Violence Trends in the Ancient Middle East between 12,000 and 400 BCE

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Abstract: How did interpersonal violence develop in early human societies? Given that homicide records are only available for the more recent period, much of human history remains virtually outside our purview. In this paper we study violence trends in the very long run by exploiting a new dataset on cranial trauma and weapon-related wounds from skeletons excavated across the Middle East, spanning the whole pre-Classical period (ca. 12,000-400 BCE). The data set includes more than 3,500 individuals. We find evidence that interpersonal violence peaked during the Chalcolithic period (ca. 4,500-3,300 BCE). It then steadily declined during the Early and Middle Bronze Ages (ca. 3,300-1,500 BCE) and increased again between the Late Bronze and the Iron Age (1,500-400 BCE). By documenting variations in violence patterns across a vast temporal and geographical scale in an incredibly rich historical setting, we broaden perspectives on the early history of human conflict.

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Main:

How did violence develop in the very long run? Some recent studies argued for a secular trend toward less violence over centuries or even millennia[1,2,3]. However, the prevalent claim that interpersonal violence (assault, murder, slavery, torture, despotism, cruel punishment, violent feuds, etc.) has declined over millennia–and more rapidly since the Enlightenment–has been variously challenged[4,5]. But so far, no consensus has been reached. In fact, because homicide statistics are only available for recent periods[3,4], and because conflict records are subject to reporting biases[6], our understanding of long-term violence trends is still limited, the further back we go in time. This situation has generated highly polarized narratives about the early history of violence[7,8,9]. Indeed, the scholarship on the origins of warfare split into two major factions, one–the so-called "pacified past" group, or "doves"–thinking that violence in human history picked up only after the Agricultural Revolution and the rise of states, while the other saw warfare as pervasive in prehistory, i.e. the "hawks"[9,10,11]. Although the hawks/doves division fueled much debate between the 1990s and early 2000s, nowadays a more nuanced picture is emerging.

Lately, social scientists, anthropologists, biologists, and archaeologists interested in historical conflict have started to converge in terms of methods and scopes. As a matter of fact, studies investigating the causal mechanics of violence, often adopting a cross-cultural approach, have started to better document variations in conflict patterns through the accumulation of new skeletal information[12,13,14,15,16,17,18]. Indeed, recent progress in forensic investigation techniques applied to human skeletal remains prompted the proliferation of standardized databases of excavated skeletal data[19,20,21], thus contributing tremendously to studying variations in human

violence across different spatial, social, and temporal scales, which is crucial to correctly frame the role of conflict in human evolution[18].

We build upon these theoretical and methodological advances to construct and analyze a dataset of skeletal evidence which allows us to study long-term violence trends in the ancient Middle East, spanning almost twelve millennia and covering all its major geo-cultural regions (see **Figure 1**). Our evidence-based contribution champions the potential for biocultural interpretation of large bioarchaeological datasets when answering bigger questions about past violence. Understanding differences in levels of violence in the past is not only a central issue in social sciences[1,22] , but also in anthropology, archaeology, and history[7,10,23,24].

We formulate several hypotheses, based on the existing literature: (Hypothesis 1) During the Neolithic period, the population density was still very low, and therefore potentially conflicting groups could easily avoid each other. During this period, we would expect relatively low incidence of violence, roughly in the range or slightly below the European violence levels observed by Fibiger et al.[25] (Hypothesis 2) During the Chalcolithic, when the first cities emerged, we would expect more common violence. This was a period that witnessed stressful changes such as urbanization and the emergence of proto-states[26]. (Hypothesis 3) During the Early and Middle Bronze Age, the synergetic effect of state, law and trade development reduced interpersonal violence. Finally (Hypothesis 4): During the Late Bronze and Iron Ages, we would expect higher violence due to the frequently postulated "collapse" phenomena and the only gradual recovery of conflict-reducing state activities.

Results:

Scope of the study

In this paper, we report the findings of a study based on the analysis of a new dataset on violence-related injuries in seven Middle Eastern countries (Turkey, Iraq, Iran, Syria, Lebanon, Israel, and Jordan). We study no less than 3,539 well-provenanced skeletons dated to the period from the Mesolithic to the onset of Classical Antiquity, i.e. c. 12,000-400 BCE(Table 1)[27,28,29]. We define the intensity of interpersonal violence as the share of individuals exhibiting weapon-related wounds or cranial traumas (see our discussion in Supplement section "Material and Methods"). We combine primary data analyses and the re-analysis of published material that used different reporting systems (i.e., ways of representing the observations using numerical values), as well as published sources of cranial trauma and weapon wound aggregates that do not always provide a catalogue of raw data. We need to emphasize that perfect standardization is impossible, especially with the latter type of source (for a detailed discussion of the limitations, for example arising from the crude-vs-"true" rates see Supplement section "Material and Methods"). However, we carefully assess the robustness and plausibility of our findings and observe them to be informative.

