleeding out") has likely provided

a large proportion of all penetrating-wound homicides in areas—especially rural counties—with sparse or no medical resources.

11. Short run dips and rises in the lethality of assault such as the rise between 1985 and 1993 seen in large U.S. cities are most likely a function of local cycles of competing weaponry and medical technology and technique, with medical resources eventually eroding the lethality of newly introduced weaponry, followed then by a round of even more lethal forms of weaponry, and so on.

12. Zimring's work is especially instructive in its focus on the importance of weaponry—particularly the role of firearms—in framing general criminological analysis (e.g., Zimring, 1968, 1972), especially including cross-national comparisons of crime (Zimring & Hawkins, 1997; also see Cook, 1991). Thus, the same sort of "less lethal weapons" explanation might account for the extraordinarily different lethality ratios observed in comparing the United States and other industrial democracies (Reiss & Roth, 1993; Zimring, 1972; Zimring & Hawkins, 1997), with U.S. lethality ratios running consistently higher than those in other industrial democracies because of more lethal weaponry.

13. Using arrest data has several potentially important consequences. One is that because more serious crimes such as homicide are cleared by arrest more frequently than less serious crimes, such as aggravated assault, in the denominator (homicide + aggravated assault), our lethality measure captures a larger proportion of known homicide than known aggravated assault, therefore yielding higher absolute lethality levels than an offenses-known based measure. (The lethality ratios based on arrest that we observed are generally 20%-50% higher than those based on offenses known to the police.) As long as the difference between the two measures does not vary systematically by some other key factor, such as time, for most purposes the choice does not matter. If, however, observed drops in LR are due to historical changes in the "capture ratio" of homicides to aggravated assault, an explanatory rival to the improved medical care/lowered lethality hypothesis would be provided. A marked drop in the U.S. clearance rate for homicide (from more than 90% in the 1960s to just about 66% in the later 1990s) that is not matched by a parallel drop in clearance rate for aggravated assaults would produce an artificial deflation in the LR rather than a "real" one. As it turns out, the difference in question—captured in a ratio of lethality ratios (RLR)—actually does vary significantly by time, but not by much. In at least a chunk of the 1960-1999 time period examined—from 1976 to 1993—by using the RLR we were able to see and estimate that portion of any LR drop produced through the use of arrest rather than offenses-known data. Techniques involving the regression of the RLR on time yield estimates that the arrest-based approach introduces a statistically real but modest contribution of about 4% to the observation of the decrease in the lethality trend line. This leaves two important conclusions. The first is that 96% or so of the drop needs to be explained by other factors, including improvements in the nature and delivery of medical care. The second is that the drop in aggravated offense clearance is thus very nearly as ominous as the one in homicide.

14. Chilton and Weber (2000) have compiled these police-agency–level data for public download at the Institute for Social and Political Research at the University of Michigan. These data are currently limited to agencies in Metropolitan Statistical Areas. Professors Chilton and Weber were kind enough to provide the authors additional matching data for the remaining non-MSA counties during this time (1960-1997), with public download availability expected in 2001 or 2002. We aggregate these agency data to the county level. Although national coverage is almost complete, some of the typically smaller agencies do not report data, and some of the agencies, not necessarily smaller, do not complete the full 12-month reporting schedule. UCR-reported information of months covered for an agency only begins in 1974. Since then, criminologists will occasionally impute annual agency results by inflating 6 to 11 months' worth of agency data. We chose not to do so, dropping all "annual" agency reports not based on 12-month data (about 10% of the predrop total).

Doing this does not appear to bias the results, as the 1974-1997 correlation between reporting year and "full 12 month coverage" is miniscule ($r = -.013$, ns). One result of working with a "full 12 month only" dataset is that our absolute crime counts are almost always a little lower than published national counts.

15. If we had included all the medical variables considered, we would still report a strong relationship between medical resources and lethality. Multicollinearity among these variables makes it impossible to differentiate the separate contributions of these variables, but it does not prevent us from discerning their joint effect.

16. We would like to thank Tom Petee and Jay Corzine for raising this issue and Steve Messner and his associates at NCOVR for providing us with the relevant data (Messner et al., 1998).

17. These data are part of a more recently initiated time-series collected by the American Hospital Association, are the only such national data, and surprisingly, are proprietary and currently available as fee-based only.

18. This is by no means as clear-cut a finding as it might appear. We observed lethality drops for firearm assaults in general and were unable to adjust for specific historical trends in caliber or an increase in multiple penetrating injuries likely to have been correlated with the post-1985 increases in automatic weapons use cited by many (see Wintemute, 2000). Along with other unexamined trends from 1960 to 1999 that may actually have suppressed our observed lethality drops—such as lower UCR reporting rates of rural agencies with high lethality levels in the 1960s and 1970s—we suspect that an unmeasured overall increase in the firepower of criminally used firearms from 1985 on, if not for the entire period, acted to suppress even greater drops than those observed in firearm mortality, clearly the most important portion of the weapons mix for the purpose of estimating criminal lethality.

19. Because, during the period 1960 to 1999, the mean age of victims of assault dropped significantly, this age drop becomes a plausible rival explanation of our observed drop in lethality. In the logistic analysis of the lethality of long gun injuries compared to handgun injuries we referred to in note 10, victim's age was included as a control variable. As fully expected, increasing age was significantly related to increased mortality from firearm injuries. Based on these data, we conservatively estimate the impact of age on mortality at +4% per 10 years of age. The question is, How much did the age of assault victims drop during this time? Exact estimates are difficult to produce. Using national UCR data from 1976 to 1999, the mean annual drop in victims' age in years is .10 (Bureau of Justice Statistics, 2000). Using NCVS data for all violent crime from 1973 to 1994, the corresponding estimate is about .07 (Bureau of Justice Statistics, 1997). Using Chicago homicide data from 1965 to 1995, the mean annual drop in victims' age in years is .24 (Block et al., 1998). Extrapolating the latter, largest estimate to all assaults for the period 1965 to 1999 produces an estimated drop of 8.22 years of age among assault victims during the entire research period. Rounding this age drop to 10 years, and then applying the 4% increase in mortality per 10 years of age observed in the CDC/Supplemental Homicide data, implies that the maximum impact of the age drop on lethality during the period studied was 4% ((10/10) * 4%). Because the lethality drops we observed during this period ranged from approximately 60% to 75%, if our extrapolation is correct, the most the drop in the victims' age could account for in the overall lethality drop is thus about 7% (4%/60%).

20. As a worst case example, it might be proposed that of all assaults, family-aggravated assaults in 1980 made up only one quarter (5.9%) of the 23.8% seen in 1995. Assuming constancy in the family and nonfamily major injury proportions, 24.4% and 20.5%, respectively, the overall major injury rate in 1980 would have been 24.2%, as opposed to an overall rate of 23.7% in 1995—an overall major injury outcome in aggravated assaults dilution of only 2.1%. Alternatively, assuming the same 1980 family-aggravated assault proportion of all aggravated assaults, but with an extremely high major

injury fraction of 50% in 1980, produces an overall major injury rate in 1980 of 25.9%, as opposed to an overall rate of 23.7% in 1995—a worst-case dilution of 8.5%.

21. Measurement problems would not be resolved by sampling only assaults with serious or even life-threatening injuries. Because victim or host characteristics such as age mediate the life-threatening properties of an injury, in any such analysis it would be important to score seriousness of all assault-produced injuries.

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