The History of Violence in Europe: Evidence from Cranial and Postcranial Bone Traumata [1]

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Abstract

Skeletal remains allow us to measure how the intensity of violence changed over the past two millennia. Cranial traumata observed in skeletons often resulted from interpersonal violence, as do the cases in which the evidence points to weapon wounds. The main indicator used in this study is the share individuals with well-enough preserved skeletal remains exhibiting weapon wounds or cranial traumata. We find no dramatic decline of interpersonal violence between the first and fifteenth centuries of the common era. In fact, violence even increased during the late medieval period. Secondly, we find generally lower violence in the northwestern part of Europe, with a minimum value at the continental North Sea coast (today's Netherlands and parts of NW Germany). In general, the Mediterranean and central, eastern and southeastern Europe had higher levels of violence.

Introduction

Skeletal remains potentially allow us to measure the intensity of interpersonal violence, learning how it may have changed over time or differed across subgroups of the population. We argue that cranial trauma and weapon wounds on any part of skeletal remains were often the result of interpersonal violence. Our main indicator is the proportion of individuals with adequately preserved skeletal remains

[1] For important advice and crucial work on the classification of the trauma data we thank Megan Brickley (McMaster Univ.).

from non-battlefield burial sites that exhibited such trauma. Earlier studies had found that violence was an anthropological constant of human behavior for the last 800,000 years, although the rate of violence differed (Parker, 2001; Martin and Frayer, 1998, Schulting *et al.*, 2012, Walker, 2001; Burkett *et al.*, 2017). However, a standardized indicator for human violence in Europe over the past 2,000 years has not been proposed until now.

We investigate how and why the intensity of interpersonal violence changed over the last two millennia and across regions and social groups. The relevance of such a study hardly needs to be stressed – personal security has always been one of the most important aspects of human welfare, and remains so today. The absence of violence is a precondition for the development of social capital and, hence, economic growth. Taking a long-run perspective provides crucial insights about the propensity of humans to act violently against others. The major challenge of a study that covers two millennia is finding indicators that are sufficiently informative, reliable, and representative. Obviously, any single indicator will contain biases or measurement error if it is used over such a long period, as explored in this project, so we assess carefully the validity of the archaeological evidence. We also compare the observed trends with other indicators of interpersonal violence.

In particular, we will assess differences in the speed of the violence decline which Eisner (2014) and Pinker (2011) observed. We will assess whether violence decreased in Europe continuously, and whether there were periods of unusually strong decline. We also study signs for a reversal of the trend during some centuries. Secondly, we assess the geographical pattern: was our indicator of interpersonal violence generally lower in some parts of Europe, and higher in others? Finally, we turn to potential determinants of violence that might explain geographical and inter-temporal patterns. These will be adopted from the modern literature on violence (Baten *et al.*, 2014): Wilkinson (2002) argued that inequality played a strong role in determining violence and crime, for example. We will also consider the hypothesis that commercial empires had an incentive to control violence that was adverse to trade (Jellema, 1995). We will investigate whether patterns of violence differed between rural and urban areas. Finally, a relationship between human capital and the reduction of violence could be hypothesized, as more educated individuals tend to find easier or more efficient solutions for conflicts (Eisner, 2014; Pinker, 2011).

Background

As personal security is an important component of welfare, a number of scholars have studied the determinants of violence. Pinker (2011) and Eisner (2014), following the tradition of Elias (1978), argue that there was a "civilizing process" which resulted in lower homicide rates. Eisner (2014) presents evidence that the European population exchanged "swords with words" in light of the increasing number of books that had been produced since the Middle Ages (Buringh and van Zanden, 2009; Baten and van Zanden, 2008), among other indicators of literacy and human capital accumulation. Eisner compiled a large data set of homicide events that made it possible to trace violent tendencies in Europe back to the early modern period, and as far back as the fourteenth century for England and Germany.

Another approach uses bioarchaeological data, such as the prevalence of cranial trauma in the remains of historical populations, to explore the likelihood of violence. Stewart and Quade (1969), for example, studied cranial wounds of more than 1,400 prehistoric adult skulls of American Indians (Atlantic seaboard, Midwest, Southwest) arguing that they can be used to gain insights into differences in violent behavior. Walker and Hollimon (1989) analyzed evidence of cranial trauma in skeletons from the Californian General Islands and found that ritualized fights explained some of the violence, especially against women (see also Knüsel and Smith, 2013).[2] In their study of Native Californians, Walker and Thornton (2002) found a long term decline in cranial trauma frequencies from the period before 1000 BCE onwards. Rates declined substantially during the period between the thirteenth and the eighteenth century, until finally no cranial injuries were visible by the nineteenth century.

Larsen *et al.* (2002) expected an increase in interpersonal violence for the period of first contact between American native populations and Europeans in the Georgia Bight, but they did not find a higher number of weapon wounds than before contact. Similarly, there was no observable increase of violence during the contact period of the early Spanish conquista in Ecuador (Ubelaker and Newson, 2002). However, the authors note that the small number of skeletal remains and their relation to church institutions might have affected the results. In the American Southwest, however, Stodder *et al.* (2002: 496) observe increasing numbers of people with cranial trauma following Spanish contact. In general, low cranial trauma rates were found among central Mexican and Maya populations, often as low as one or two percent of the total individuals in the skeleton sample (Morfin *et al.*, 2002: 325). Very high rates of violence-related trauma were observed among the equestrian nomads of the North American plains (up to 30 percent with cranial trauma). Among them, the Cheyenne had the highest rate of weapon wounds, consistent with their military reputation (Johansson and Owsley, 2002).

In Europe, few studies have evaluated cranial trauma in a systematic way. Notable exceptions are a study of the British Isles (Roberts and Cox, 2003) and central Europe, where Peter-Röcher (2007) reported on a large sample of skeletons with cranial trauma and weapon wounds. She did not calculate frequency rates, because she considered the data classification in the underlying source material as too heterogeneous. For our study below, it is important that Peter-Röcher`s count of cranial trauma in relation to the total number of skeletons studied with preserved skulls moved in tandem between antiquity and the early medieval period, whereas in the late medieval/early modern period, the number of skulls showing cranial trauma was relatively higher.[3] Although Peter-Röcher (2007) expresses doubts about her numbers due to potential misclassification bias, we note that the basic pattern she found

[2] Goodman and Martin (2002) report fractures that can be observed for upper parts of the forearm are more often indications of warding off a blow -- this is often related to violence. These fractures are also called parry fractures. Lovejoy and Heiple (1981) studied long bone fractures. They found that most fractures were probably related to accidents and the fracture rate was highest among the ages 10-25 and among the 45+ age groups. The latter was probably because fractures accumulated over the lifetime.

[3] Although she names the period “Late medieval/early modern”, most of her evidence relates to the late medieval period.

corresponds with the results of our study. Cohen *et al.* (2014) collected evidence on violence-related traumata in the Levant (eastern Mediterranean), and found "no significant differences" between 4300 BCE and 1917 CE. In the skeletons from periods that they analyzed (earliest to sixth Century BCE, fourth Century BCE to thirteenth Century CE, thirteenth Century CE to early twentieth Century) they estimated very high and very constant rates of cranial trauma. Wahl and Zäuner (2015) emphasize that there are important pre-conditions for a reasonable interpretation of trauma data, and they challenged some of Cohen *et al.*'s interpretations. We will discuss these issues related to our data below.

Bone trauma and indicators of violence

Our main measure of violence is the share of individuals with sufficiently well-preserved skeletal remains that have weapon wounds or cranial trauma. Our evidence was collected as described in the codebook chapter of the appendix (Chapter 14, this volume). For trauma in particular, each member of the anthropological team who coded the evidence was asked whether they observed trauma and which bones were affected. They also remarked healing signals and indications of pre-, peri- and postmortal traumata (the latter were excluded here). As we adopt a "bird-eye" perspective in this overview study on two millennia of human violence in all European regions, a number of simplifications were unavoidable, relative to what anthropologists normally study who work on smaller samples of skeletons, and we focus on other research questions. For example, we do not study the distribution patterns of lesions of trauma and the information on healing status in detail, but form a main indicator by counting the number of cranial traumata plus weapon wounds relative to the total number of skeletons. However, we do consider the distribution of traumata below and above the hat brim line in the following part. Kremer *et al.* (2008) argued for a high likelihood of a violent crime if a cranial trauma is located above the hat brim line (the line where an imagined hat brim touches the head), because a violent blow more often affects this part of the skull (the parietal or the frontal bones). Conversely, accidents – from falling, example, cause more often cranial trauma below the hat brim line (Kremer *et al.*, 2008). Moreover, the three categories of skull trauma (sharp, blunt, projectile) were pooled for our overview purpose, even if it is obvious that the forces and velocity vary according to the type of injury. Post-mortem traumata were excluded. As Steckel *et al.* note in the codebook chapter 14 (this volume), postmortem fractures can be identified – again with some measurement error – by the amount of collagen of the bone that was already lost at the time of the fracture. These fractures tend to "propagate at right angles to the bone surface", rather than an oblique angle as in the case of perimortal trauma (Chapter 14 in this volume). Often, a color difference relative to the undamaged bone surface is visible in the case of postmortal trauma (Walker, 2001)

Weapon wounds are an obvious indicator of violence. This measure understates the level of violence, however, because some weapon wounds may not leave marks on bones. For example, wounds lethal to the abdomen, such as a dagger to the stomach, may not impact the bones of the skeleton. Nor would other forms of killing (poisoning, for example) generally result in bone trauma. The development of both defensive and offensive weapon technology is another confounding factor. It makes a difference

whether victims of violence were killed with a wooden stick or with a sword, because wounds caused by some weapons, such as large sticks, cannot be easily distinguished from trauma caused by accidents, especially if they affected postcranial parts of the skeleton.