The pre-Classical Middle East is a key laboratory for our exercise because it allows us to study changes in violence trends across several crucial historical transformations, such as the transition from foraging to farming, the Urban Revolution, the rise of agrarian states and their evolution up to universalistic empires, globalism, etc.[30], and because no systematic studies of comparable scale have been attempted before in this setting.

Our results inform both a social scientific literature seeing the emergence of early states as a social technology instrumental for reducing violence[22] and the debate about the origins of violence in archaeology and anthropology, where an influential view is that increasingly complex political organization brought about higher intensity of warfare and coercive capabilities, with higher casualties and burdens for the population[10,11,23]. Our findings provide three advances over

the extant literature. First, our approach combines methods in historical econometrics and anthropology for reliably assessing violence levels across the full spectrum of the historical experience–provided that sufficient bioarcheological data are available–thus enhancing replicability. Second, we fill a gap in scholarship by shedding light on twelve thousand years of conflict in an exceptionally important historical setting, i.e., the pre-Classical Middle East. Third, we document that although the rise of first states was accompanied by a dramatic increase in strife, the development of "mature" Bronze Age states went in parallel with a strong reduction of interpersonal violence, which aligns with the idea that by building state capacity, early institutions could provide some key benefits to their populations.

A short history of the Ancient Middle East

We begin with a short historical overview. How did some core aspects of ancient Middle Eastern societies develop over the time frame from 12,000 to 400 BCE? We define these "core aspects" as (i) the ability of the state to constrain interpersonal violence, (ii) population density, (iii) climate (with its impact on harvests), and (iv) military development.

During the Neolithic, population density remained low, despite the gradual diffusion of farming technologies[31]. However, during the Late Chalcolithic period (from ca 4400 BCE), a trend towards drier conditions was one of the factors potentially triggering urbanization, with population flowing from the countryside to major sites rapidly turning into cities, where emerging elites started to compete over the control of resources[32,33,34]. Crowding and rising inequality may have triggered conflicts following appropriation of other groups´ resources resulting in higher interpersonal violence[35]. The Chalcolithic saw also the rise of the first proto-states[36]. Following the idea that these were low-capacity states[37,38], their ability to settle conflicts within their populations was seemingly still quite limited.

The following Early Bronze Age and Middle Bronze Age–hereafter EBA, MBA–(ca 3,100 to 1,550 BCE) were the first "Golden Age" periods in Mesopotamia, Levant, and partially in the neighboring regions. City-states and empires developed increasing state capacity which we define as the ability of the state to reach its aims via taxation, constraining interpersonal violence, and other classical roles of the state. This is attested by increasingly ambitious building programs (fortifications, temples, palaces[39,40]) and steady territorial expansion[41,42]. Furthermore, a relatively high sophistication in settling conflicts using ideological, bureaucratic, and legal means was achieved. As a matter of fact, codified legal systems[43], ramified bureaucracies, and strongly centralized military control[44], the diffusion of inter-city religious festivals[45,46], cooperative projects[47] and risk-sharing activities contributed to transforming followers into citizens[48,49], which was instrumental for controlling social violence. This is further attested by the fact that although the transition between the E-MBA was characterized by high population thresholds[50], extended drought[51] (the 4.2ka BP event), and by a take-off of military activity–in terms of intensity and development of bronze weaponry[52,53]–, interpersonal violence kept decreasing.

Moreover, during the E-MBA, long-distance trade flourished[54,55], as merchants were relatively protected against expropriation by rulers–especially private merchants in Mesopotamia[56]. This prosperity could be sustained for several centuries, even in the face of increasingly arid conditions[57] and rising inequality[58,59]. In fact, the combination of declining crop yields, increasing privatization, and monetization of economic activities, impoverished farmers, while private traders and businessmen were able to amass increasingly large economic and political power due to their role as money-lenders, tax-farmers and enterpreneurs[60]. As to the military sector, the eclipse of the regional Akkadian and Ur III empires was followed by a

balkanized landscape of city and territorial states that competed for supremacy, often through warfare[61,53]. Noteworthy is the professionalization of army service in this phase and the increasing reliance on mercenary troops for fighting wars[62], which may have contributed to lower the occurrence of violence-related injuries in the social sectors not directly involved in warfare[28].

Finally, the Late Bronze Age and Early Iron Age–hereafter LBA and IA–(ca 1550-1100 BCE) saw, after a temporary flourishing of the Levant region with the rise of the Hittite and Mitannian powers[42], a substantial crisis of the Bronze Age societies followed. This was propelled by a 300-years drought, climate-induced migratory movements and general economic decay[63,64,65]. Many famous cities were burnt by foreign invaders[63], and climatic worsening reduced the population density strongly, especially in Mesopotamia[66]. The spread of iron weapon technology and mounted warfare not only revolutionized warfare through the creation of iron-armed and armored shock troops, leading to a change in social structure: hegemonic empires expanded in an unprecedented way[67], and this also triggered a proper "arms race" in Eurasian societies[68,69]. Consequently, in the "Age of Empires", a larger share of the population participated–directly as mass-mobilized soldiers or indirectly as civilian casualties or deportees–in warfare[70,71]. Another byproduct of the formation of empires controlling vast territories and endowed with unparalleled powers of extraction and mobilization was a greater and even more unequal wealth accumulation, especially concentrated in very large imperial centers[72,73]. Repressive policies, large-scale warfare, and unprecedented levels of inequality may have also had implications for interpersonal violence. As a matter of fact, widespread resistance to imperial power in shape of rebellions and insurgencies is attested in the written sources of the time, especially in the peripheral and remote areas of the empire, as well as intra-elite fighting[74].

Empirical findings

We assigned each observation to one of the six time periods, namely the Mesolithic/Neolithic period (from ca. 12,000 to 4,500 BCE), the Chalcolithic (ca. 4,500 to 3,300), the EBA (ca. 3,300 to 2,000), the MBA (2,000 to 1,550), the LBA (1,550 to 1,200), and finally the IA (1,200-400). The Mesolithic/Neolithic period is dominated by the much larger Neolithic sample; hence we summarize it under "Neolithic" in the following (see also notes to **Figure 2**). We follow the archaeological periodization in line with previous influential studies[30]. We define "Levant" as the rain-fed region encompassing modern western and northern Syria, Israel, and Lebanon; whereas "Mesopotamia" corresponds to the region where irrigated farming was practiced, i.e. modern Iraq and eastern Syria, up to the area of Tell Ashara (Euphrates/Habur confluence, see **Figure 1**). Ancient Turkey corresponds to modern-day Turkey as ancient Iran to the modern country.

The empirical results suggest that there was a high level of violence in the Chalcolithic period, and elevated levels during the Iron Age (see **Figure 2**). In statistical tests, we observe that the differences between the Neolithic and Chalcolithic are statistically significant, with a Cohen's D effect size of 1.193 (b=coefficient, z-Statistic with degrees of freedom in brackets, Cohen's D effect size calculated as coefficient relative to standard deviation, CI=confidence intervals, we consider model 3 as normality can be confirmed, see notes to **Table 2**): Neolithic versus Chalcolithic: b -1.332, z(70)=-4.33, p=0.000, Cohen's d effect size 1.193, 95%CI -1.934, -0.729 (**Table 2**, column 3). Similarly, the difference between Chalcolithic and E-MBA were statistically significant. Notably, the data from the E-MBA show a consistently lower level of violence in the region than before (Early Bronze b -0.800, z(70)=-3.22, p=0.001, Cohen's d effect size 0.741, 95%CI -1.287,-0.312. Mid-Bronze b -1.815, test stat. z(70)=-2.55, p=0.011, Cohen's d effect size 2.852, 95%CI -3.210,-0.420). Moreover, the Iron Age was different from the Chalcolithic: b -1.114, z(70)=-4.38, p=0.000, Cohen's d effect size 0.997, 95%CI -1.612, -0.615. We observe

significant difference for burial contexts that were related to battles (b 1.157, z(70)=2.600, p=0.009, Cohen's d effect size 1.134, 95%CI 0.283, 2.031) and royal context (b 1.861, z(70)=3.970, p=0.000, Cohen's d effect size 1.824, 95%CI 0.941, 2.781). The coefficients are reported In logs (on the logarithmic transformation, see section "Methods"). If we want to express the effect in percent, we need to calculate the exponential. For example, the coefficient of MBA (relative to Chalcolithic) is exp(1.815) = 6.141, with a negative sign, more than 6% decline in violence.