However, to conclude, some marks on certain parts of the body were identified in earlier studies as resulting typically from violence: A substantial share of cranial traumata thus results from interpersonal violence (Walker and Thornton, 2002). Krakowka (2017) compares skull trauma with the coroners' reports for the Medieval City of London and finds that a high rate of all homicides are directly related to skull trauma, mostly using staffs as weapons. She used a large sample of skeletons, comparing the skull trauma share with archival records.

Another area of the body where bone trauma can suggest violence are the forearms, and in particular Parry fractures (Judd, 2008). Because the large majority of the population uses the right arm for attacks, these Parry fractures should mostly occur on the left ulna, because victims raise the left arm to prevent the attack from violating their head (Judd, 2008). Parry fractures are often mentioned in bioarchaeological research as potential indicators of interpersonal violence, i.e. defending a blow, but they have not yet been quantitatively studied for large regions and time periods. It would have been interesting to study Parry fractures in this project, but unfortunately the exact location of fractures of the left ulna were not recorded for a substantial share of skeletons in this dataset (for the whole set of criteria, see Judd, 2008). For Parry fractures, it matters whether the ulna is broken at the central part of the shaft or near the wrist, for example, as the fractures at the latter position are often the result of accidents. Judd (2008) emphasized that a "parry problem" arises if violence is overestimated due to the inclusion of ulna trauma not related to violence. Additionally, only 59 skeletons were recorded to have fractures to their left ulna from sites dated to the pre-medieval and medieval periods, while a total of about 6 000 are relatively well-preserved. It turns out that cranial trauma, which are probably violence related, and weapon wounds are a better research instrument for the study of differences in violence in people between time periods, regions and groups, since they are a much more common indicator.[4] In general, of course, other parts of the body were also sometimes affected by violence, but the likelihood has been shown in earlier studies to be somewhat lower. Leg bone trauma, for example, is often caused by accidents, and are among the most frequent trauma of all (Merbs, 1989; Goodman and Martin, 2002).

Wahl and Zäuner (2015) re-emphasize that a number of aspects need to be considered if the evidence for trauma to be interpreted as a proxy for violence. (1) Firstly, the representative nature of the skeletons studied for the population who lived at that time is a major issue and should be studied carefully. The data collected should not be from special cemeteries (such as nobility cemeteries) or be otherwise unrepresentative of the underlying population. (2) Secondly, survival biases of bones and trauma signs need to be considered: Did only a selection of bones and trauma evidence survive until an

[4] Similarly, it would be tempting to analyse domestic violence against women, an in particular consider facial trauma. However, evidence for facial trauma during the whole of the medieval and pre-medieval periods could only be identified in as little as seven individuals.

excavation took place? Especially in soils in which bone may decompose quickly, the signals of trauma cannot be identified in poorly-preserved remains, especially after centuries or millennia. (3) Trauma is of course differentiated into antemortem, perimortem or postmortem, with the distinction between peri- and post-mortem being most important. Post-mortem trauma does not necessarily indicate interpersonal violence; more specifically, it indicates postmortem damage to the skeleton. The distinction is sometimes difficult as some postmortem traumatic lesions look similar to perimortem damage. Trampling behavior of animals also needs to be considered: did large animals destroy bones that were buried close to the surface by trampling over it? (4) Some causes of death, such as poisoning or soft tissue wounds, do not leave marks on the bones. (5) Finally, the differentiation between violent trauma and accidental trauma is an issue. The "hat brim line rule" is one example of a strategy to distinguish violent from accidental cranial trauma (Wahl and Zäuner, 2015), and there are other strategies for other parts of the human body. In this study, we take these aspects into consideration, and also add to the literature by comparing the share of individuals having cranial trauma or weapon wounds to other indicators of violence.

For our dataset, cranial trauma and weapon wounds were observed and described in detail. Regarding the first of Wahl and Zäuner's (2015) points, the skeletons used in the study are unique with regard to their coverage of many European regions and them being reported according to a common scheme (detailed in the Codebook chapter of this volume). However, selectivity still limits how detailed the evidence can be interpreted. Although we have been able to obtain trauma evidence from skeletons from more than 70 sites in all European regions, both regional and social selectivity is clearly an issue. In order to account for regional selectivity, we ensured that sites from all European regions were included for all the broad period categories. Additionally, we paid attention to the diversity of topographical features (sites located at the coast and in the interior, for example) as well as to urban/rural composition. Our strategy to minimize social selectivity was to preferably include skeletons from burial sites that cover as completely as possible village or city populations (rather than, say, graves of the nobility or poor houses). In the few cases where we include burial sites of military units (such as battlefields) or other special social groups, we identified them with appropriate dummy variables. Our time trend estimates are based on regression results, controlling for regional and social composition at the cemetery-level. Labor market selectivity, which is sometimes a potential issue for voluntary army or prison samples based on archival data, is unlikely to be an issue for our analysis, because we consider the whole population of a settlement that was buried in the cemetery of this settlement. In sum, we take into consideration the representativeness and selectivity issue as careful as this is possible for excavation data with site-level covariates.

On the Wahl/Zäuner issue (2), we also relate our trauma evidence to measures of bone preservation (such as the share of skeletons for which 75% of the cranial vault was preserved) and only include evidence for which sufficient bone of the skull was available to calculate the rates. Moreover,

on (3), the problem of perimortem trauma was assessed carefully by the team of bioarchaeologists who collected and coded our data.

The lack of evidence for a cause of death, including violence, on the bones (4) is addressed using a comparison of our indicators of violence and trauma in general with other indicators of violence such as homicide, regicide and nobilicide (the killing of noblemen). On (5), we also discuss the distinction between violent and accidental trauma in detail in the following and apply, for example, the hat brim line rule.

Results

Our data for this study were collected from skeletons from a large number of European sites and reflects several time periods (Table 1). Evidence was observable for 4 738 crania of which 4 726 had at least 50 percent of the cranial bones preserved (and more than 75 percent for 4 696 individuals). For weapon wounds, we use the same preservation criterion. However, postcranial weapon wounds were relatively few. We include both healed and unhealed (antemortem and perimortem) cranial trauma, as both indicate violence. Postmortem trauma were excluded from our data set. We include only skeletons aged 18 and above to remove bias relating to violence against children and adolescents, because violence against children might have be stigmatized or not, depending on cultural attitudes. Including violence against children would make the evidence less homogeneous. In total, 5.36 percent of the people in our dataset had cranial trauma and 5.53 percent had either a cranial trauma and/or a weapon wound (if both applied, we counted this under "cranial trauma" in this calculation). Most of the people in the sample date to the early medieval period (35 percent). The high medieval and late medieval periods are represented by shares of 13 and ten percent, respectively. For the pre-medieval period, it was 8 percent. The remaining seven percent are in skeletons representing the industrial period (not listed in the Table). There are roughly equal shares of people buried at archaeological sites in North-Eastern Europe, North-Western Europe, and Central and South-Eastern Europe. Unfortunately, there was much less evidence from the Mediterranean area (not listed in Table 1). Forty-six percent of the sample was female, hence the female deficit is observable but not very strong. Seventy-two percent of people died (and probably lived) in the interior, i.e. not near the coast or the flood plains of large rivers. Thirty-six percent of the people were from settlements dominated by craft and artisanal production, and most of the remainder were from agrarian settlements. Roughly half of the data come from people buried in rural areas and the other half from urban contexts.

How balanced were the trauma observations by region and time period? Table 2. describes the composition by region and time period. In general, the data from the regions were quite balanced (Table 2). However, as noted above, there were fewer people from the Mediterranean, and there are three time-region units for which no observations were available. Most other units have at least 30 observations per region and time unit. Only North-Western Europe has no sites represented from the high medieval period, and the Central and South-Eastern European sample has no people buried at late medieval sites represented.