As to regional distribution, we detect an occurrence of traumas of 8.4% in Turkey, 18.6% in Iran, and 10.8% in Levant–and for Mesopotamia, 6.3% (see **Figure 3**). However, the error bars (representing standard errors) indicate that the data for each region vary quite strongly. One potential reason is the fact that changes over time were quite substantial (as we see below in the data), and this variation enters the total standard error of each region.

Discussion

In the following, we interpret these changes based on our initially formulated hypotheses. The elevated levels during the Chalcolithic and IA periods are not unexpected. Indeed, the Chalcolithic period witnessed the shift from occasional feuding to large-scale organized conflict which has been connected to the emergence of the first centralized proto-states[26,75,23]. Similarly, the transition to the IA experienced major upheavals–a 300-year drought, population displacements, resource stress, and state dissolutions, especially in the Levantine regions and Iran[64]–followed by the rise of superpowers, such as the Assyrian empire, that expanded through military campaigns, forced taxation and mass-scale deportations[76,22]. A possibly similar mechanism is identified by McCool et al. for the Inca period Nasca highlands in Peru, where a reduction in resource availability due to negative climate shocks triggered competition and escalation in lethal conflict in populations with high demographic thresholds[15].

However, a substantial and continuous decline in lethal aggressions was experienced between 3,000 and 1,500 BCE, i.e. during the EBA and especially MBA. Notably, despite state formation/decline episodes, droughts, and warfare[44]–especially across the transition between the 3rd and 2nd millennia, when a shift towards drier conditions increased pressure on resources and was one of the triggers of demographic changes[77,78]–the Bronze Age Mesopotamian societies managed to reduce internal violence. They partly redirected conflict towards external enemies, as indicated by lower levels of trauma in Mesopotamia and by the match between the concentration of traumas and the royal inscriptions documenting the warfare campaigns of Mesopotamian kings along the eastern borders[28,52].

An influential literature on historical violence trajectories[1,3,79] posits that the combined effect of the development of state capacity and trading systems is possibly the main force behind the declining homicide rates in Medieval Europe. Three key historical facts from our sample seem to support this idea (see also Supplementary Materials: Appendix A). First, although proto-states emerged very early[41], it is only around 2,500 BCE that Mesopotamian polities morph into territorially centralized kingdoms. Later they developed into empires with extensive administrative apparatuses and strong policing capabilities[80,41]. Second, written law codes and legal remedies for private rights–enforced by formal courts–expanded the most between 2,400 and 1,700 BCE[81]. Third, empirical analysis of long-distance exchanges indicates that trade expansion peaked between the late EBA and the early MBA[82,55,54]. Notably, together with the post-2,000 BCE "trade revolution", cuneiform writing expanded dramatically both geographically and socially, indicating rising levels of literacy[83]. These changes were flanked by the increasing professionalization of

Mesopotamian armies[62], which possibly contributed to confining interpersonal violence to specific social arenas. Thus, state consolidation and the expansion of legal and commercial systems may have exerted an effect of lessening the propensity for violence in the sample.

Moreover, we assessed whether the changes towards less interpersonal violence during the E-MBA might have been rather correlated with inequality, climate, population fluctuations, or major military innovations. Consistent with our main hypothesis, we found that these alternative explanations do not seem to bear much weight. First, inequality–a possible driver of violence[84]–steadily increased during the Bronze Age[58,59], and it is therefore at odds with our findings. Second, when we formally assess the relationship with droughts, demography, and the technological innovations (see section "main results of regressions" below) associated with the "cavalry revolution"[69] (see **Table 2** below), we did not observe a strong correlation with lethal aggression. Overall, this test, although limited to the violence covariates that are most efficiently measurable in archaeological and historical records, suggests that it is difficult to envision mechanisms different from the ones we take into consideration.

Similarly and compatible with our regional results, Kohler et al. find evidence of declining violence in the most strongly organized Pueblo societies (i.e., when their state became more capable), in the US South-West, that could be linked to the creation of inter-village confederacies, whereas the expansion of aggressive polities and societal collapse seemingly increased strife[18,79].

Although we cannot draw any causal conclusion or generalization from the observed synchronisms, we can confirm for this specific case of the Ancient Middle East that the violence decline took place at a time when early states achieved substantial capacities to reduce conflicts in their societies[81,82], and then increased again between the LBA and the IA (1,500-400 BCE), when major crises and the expansion of empires caused upheavals across the whole region[63,76]. Given that the number of observations is quite low for the LBA, we need to take the results for this period with caution (the statistical significance of the LBA is also not given in Column 2 to 7 of **Table 2**). The increase in violence between the MBA and the LBA is plausible, though, if we see the higher violence level of the LBA and the IA together. The early IA especially shares characteristics with the LBA.

In sum, through a standardized methodology for inferring cranial and weapon-related trauma in sufficiently well-preserved skeletons (details in supplement section "Material and Methods"), we find that interpersonal violence peaked during the Chalcolithic period (ca. 4,500-3,300 BCE). Then, violence steadily declined during the E-MBA (ca. 3,300-1,500 BCE). In an additional analysis (Supplementary section "Robustness and sensitivity tests"), we observe that the Chalcolithic increase or the E-MBA decline of violence was by far not only a proto-urban phenomenon, as the splitting into urban and rural effects results in overall significant effects, but not a separate urban effect.

We also assess (and reject) the possibility below that "warrior idealization" might have biased the trends. We discuss that this idealization might be reflected in a high number of bronze weapons which increased during the Middle Bronze Age (**Figure 4,** for a detailed discussion, see the Methods section)[69]. Given that this was a period of declining personal violence, a "warrior idealization bias" seems not to have implied a higher rate of cranial trauma and weapon wounds from violent conflicts.

These findings are not only useful for providing an empirical grounding to the history of violence in the pre-Classical Middle East, but they also inform debates in anthropology, archaeology, and social sciences about the nexus between conflict and premodern state formation. In particular, the emergence of early states in the ancient world is usually seen as a process in

which political leaders, acting as violent entrepreneurs, establish "armed peace" via coercion and absolutism[1,22]. Given the lack of violence time series for much of early human history (except for Europe in the Neolithic[25]), this idea has not been subjected to formal scrutiny. By exploiting not previously compiled bioarcheological evidence to quantify levels of interpersonal violence in the deep past, we document more accurately when and in what circumstances ancient Middle Eastern societies became effective in controlling interpersonal violence. Indeed, we find that, although the emergence of proto-states coincided with a significant violent spike in our sample, the timing of violent rates reduction is compatible with the theory that once early states achieved core capabilities–i.e., territorial control, centralization of political violence, full-fledged legal systems–, and actively supported the expansion of trade networks, levels of lethal violence markedly dropped (Hypotheses 1-3). However, these security gains–seemingly aided by climate and epidemiological shocks temporarily reducing population pressure–were short-lived and the region witnessed major disruptions across the transition between the Bronze and Iron Ages, possibly because of the rise of more extractive powers, more widespread access to cheaper weaponry, and mounting pressure over diminishing resources (Hypothesis 4).

We conclude by reinforcing that the combination of growing availability of anthropological/archaeological proxies and the convergence of the application of statistical methods and biocultural interpretations provide new pathways for interdisciplinary cooperation between social sciences and historical disciplines on crucial debates, such as the role of violence in human evolution.

Methods

Measuring interpersonal violence

To study variations in violence levels in our sample, we measure the intensity of interpersonal violence as the share of individuals exhibiting weapon-related wounds or cranial traumas (details in supplement section "Material and Methods";[79,85]). The use of this indicator is motivated by the fact that in historical populations, cranial traumas and weapon injuries were often the results of interpersonal violence, as demonstrated by the systematic analysis of such indicators for a skeletal sample from European regions stretching 2,000 years[79]. To construct our database, we collected evidence of antemortem cranial traumas, excluding post-mortem damage. We also considered perimortem trauma if it could be clearly distinguished from post-mortem damage (following Baten and Steckel[1]). We excluded post-mortem traumata, as 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[79]. These fractures, as far as possible, tend to "propagate at right angles to the bone surface", rather than an oblique angle as in the case of perimortem trauma. Often, a color difference relative to the undamaged bone surface is visible in the case of postmortem trauma. We excluded stress or accident-related fractures. In case of the cranium, we only include traumas that were located above the hat-brim line–the line where an imagined hat brim touches the head, i.e., the frontal or parietal bone–which is usually part of the skull hit by violent blows, in contrast to accidents that usually affect the area below the hat brim line (for more details about the accident-vs-violence differentiation, see the Supplement, section "Material and Methods"). Still, we need to acknowledge that it is not possible to distinguish accidental and violent trauma in a perfect way. We included only skeletons aged 15-years and above to obtain a more homogeneous sample based on the age criteria. In addition, we collected data about postcranial marks typically resulting from weapon wounds, such as arrowheads (see Supplementary Material: Material and Methods). This makes our study compatible with the Global History of Health project studies[79].