5 Discussion: Trends of violence in Europe

We assigned each site to one of six time periods, namely the pre-medieval period (from 0 CE to the fourth century), the early- (fifth -tenth century), high- (eleventh -thirteenth century), and late-medieval period (fourteenth-fifteenth century), the early modern (sixteenth-eighteenth century), and the industrial period (nineteenth and twentieth century). We organized our analysis into three different regression analyses (Table 3). In all three, we include region controls, which we discuss below, controls for the age structure of the skeletons providing trauma data, and in the first two models of our regression analysis we include controls for sex, whereas the third one has only female individuals. We observed that there was a much higher level of violence in populations from the early and late medieval periods, and significantly elevated relative to the industrial period, which serves as the reference category. Slightly higher, but statistically insignificant differences compared to the industrial period were found in the data for the pre-medieval, high medieval and early modern periods.

The elevated levels of violence in the pre-medieval, early medieval, and late medieval periods is not an unexpected result. Roman Antiquity and the pre-medieval period were reportedly unusually violent periods in the Northwest region of Europe (Bloxham and Moses, 2010). Some scholars have even argued that genocidal events took place in Gaul at that time. Roman troops supposedly performed mass killings among relatively peaceful ethnic groups in that area (Bloxham and Moses, 2010). The early medieval period was initially characterized by the dissolution of former state structures and moving Germanic and Asian tribes. Later, the Vikings played a violent role on the Northern and North-Western European coasts. In the late medieval period, a substantial struggle over resources and trading routes followed the "Black Death." In the Southeast, violent conflicts with the growing Ottoman power arose. Hence, the violence level of these periods is quite high.

The trends are shown graphically for males and females in Figure 1. Notably, violence did not decline before the late medieval period. If anything, our estimates suggest a small increase up to the late medieval period. A substantial and continuous decline began only after the late medieval period. This pattern is rather robust across many specifications: We observed the same pattern for both men and women, even though males, generally, had a much higher violence rate, which rose above ten percent in the late medieval period. Male cranial trauma rates were still higher than zero in the industrial period. In contrast, women had lower rates by a factor of between three and four (Figure 1). Nevertheless, the same trend is visible for both genders. Comparing the cranial trauma data by time series, using the cranial preservation criterion of at least 50 percent or at least 75 percent present, we observe very similar patterns (Figure 2). The deflation by 75 percent and above leads to a slightly lower general level. The trend lines of cranial trauma and cranial trauma plus weapon wounds were virtually identical, with a correlation coefficient of 0.99.

An important factor that needs to be considered is the aforementioned hat brim line rule in interpreting the data for cranial trauma, and its use in inferring interpersional violence (Wahl and Zäuner, 2015; Kremer *et al.,* 2008). Bioarchaeologists and pathologists have suggested that the likelihood of a

violent crime is much higher if the cranial trauma is located above the hat brim line (the line where an imagined hat brim touches the head). Conversely, cranial trauma below the hat brim line is more often the result of accidents. The former applies to injuries located on the parietal or the frontal bones. If we only take into account cranial trauma above the hat brim line, again the data are very similar for both males and females (Figure 3).

A number of caveats need to be discussed in working with cranial trauma as an indicator of violence. One of our strategies in this study was to compare the presence of trauma with other proxies for interpersonal violence, such as evidence for homicide, regicide and nobilicide in order to place into perspective the cranial data for each time period where we have both pieces of evidence. From the high medieval period onwards, Eisner (2014) developed estimates of homicide based on trial data, murder, and other sources compiled by historians of crime. This evidence for homicide trends indicates a secular decline of violence in all European countries studied so far (Figure 4, Eisner, 2014)). Another source of evidence for interpersonal violence is suggested to be regicide (Eisner 2011), or, the killing of kings, both in battle as well as through deliberate murder (for an econometric comparison of regicide and homicide, see Keywood and Baten, 2017). Although the numbers per century and country are necessarily small, the multitude of European kingdoms implies a sufficient number of cases for analysis. Again, our cranial trauma trends share some similarities with the share of assassinated kings; both remained high until the fourteenth century whereas afterwards a dramatic decline started. However, the regicide data do not show an increase during the late middle ages. We will discuss potential explanations for the decline of violence below, as well as the particular case of the 14th century.

Cummins (2014) has also developed a useful method for studying the share of the nobility who were killed in battles. His idea was to use a large database of European nobility deaths and to identify how many of them died on the same date. If a large number of deaths occurred on a single day, we can be reasonably sure that they died in a major battle. A substantial number of French nobles, for example, died on 26 August 1346, which was the day on which the English famously engaged and defeated a French army in the battle of Crécy. Both the European nobility (including many French, German, Spanish, and Italians, but also some from other regions) as well as British peerage show an increase of same-day-deaths in the fourteenth century and a decline thereafter (Figure 5).

5.1 Cross-sectional patterns: trauma in people from different European regions

In Table 4 two regression analyses of cranial trauma and weapon wounds are shown, with additional explanatory variables that reflect the cross-sectional patterns. Firstly, the regional dummy variable coefficients show that the small sample of people from the Mediterranean had a much higher rate of violent trauma than the North-Western European reference category. The Central and South-Eastern European region also had a substantially higher level, whereas the North-Eastern region had only a slightly higher rate. Coefficients of the latter two regions are seldom statistically significant.

We also consider cross-sectional patterns by country, as shown in Figure 6. We organized the data according to sites located within countries defined by modern definitions. We then adjusted for

temporal and other variation. In this regard, we observed the lowest levels of interpersonal violence of all settings in what later became the Netherlands. In the early medieval period, where a substantial part of our overall data derives, this was the Frisian Empire which became the trading center of northern Europe. The Frisian traders both imposed order and enforced peace (Jellema, 1995). There are the lowest levels of violence in this region, moderate rates of violence in neighboring England, France, Switzerland, and Germany, and a much higher violence rate further to the East and South, with the exception of Lithuania and possibly Hungary, which are outlying cases in central Eastern Europe.

5.2 Cross-sectional patterns: the impact of sex, topography, occupation, and "institutional" context

Per many settings, past and present, women had lower rates of cranial and/or weapon related trauma deriving from interpersonal violence. The topographic variable "interior" was not statistically significantly different from the coast, but had slightly lower rates. In addition, occupational and institutional affiliations for some sites were not very significant in relation to interpersonal violence evidence. That is, sites where people predominantly engaged in craft and artisanal production had a slightly higher, but not statistically significant, rate of violent trauma. People buried in cemeteries associated with religious communities had a slightly lower coefficient (again statistically insignificant, perhaps because of small N). The same - but with a positive sign of the coefficient - applies to the other categories of socioeconomic specialization (fishing villages, hospital populations and others).

In earlier studies, typically violent trauma has been found to increase with age (e.g., Cohen *et al.*, 2014). In the current study, however, cranial trauma rates for young adults (aged 18-40) and older adults (aged 40 and above) were the same in the raw data. The trauma rate was 5.4% for the young adults and 5.3% for the older adults, respectively, if we do not control for composition effects. Our main regression table includes an old-age dummy variable (Table 4). If we do control for composition effects, old-age seems to have had a negative impact - contrary to our expectations that pre-mortem trauma might have cumulated during lifetime - even though it is only significant at the ten percent level (Cohen *et al.*, 2014 found also a higher cranial trauma frequency rate for the age groups 19-40 relative to 40 and above in the period 332 BCE to 640 CE, whereas in an earlier sample (580 BCE to 585 BCE) and a later sample (640 CE to 970 CE) the older cumulated trauma over their lifetime. This result is difficult to interpret, because we do not have precise evidence about the selection process of those individuals who died young, as opposed to those who survived to higher age. We could imagine that the violent young people simply died early, leaving the less violent to survive. The results do not change substantially compared to a regression without controlling for the age structure.

Most notably, the urban coefficient is statistically significant and negative in the first regression model of Table 4). Hence, we can conclude that it may have been safer to live within city walls (this was also true for the Western Hemisphere, see Burkett *et al.*, 2017). Higher population density apparently did not lead to more aggression, as reflected in cranial trauma and weapon wounds of postcranial bones. An important strand of the literature would have expected the opposite (for a review

on modern urban violence, see Baten e*t al.*, 2014; Kubrin and Weizer, 2003). These cross-sectional patterns are also further explored over time in Figure 7. The increase in violence rates in the high and late medieval periods was mainly within the populations buried at agrarian sites. However, the prevalence of cranial trauma and weapon wounds for populations dominated by craftspeople did not increase between ancient and high medieval times. This group showed substantial improvement towards less violence during the early modern and industrial periods, whereas the farming group followed this trajectory only slowly. Most of the populations primarily engaged in craft and artisanal production lived in urban environments. Hence, it is not clear whether it was their work environment or the urban location which mattered most when they sustained interpersonal violent injuries.