However, the share of post-cranial weapon wounds was tiny, and most of our evidence comes from cranial trauma. Although cranial and weapon traumas are obvious indicators of violent behaviors and allow us to measure the intensity of interpersonal violence in our sample, it must be stated that such a strategy typically underestimates violent deaths since a variety of wounds, particularly those to the soft tissues (e.g., poison, septic wounds, ruptured organs, etc.), do not leave specific marks on bones. Notably, Baten and Steckel[79] demonstrated that this data agrees well with other proxies for interpersonal violence, such as historical records on homicide, regicide, and elite deaths in battle–the latter include violence against soft tissues of course, such as stabbing a knife into the stomach. We calculated trauma shares, which correspond to the ratio between the number of cranial and postcranial weapon wounds and the total number of sufficiently well-preserved skeletons from a given site/period. Our sample consists of 3,539 total individual human remains examined with an overall number of traumas attested on 323 individuals, i.e., a weighted average share of 9.1% (**Table 1**).

Turning to potential selectivity biases that may affect our trends, we controlled for the distribution of observations between urban and non-urban (burial sites, rural villages, pre-urban communities, etc.) environments. We created dummy variables for special contexts, such as sacrifice of human retainers in royal interments. These variables allow us to adjust for religious and royal samples in the following regression-based estimates. Moreover, we identified clearly defined battle sites or cases of military attacks. In case of violence occurrence, the division between urban and rural contexts is considered meaningful by a substantial strand of historical literature[79,77]. Overall, our sample is quite well-balanced with 1,310 cases coming from urban contexts and 2,229 from non-urban ones, with this category grouping rural communities, burial sites, and pre-urban communities.

Assessing the representativeness (or selectivity) of the violence data set

We assess, in this part of the study, to which degree the selectivity of burials changed over time. Of course, we cannot claim full representativeness, as probably no bioarchaeological sample for such a comprehensive (early) period and region can be fully representative. In the following, we discuss at which points our sample deviates from full representativeness, and how substantial these differences are. Fortunately, we can provide a large body of evidence and plausibility assessments that indicate that our sample does not fundamentally deviate from this ideal.

Theoretically, we could imagine a bias from the fact that in some societies individuals who were more at risk of violence were better represented among the burials that we can observe. For example, in societies that emphasized and idealized military values, their soldiers might have been buried with more care and perhaps more likely been found by modern archaeologists. We call this a "potential warrior idealization bias". How can we assess whether such a bias existed, and was substantial? Several possibilities exist. First, one strategy is to discuss whether during some periods and in regions of our study area military success was exceptionally highly considered, even idealized, and whether this resulted in the practice of burying military individuals with greater care. This might lead to more individuals with violent trauma among the overall number of buried persons recorded in excavation reports. In fact, some qualitative changes in military presence took place in society, especially when metal weapons became more widespread in graves during the Bronze Age, and graves of warriors became richer, and burials were performed with greater care. The evidence strongly indicates that although swords and metal weapons were already introduced during the Chalcolithic period–when feuding turned into warfare[86,87]–weapons start to be routinely

found in the graves during the E-MBA. Several leading scholars elaborated on the creation of an elite warlike ethos as reflected in burials[88,89,90]. Bronze weapons gave warriors a special status[91].

Gernez surveyed all the bronze weapons excavated in the Ancient Middle East[92,93]. Most of the weapons were excavated in warriors' burials, and their frequency takes off after 3,000 BCE (**Figure 4**). Notably, this increase is dramatically larger than the increase in overall population. For the pre-Chalcolithic period we need to add a cautionary note: many weapons were tools that were mostly used for other purposes such as hunting, farming, etc., but that could also be used as weapons. At the same time, during most of the Bronze Age we observe a relatively modest and declining violence level, so this bias cannot make our findings obsolete–quite the contrary, Bronze Age violence levels might be even lower if we take this high status of warriors into account. In other words, we see an inverse trend in our trauma data: Exactly when the warrior burials were richer and more elaborate, which Gernez interprets as reflecting a society with strong warrior idealization, the cranial trauma and weapon wound evidence suggest less interpersonal violence. In sum, we find arguments that the warrior idealization bias was probably not too substantial, as for the most extreme case it did not hold. We could even put forward the argument that the bias would reinforce our results. Moreover, we control for battle sites and massacres so the bias might not be large. Of course, this corresponds to our discussion about substituting interpersonal violence with violence against foreign states. The Bronze Age states succeeded in reducing interpersonal violence, but they channeled the aggression of the military parts of their societies against other states and societies[92,93]. Hence, another possible interpretation would be the specialization of warrior activities, which leads to less violence outside the warrior occupation[92,93].

Next, we pursue a second strategy to assess potential bias by comparing different regions (**Figure 2**). The cross-sectional differences of potential excavation bias can be assessed by comparing similar trends for different regions. In our case, we observe graphically a strong interregional co-movement of violence rates, and it seems less likely that all these societies had similar levels of warrior idealization bias. While the changing selectivity could be imagined having taken place in these other regions as well, such synchronicity is less likely under different institutional and social circumstances. Hence, similar trends increase the plausibility of individual trend estimates.

Thirdly, the correlation with possible determinants of interpersonal violence makes the estimates even more plausible. The literature on the Ancient Middle East clarifies that the Early and MBA were periods in which the states had developed skills to convince their people that less interpersonal violence should be used, as, for example, increasingly codified legal systems helped to solve conflicts without violence[94] (see Supplement: Appendix A). As a result of these new capabilities of states, interregional trade flourished. This correspondence of potential causes and consequences makes it substantially less likely that our observed trends stem from social selectivity of excavated individuals. All three strategies of bias assessment add additional plausibility to the new estimates.

Empirical approach: were other variables related to violence trends?

In the following, we formally assess in a multiple regression analysis whether the changes over time that we observed were statistically significant (see notes to **Table 2**). Moreover, we include control variables to analyze whether the changes towards less interpersonal violence during the E-MBA might have been rather correlated with third variables such as climatic shocks, population pressure, or military innovations, instead of the correlation with the period variables E-MBA. Following the extant research on violence, it is possible to single out many factors as potential

covariates, such as state capacity, demography, income, inequality, trade, human capital, military technologies, climate, diet, geography, etc.[12,95,79]. We focus here on some key factors that can be reliably measured in the archaeological record, and we evaluate whether our estimates are affected by them or not. We control for settlement size[77], the most important military innovations–i.e. iron technologies and mounted warfare[69]–, climate shocks–i.e. droughts (unusually cold/dry spells)[96]–, and population fluctuations. Our main control variables are defined as follows: "urban versus rural" character is 1 if a threshold of 5 hectares area size is reached, and 0 otherwise. "Climatic shocks" are defined as the share of the period that is characterized by a rapid climate change event consisting of cool and dry spells[97], reducing temperature and precipitations, and generating droughts that negatively affected agricultural production[98].

How do we measure weather shocks? Several studies have focused on paleoclimatic evidence especially in the debate about the transformation towards agriculture and urbanization, in the debate about the collapse events 4.2ka and 3.2ka before present, and on the impact of climate change and state evolution. Paleoclimatic evidence routinely exploited by this literature consists of natural archives of high-resolution proxies (i.e. speleothems) or global simulated trends scaled at various spatial resolutions. According to growing evidence about the positive correlation of lethal violence and drought-induced resource shortages in the pre-industrial world[17,32,69,15,65] in our study, we focus on controlling for the impact of droughts–i.e. unusually cold and dry climatic spans–which were negatively related with production by lengthening the dormant phase of plants growth (winter crops in the study sample), creating mismatches in the agricultural cycle[53]. Although local conditions may vary slightly, extended droughts–such as millennial-scale events–tend to be correlated between regions. Accordingly, we wanted to be able to check whether in the aftermath of major drought spells violence spiked in our sample.

"Iron technology" is defined as 1 if the excavated site yielded iron materials and especially iron weapons. This military technology was introduced first in the Caucasus region and then imported into Mesopotamia[69] and other regions of the Middle East. It might have been related to social change in our regions. Similarly, we add a control variable for the emergence of horse-mounted warfare. Horse-based military technology arrived from Central Asia and the Caucasus region[69]. This variable is 1 if horses are shown in pictorial finds, mentioned in cuneiform tablets, or bioarchaeologically attested[69,99]. Finally, "population size" is included in the equation. We use the estimates of population size based on the area of the excavation locations during a specific time-period, to control population pressure effects. We do not make any claims about the direction of causality or the exogenous nature of these variables. We only want to assess whether these variables might have made the change from the Chalcolithic to the E-MBA statistically insignificant.