Looking directly at the development of violence in the urban and the rural regions of Europe, as represented by the sites studied, provides further insights into patterns of human aggression behavior (Figure 8). Data from people with interpersonal violent injuries buried at early medieval urban sites are a strong outlier, but the number of cases is small (n=36 individuals). In general, there was a rather small urban share of evidence after the collapse of the Roman Empire. Life in those few remaining urban areas seems to have been rather violent, with trauma rates of more than 16 percent of individuals. Nonetheless, at least from the high medieval period onwards, urban populations apparently began to live much safer lives, according to this indicator, as the increase in violence in the late medieval period mainly took place in the rural areas.

6 Overall summary of the data

Modern research on violence suggests a number of factors that could have an influence on violence (see the review in Baten *et al.*, 2014), including the following social and behavioral attributes:

1. rule of law / state monopoly of violence / deterrence
2. demography: percentage of young males
3. income / opportunity costs
4. inequality
5. trading centers: economic motivation and purchasing power for security
6. education and human capital / social stigma of violence

6.1 Rule of law / state monopoly of violence / deterrence

The rule of law and the state monopoly of violence should reduce levels of interpersonal violence in a region, if governmental laws are widely accepted and followed. Hypothetically, the presence of these attributes indicates less homicide and other forms of violence evident in the population. Elias (1978) has strongly emphasized the state monopoly of violence as a pre-condition for a “civilized” (relatively peaceful) society. The severity of deterrence could be a related factor, because any person planning to perform a criminal or violent activity will weigh up the potential costs of this activity with its expected benefits (Becker, 1968). If deterrence is plausible and functioning, the effect on violence should be negative. For a transitory period (such as the Late Middle Ages), however, we could imagine that the introduction of state monopoly of violence - in combination with the formation of new states - might

lead to more violence. Only after this transitory phase, does state monopoly of violence transform societies to become less aggressive (Gennaioli and Voth, 2014).

The temporary and modest decline of violence in the high middle-ages – as we tentatively suggest -- might also be explained by a slightly higher rule of law compared to the early medieval period, when many of the governmental structures had broken down. In urban environments, where the rule of law could have been established earlier, there was also a lower violence rate. However, it is not so clear whether this urban-rural difference in the rule of law is really ubiquitous. For example, the rule of law was frequently violated in London around 1800, whereas the English countryside was less plagued by high crime rates (see Horrell *et al.*, 2009 who documents the criminal population in London and rural England). Some of the large cities also tended to develop a very high crime rate (Horrell *et al*., 2009).

The expansion of the rule of law contributed arguably more to the decline of violence in the early modern and industrial period than deterrence alone. Deterrence by punishment as a reason for the secular decline in violence is rejected by Eisner (2014). Quite the opposite: He finds a strong correlation between temporary increases of violence and the harshness of punishments in the early-modern period. Eisner argues that harsh early-modern punishments were other expressions of a propensity to violence (in this case of the ruling class). Therefore, this strong positive correlation between severity of punishment and violence is an argument against deterrence being instrumental in reducing violence (Eisner, 2014). Harsh punishments did not serve its initial purpose to deter crime. Pinker argues that both were gradually becoming less violent due to the "civilizing process" during the early modern and modern period, as we observe here.

6.2 Demography: percentage of young males

Particularly in recent times, victims and murderers are both very often young men between 20 and 30, partly because they are the labor force of criminal gangs (Baten *et al.*, 2014). It has been argued that strong young male cohorts increase the propensity of violence. On the other hand, aging societies seem to be less affected by violent behavior, even if we control for other criteria (Baten *et al.*, 2014).

With regard to the young male share, firstly life expectancy remained relatively constant during the early modern period – for which earlier research provided reliable evidence -- and in some countries even up to the industrial era (Wrigley and Schofield, 1989). Therefore, the age structure had a certain variation in the short run but did not change dramatically in the long run (Wrigley and Schofield, 1989). However, there are interesting deviations. For example, over the last two millennia, Europe experienced several severe plagues, wars, and famines, the best known of which, the Black Death, killed more than a third of the population (Scheidel, 2017). It could be imagined that there was strong demographic recovery after the Black Death, because the large population losses encouraged more births in the decades thereafter. This resulted in a high share of young adults. Following the theory mentioned above, this might result in temporarily higher violence rates. Although this could explain some of the late-medieval violence maximum, the data do not allow testing of this hypothesis, because we cannot obtain a fine temporal disaggregation: we do not have decadal evidence, but rather an estimate for several

centuries. The seventeenth century is another period where we would expect such a demographic factor to play a role. In this regard, there was a dramatic reduction of the population during the Thirty Years' War in central Europe and a number of major epidemics. However, in the early modern period, we do not see a dramatic increase in our violence data. Finally, the Justinian Plague of the early medieval period could have also triggered such a phenomenon, which again cannot be assessed with our data, because no disaggregated data is available.

6.3 Income / opportunity costs

Income is strongly correlated with personal security in the modern world, or negatively correlated with violence (Baten *et al.*, 2014). For example, if people have an alternative way of earning high income, rather than through forming criminal gangs to acquire income, then one of the motivations of exerting violence will be absent (Baten *et al.*, 2014).

In terms of average income, there seems to be a broad correspondence between income and lower violence levels given that average incomes in Europe increased only after the medieval period, and had before stagnated or even declined slightly since late Antiquity (Maddison, 2001). However, the cross-sectional evidence is less clear. We observe lower rates of violence-related traumata in North-Western Europe, for example, although recent research by Broadberry (2016) indicates that North-Western Europe was much poorer than Italy or Spain, for example, in the late medieval period.

6.4 Inequality

Today, high levels of inequality are generally associated with high homicide rates, as is evident in the modern countries of South Africa, Brazil, and Russia, for example. For some, it is always tempting to extract income from a small rich elite, which might lead to the formation of criminal gangs (Baten *et al.*, 2014). Envy-related effects can also be imagined to play a role, as could high psychological pressure that people living in countries with high inequality might experience (Baten *et al.*, 2014). Larsen (2015) expects that violence would have increased with growing population density and more hierarchic organization in ancient societies.

However, the European trend of inequality over the last 2000 years does not explain our estimates of violence. Inequality probably declined from Antiquity to the early medieval period, given that the former slave economies dissipated and newly-developing early medieval economies mostly relied on small-scale agricultural production. However, the record shows no discernable corresponding decline in violence. In general, Koepke and Baten (2005) find rising average height differences between members of the elite and non-elite people in ancient and medieval times, and especially during the early modern period. Therefore, the inferred increase in inequality in the early modern period, which is also supported by income estimates (see Hoffman *et al.*, 2005), does not correspond with our violence estimates. Why was this the case? It seems that the growing capacity of the state and the increase of human capital reduced violence to a larger degree, whereas the opposite force of inequality driven violence was much weaker.

6.5 Trading centers: economic motivation and purchasing power for security

Some regions of the world specialize more than others in trade today, which is particularly sensitive to criminal activity and violence (Baten *et al.*, 2014). We would expect trading centers to invest more into the police force or other institutions that prevent crime and violence than other regions.

The centers of commerce are only weakly documented for the pre-medieval and medieval period, although in Antiquity the most important centers were the major cities of the Roman Empire and later of the East-Roman Empire (Constantinople). Alexandria in Egypt, Marseille in France, Carthage in Northern Africa, and the Lebanese coast in the preceding period were other important trading centers (Bosker *et al.*, 2013). As the well-known diffusion of Jewish traders across Europe shows, these centers were quite widely spread in the Early Middle Ages (Botticini and Eckstein, 2012). Another, more regionally concentrated, trading population was the Frisians who formed a commercial empire in North-Western and Central Europe (Jellema, 1995) before being included into the Frankish Empire. Even though the Vikings later plundered many Frisian harbors, the trading centers were not destroyed permanently. Later, however, trade shifted to the Mediterranean (Venice, and Genova in Italy, and other cities), to the East (the Hanseatic League), and across the English channel to London. The institutions of commercial centers and the behavioral patterns that were cultivated there often remained present and functioning for long periods of time. This may explain why rates of violence tend to be low in the continental North-Sea area.

6.6 Education and human capital; the social stigma of violence

Education is another factor that could be related to the propensity for violence, since people in less educated societies may have fewer options to resolve conflicts without resorting to violence (Eisner, 2014).

Can a comparison with human capital indicators explain the regional cross-sectional variation? Figure 9 shows a very rough indicator of human capital, namely the number of manuscripts created in medieval monasteries in the fifteenth century (see Buringh and van Zanden, 2009). We observe some correlation, seeing that the highest value according to this human capital index is found on the North Sea coast (today's Netherlands), where we also observe the lowest violence level. France had a higher human capital according to this measure and also a quite modest violence level. Skeletal remains from sites in Ukraine and Romania showed evidence of a relatively high share of violence-related trauma, but unfortunately, there are not data on the number of medieval manuscripts (we use the estimate for Bohemia as a proxy). From slightly later measurements of human capital, however, we can be relatively certain that their level of education was among the lowest of the regions considered here (Baten and van Zanden, 2008).

Switzerland is rather an outlier with a very low number of medieval manuscripts recorded. Because Switzerland had the highest book production in early modern times (Baten and van Zanden, 2008), the lower medieval level could result from an underestimate of Swiss medieval manuscripts. Together, this supports the hypothesis that human capital was important for the differences in violence-

levels between countries. On a similar note, we would expect earlier human capital development in urban areas where we observe lower rates of violence-related trauma.

The six factors discussed above are the most frequently studied determinants of violence and homicide in the literature of the last few decades. Although some of them are certainly related to each other, they are typically are not perfectly correlated, but assessing their relevance for interpreting interpersonal violence data from skeletal remains is challenging.

7 Conclusions

One of our main findings is that violence did not decrease dramatically between the third century CE and the late Middle Ages. In fact, levels of violence-related trauma actually increased during the late medieval period. As suggested by the bioarchaeological record, why then was this period of the fourteenth and fifteenth century so remarkably violent? We suggest the following may have contributed to the increase rates of violence. Over the preceding period, the population of Europe had grown enormously. During the early medieval period population density was initially low, and during the high middle ages population growth rates were remarkable and population density far outpaced that of the Roman Empire. This placed an enormous strain on land resources and resulted in many conflicts over land and property. In addition, the diet of the population became increasingly unhealthy, with a high proportion of carbohydrates, and little protein, which may have contributed to increased dissatisfaction and violent acts. In this explosive situation, the climate worsened substantially between 1300 and 1350 CE. In fact, some harvest failures during the beginning of the "Little Ice Age" were infamous. In this regard, all Central European rivers were frozen during the winter and the cold weather destroyed the cereal crop seeds already planted in the ground. This climatic catastrophe, along with strain on land resources, resulted in many conflicts between states, such as the Hundred Years' War between England and France, conflicts between European states and the Seljuks and later the Ottomans, who conquered most of the East Roman Empire and the expanding Muscovite Empire in Eastern Europe. Spain finished its *Reconquista*. In general, in Central Europe and in Italy, previously strong Empires lost their stabilizing role. There were endless conflicts between small municipalities, which now had the power to decide about starting violent conflicts.

In addition, during the late medieval period, religious intolerance reached a climax. Many anti-Jewish programs were initiated. There was violent activity against Christian minority groups, such as the Cathars, Waldensians, and the Hussites (in what is today the Czech Republic). Some of these groups also exerted substantial violence. Religious intolerance was present in many periods, but it was exceptionally strong during the late Middle Ages. Finally, after the fall of Acre in Palestine during the late thirteenth century, the export of aggressive European nobility to the Middle East ceased, but this social group used their aggression within Europe. The Great Plague of the mid-fourteenth century reduced competition for land for a while, but it added conflicts over labor services, which led later in Eastern Europe to the development of the Second Serfdom. All these factors -- population increases, climate change, interstate conflict, political fragmentation, religious intolerance, and disease --

contributed to the unusually high levels of violence during the late Middle Ages that we found in this study (Scheidel, 2017 on all these issues). Accordingly, among the least violent 25 sites of our study, only one can be assigned to the late medieval period. It was an unusual site of Franciscan friary in the Netherlands. In contrast, among the top 25 violent places not less than six fell in this period. Is was a geographically wide spread sample from the United Kingdom, Poland, Lithuania, and Portugal.

Our second main finding was that generally lower violence levels were present in the northwestern part of Europe, with a minimum value in people from sites on the continental North Sea coast (today's Netherlands and parts of NW Germany). Here, Frisian merchants created a trading empire during the early medieval period. Apparently, effective control of trade-averse violence came as a side effect of a certain level of autonomy based on income from trade. In our literature review, we contrasted the relatively low trauma rates of central Mexico and the Maya cultures with the high trauma rates of the nomadic tribes of the North American Great Plains (Morfin *et al*., 2002; Johansson and Owsley, 2002). This contrast is reflected in our data, because societies oriented towards hunting and developing individual warrior skills had higher violence levels, whereas more stratified and organized societies such as the Maya and other central Mexican cultures, or the northwestern economies, in our sample had lower trauma rates. However, overall, the Mediterranean and central, eastern, and southeastern Europe had higher levels of violence. These cross sectional patterns are consistent with a human capital interpretation of early violence reduction: there were lower violence levels in the urban areas from the High Medieval period onwards, and violence started to decline earlier behind city walls, presumably because it was easier to establish the rule of law in cities and urban dwellers were slightly less uneducated. The city authorities could expel violent people. Among the rural populations, in contrast, no such downward trend could be identified before the early modern period. We found a tentative and preliminary negative interregional correlation between human capital indicators and violence (such as the number of manuscripts written in medieval monasteries). Areas with higher human capital tended to have lower levels of violence-related bone traumata, which is compatible with evidence for the post-fourteenth-century homicide rates until today in the literature (Eisner, 2014).

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Figure 10.1 Cranial traumata and Weapon wounds by gender (per skeletons with Cranial vault preservation >50)

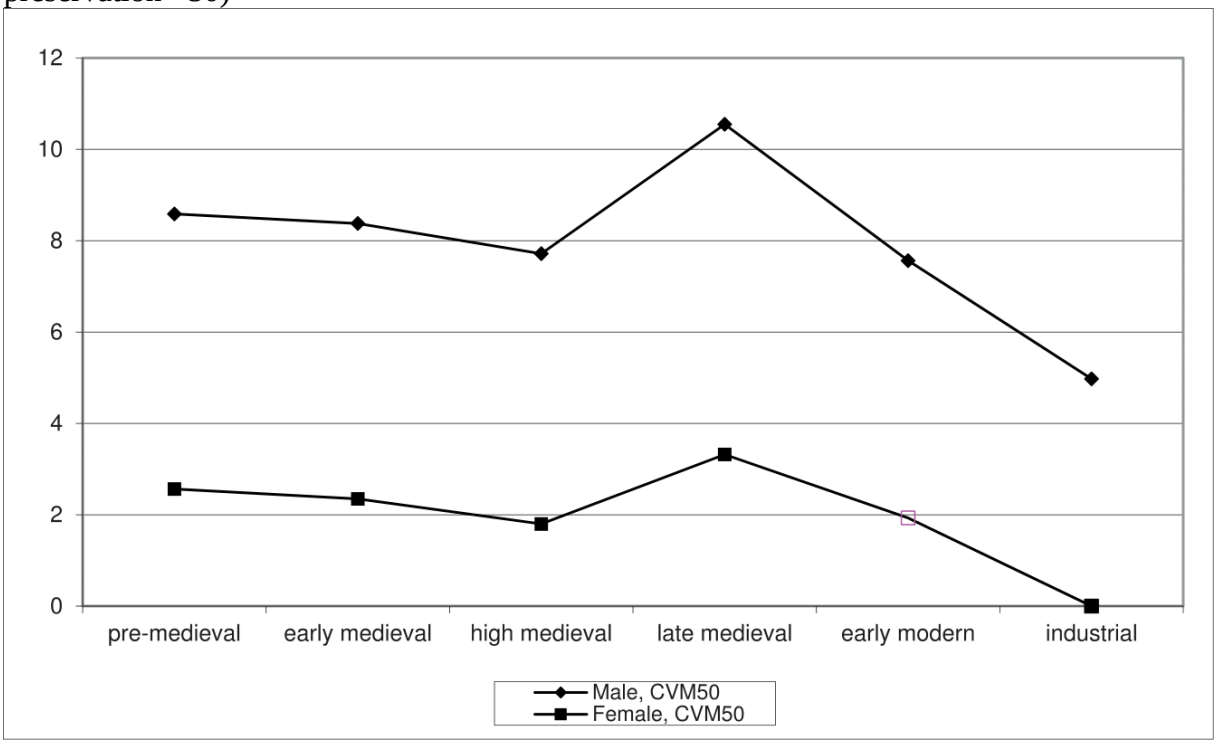


Figure 10.2 Deflating cranial trauma/weapon wounds by cranial vault preservation >50 and >75 percent)

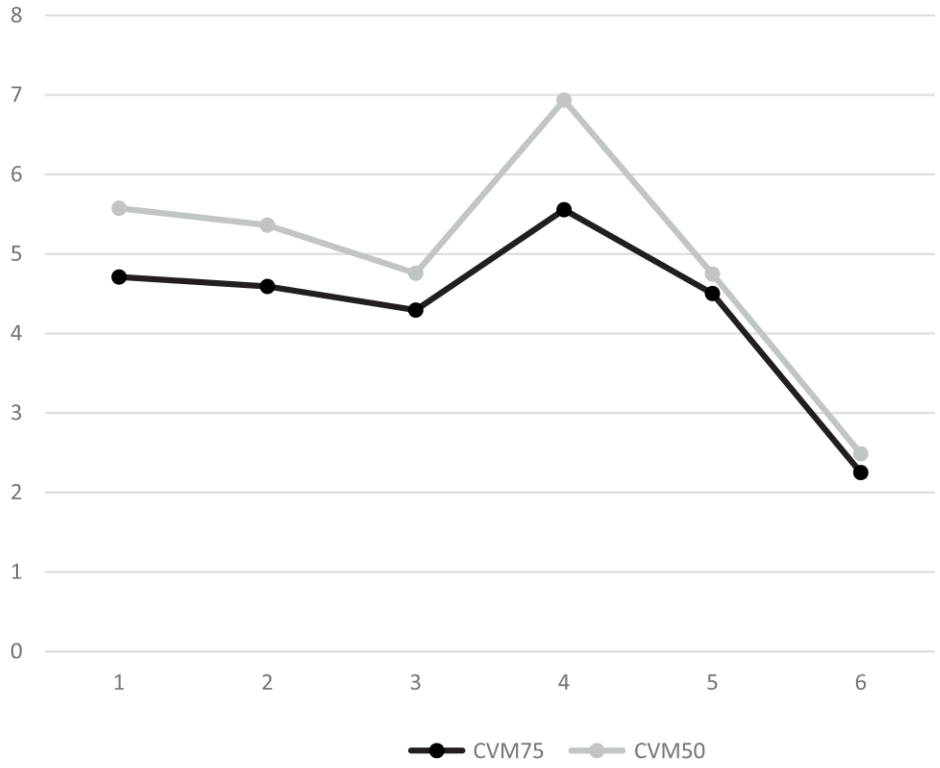


Figure 10.3 Applying the “hat brim line rule”: Cranial traumata and Weapon wounds by gender (per skeletons with cranial vault preservation >50)

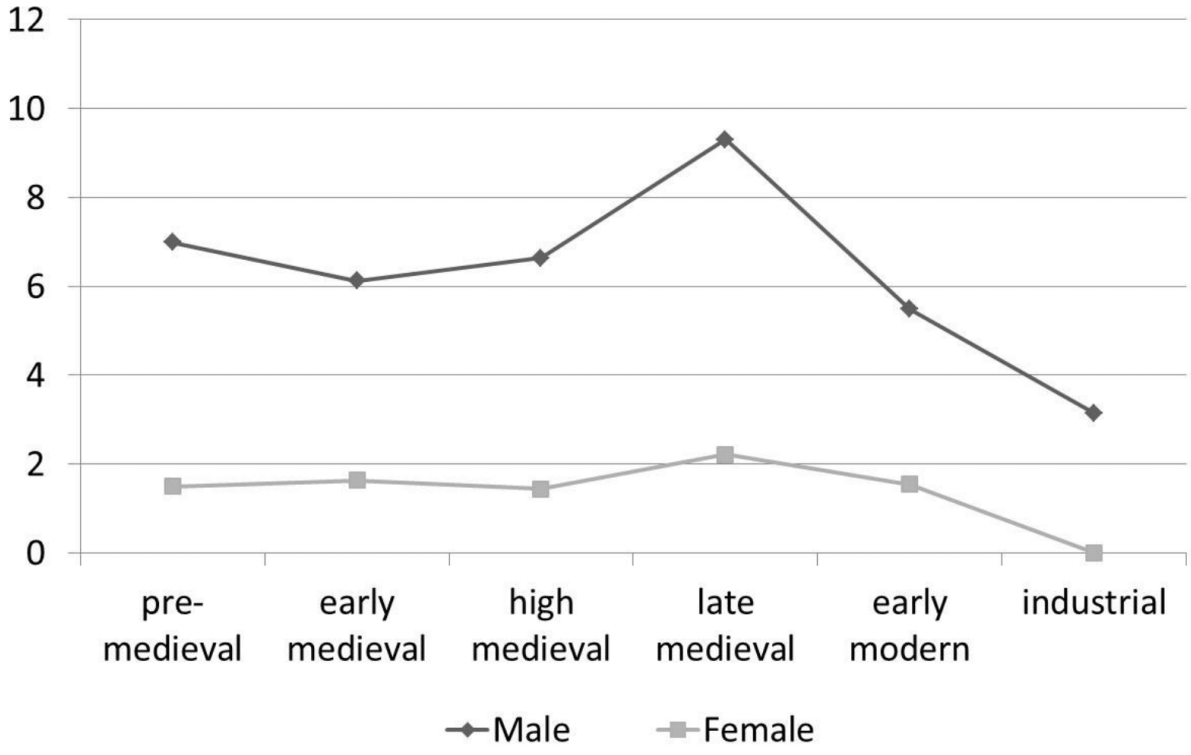
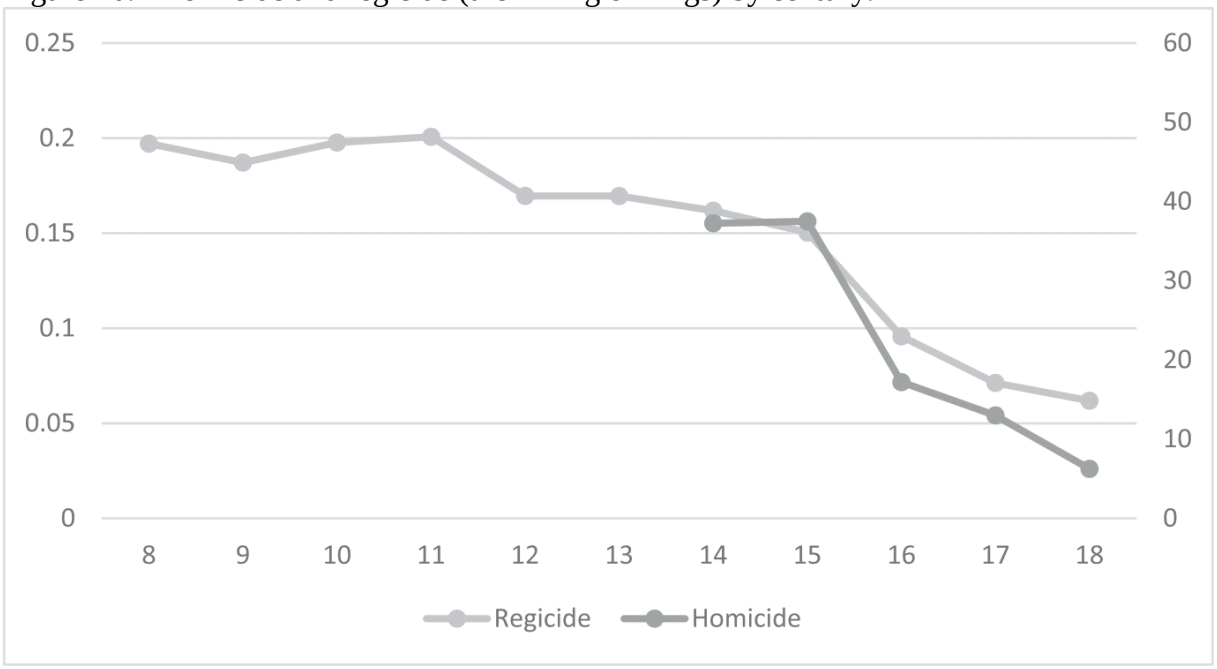
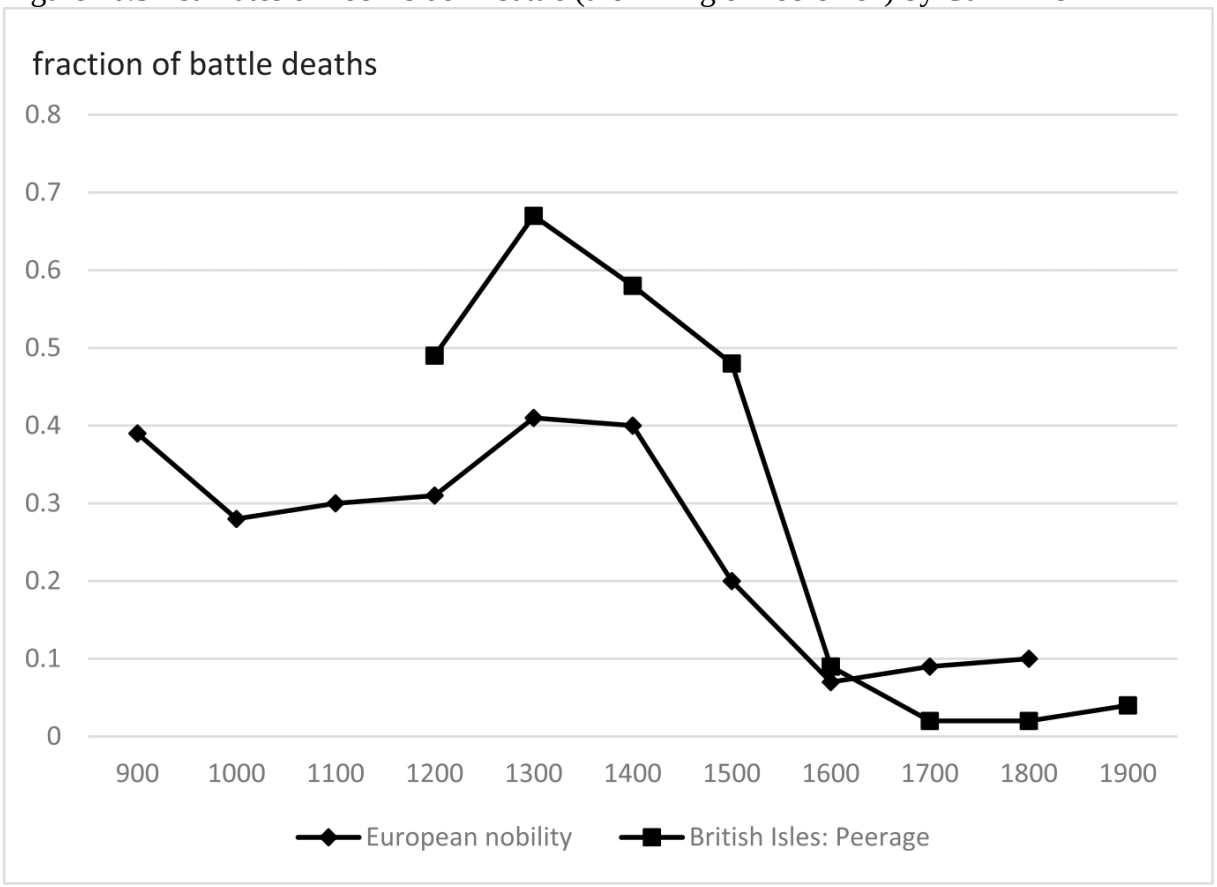


Figure 10.4 Homicide and regicide (the killing of kings) by century.



NOTE: Source: Eisner (2014) for homicide per 100 000 population (right axis); regicide recalculated based on Eisner's (2011) approach see Baten (2016), in percent (left axis).

Figure 10.5 Estimates of nobilicide in battle (the killing of noblemen) by Cummins



NOTE: Source: Redrwan and modified from Cummins (2014)

Figure 10.6 Mapping medieval violence

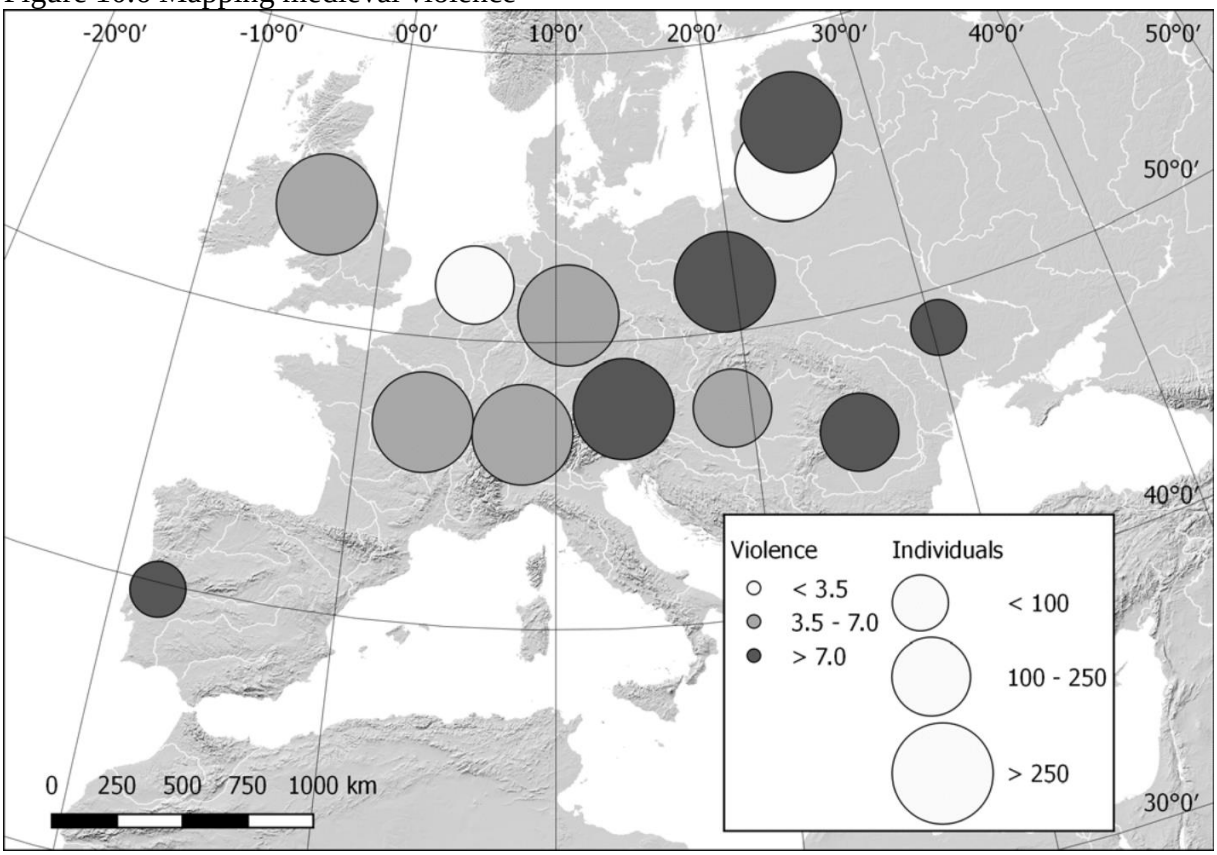


Figure 10.7 Cranial trauma/weapon wounds: farmers and craftsmen over time

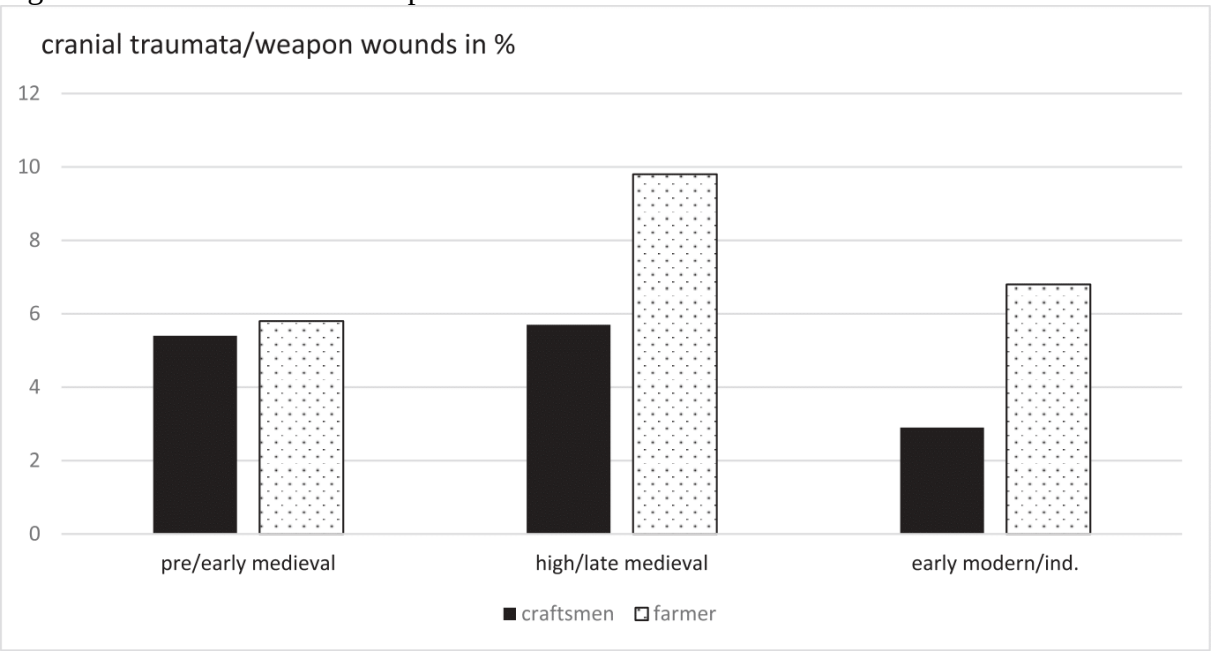


Figure 10.8 Urban and rural development over time

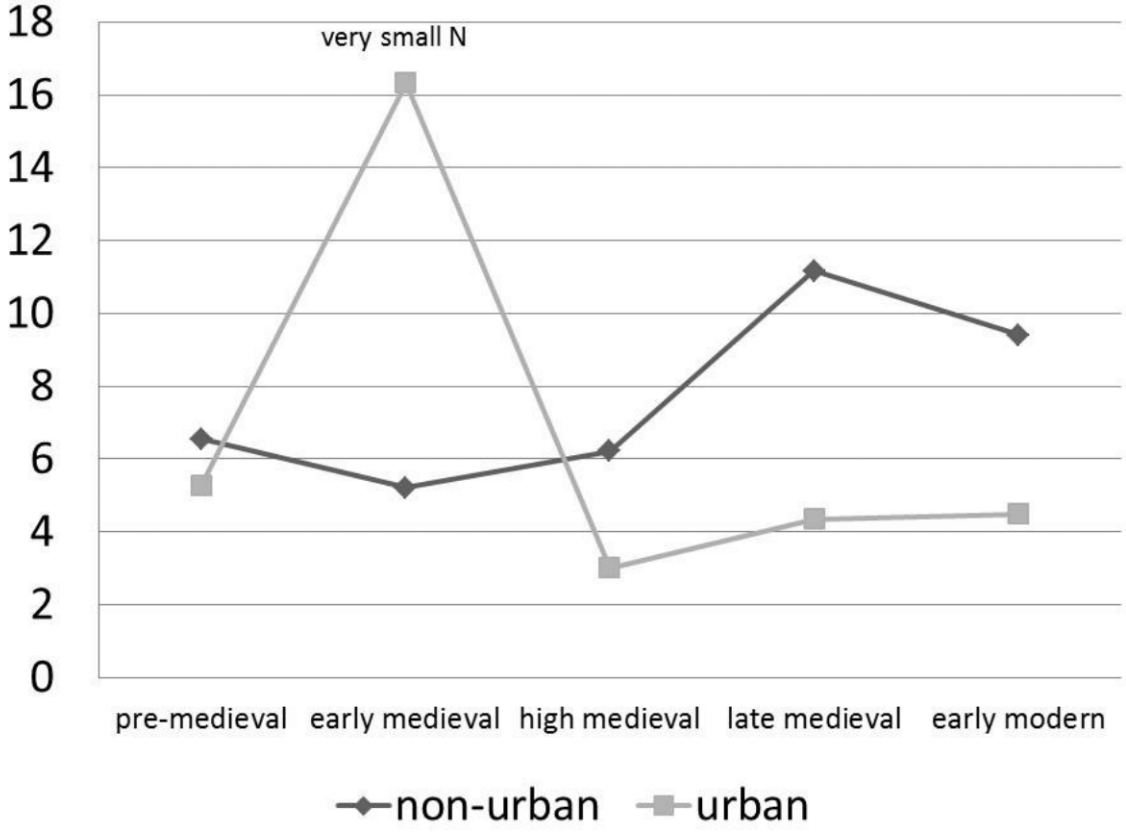
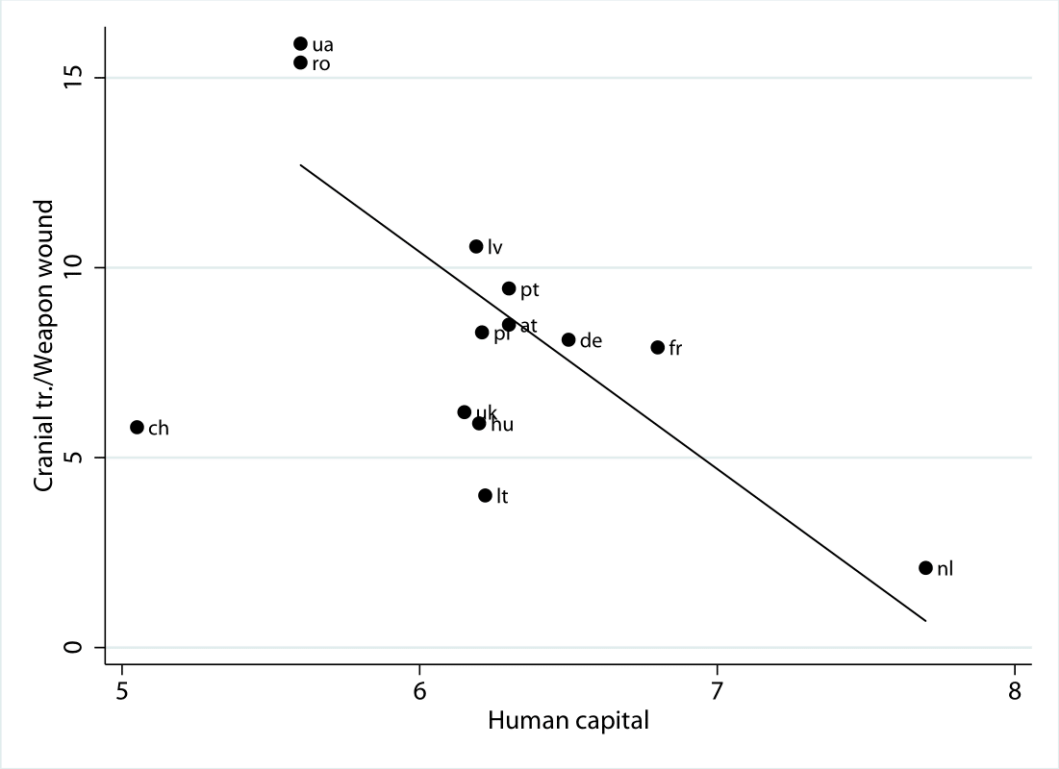


Figure 10.9 Negative correlation between human capital and cranial trauma/weapon wounds



NOTE: Source of human capital data: Buringh and van Zanden (2009).

Table 10.1 Descriptive Statistics

Variable	*Obs*	*Mean*	*Std. Dev.*	*Min*	*Max*
Cranial traumata & weapon	4738	5,53	22,86	0	100
Cranial traumata	4738	5,36	22,53	0	100
Pre-medieval	4738	0,08	0,26	0	1
Early medieval	4738	0,38	0,49	0	1
High medieval	4738	0,13	0,33	0	1
Late medieval	4738	0,10	0,30	0	1
Early medieval	4738	0,24	0,43	0	1
Northeastern Europe	4738	0,32	0,46	0	1
Nortwestern Europe	4738	0,28	0,45	0	1
Central Southeastern Europe	4738	0,39	0,49	0	1
Female	4738	0,46	0,50	0	1
Interior	4398	0,72	0,45	0	1
Craftsmen	4726	0,36	0,48	1	1
Religious	4696	0,09	0,29	1	1
Others	4738	0,06	0,23	0	0
Urban	4738	0,44	0,50	0	0
CVM50	4726	1	0	1	1
CVM75	4696	1	0	1	1

NOTE: “Pre-medieval” refers to the third to fifth centuries CE. CVM50 = cranial vault material available > 50%. CVM75 = cranial vault material available > 75%.

Table 10.2 Observations by region and time period

	North-Eastern Europe	*North-Western Europe*	*Central and South-Eastern Europe*	*Mediterranean*	*Total*
Pre-medieval	152	80	110	14	356
Early medieval	158	310	1321	12	1801
High medieval	447	0	157	0	604
Late medieval	144	297	0	37	478
Early modern	594	350	165	18	1127
Industrial	0	273	99	0	372
Total	1495	1310	1852	81	4738

Table 10.3 Trends of violence: Cranial trauma and weapon wounds, relative to all skeletons of sufficient preservation (non-military sites); controlling for age

	(1)	*(2)*	*(3)*
Preservation	>50%	>75%	>75%
Gender	Both	Both	Females
Pre-medieval	1.78	1.29	1.24
	(0.240)	(0.376)	(0.228)
Early medieval	2.04**	1.36	1.96***
	(0.048)	(0.186)	(0.004)
High medieval	0.82	0.29	1.41*
	(0.528)	(0.823)	(0.097)
Late medieval	3.65***	2.83**	2.06**
	(0.007)	(0.030)	(0.032)
Early modern	1.24	1.09	1.61**
	(0.262)	(0.321)	(0.024)
Region controls	Yes	Yes	Yes
Gender controls	Yes	Yes	No
Age controls	Yes	Yes	No
Constant	5.00***	5.08***	0.58
	(0.000)	(0.000)	(0.157)
Observations	4,726	4,696	2,153
R-squared	0.02	0.02	0.00

Table 10.4 Determinants of violence: regions, gender, topography, occupational and age variables (Cranial trauma and weapon wounds, relative to all skeletons of sufficient preservation (CVM>50%); non-military sites)

	(1)	*(2)*
Occupations	incl.	excl.
Northeastern Europe	1.05	1.55
	(0.374)	(0.152)
Mediterranean	6.49	7.44*
	(0.110)	(0.065)
Central Southeastern Europe	2.02*	2.03**
	(0.088)	(0.049)
Female	-6.04***	-6.09***
	(0.000)	(0.000)
Interior	-0.40	-0.06
	(0.726)	(0.954)
Craftsmen	0.68	
	(0.603)	
Religious	-2.31	
	(0.282)	
Others	3.42	
	(0.123)	
Urban	-3.19*	-2.20
	(0.081)	(0.144)
Old-age	-1.18*	-1.18*
	(0.091)	(0.090)
Time controls	Yes	Yes
Constant	7.84**	6.64**
	(0.013)	(0.025)
Observations	4,387	4,387
Adjusted R-squared	0.02	0.02