Main results of regression analysis (adding control variables and assessing statistical significance)

In **Table 2** we provide the regression results. The reference category (i.e., the comparison period) for the time periods is the Chalcolithic, one period with tremendous violence as seen in **Figure 2.** We reported already above the following results. Here we briefly summarize them again in order to compare them with models in which we are adding control variables. In comparison with the Chalcolithic period, we observe lower violence during the Neolithic period (column 3: b -1.332, z(70)=-4.33, p=0.000, Cohen's d effect size 1.193, 95%CI -1.934, -0.729). Again, relative to the reference categories of the Chalcolithic, we observe a decline in violence during the EBA and even

more pronounced in the MBA (early bronze b -0.800, z(70)=-3.22, p=0.001, Cohen's d effect size 0.741, 95%CI -1.287,-0.312. coeff. b -1.815, test stat. z(70)=-2.55, p=0.011, Cohen's d effect size 2.852, 95%CI -3.210,-0.420). In contrast, while for the IA the coefficient is also negative (hence less interpersonal violence than in the Chalcolithic), the coefficient is smaller (b -1.114, z(70)=-4.38, p=0.000, Cohen's d effect size 0.997, 95%CI -1.612, -0.615). The coefficients are reported in logs. If we want to express the effect in percentage, we need to take the exponential. For example, the coefficient of MBA (relative to Chalcolithic) is exp (1.815)=6.141, with a negative sign. Hence the MBA experienced a decline in violence by 6.141 percent, whereas the Iron Age only saw lower level of violence compared to the Chalcolithic. To make sure, we tested the Holm-Bonferroni adjustment in Appendix C and arrived at the same results as the results reported here without adjustment.

We tested a model without controls (Column 1) and then added the controls consequently one by one. The results of the EBA and MBA period coefficients turn out to be extraordinarily robust. In model 2 we added regional differences ("regional fixed effects") to control for differences between the four regions that could not be covered by other proxy variables. In column 3 we add the battle, royal and urban variables to control for a battle character of the site, a royal interment, or an urban character. The royal and battle variables are not tested separately in separate columns, because we do not include them with a contextual model in mind, but simply as controls. Royal and battle are associated with higher violence (b 1.157, z(70)=2.600, p=0.009, Cohen's d effect size 1.134, 95%CI 0.283, 2.031) and royal context (b 1.861, z(70)=3.970, p=0.000, Cohen's d effect size 1.824, 95%CI 0.941, 2.781). In column 4 we add climate shocks, in columns 5 and 6 the iron and horse weapon technologies, and in column 7 population size. Adding the control variables one by one, we observe that the coefficients for E-MBA are almost unchanged. Urban sites had no significantly higher interpersonal violence during this period. In **Table 2**, column 4, we add the variable for climate shocks. The coefficient of this variable is statistically insignificant. In **Table 2**, columns 5 and 6 we add iron and horse-riding technology. Again, the E-MBA coefficient was not substantially affected.

To assess the robustness and sensitivity of our results, we perform a series of tests in the Supplementary section "Robustness and sensitivity tests": (i) We begin with an assessment of time-region units with small numbers of observations. (ii) We also take a different modeling strategy for our multiple regression analysis: in the second robustness test, we do not cumulate the right-hand side variables, but include them separately. (iii) Thirdly we perform a sensitivity analysis by including an interaction term analysis of urban place and period. This allows us to assess the robustness of our results considering urban and rural differences (or not). We finish with (iv) an anthropological sensitivity analysis, namely, including or not including the so-called parry fractures (for the details and results, see Supplementary section "Material and Methods"). We conclude from all these robustness and sensitivity analyses that our results are quite stable and consistent.

In sum, the observed coefficients correspond with our hypotheses that we formulated based on the existing literature, and the additional control variables did not change the results: During the Neolithic period, when population density was very low and therefore potentially conflicting groups could easily avoid each other, interpersonal violence was low. Moreover, we formulated the hypothesis that during the E-MBA the rule of law and the synergetic effect of law with trade expanded, implying also relatively low interpersonal violence. Again, this was confirmed, even after controlling several other variables. Although we cannot generalize these results for other

regions and periods, we can however confirm that the hypothesis corresponds with the observed development of violence in the pre-Classical Middle East.

Data availability statement

The data that support the findings of this study are available in the publicly accessible Zenodo repository at: doi: 10.5281/zenodo.8010025 and as attachments to this article.

Code availability statement

Custom code that supports the findings of this study is available in the publicly accessible Zenodo repository at: doi: 10.5281/zenodo.8010025. The Stata code is also available as an attachment to this article.

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Tables:

Region	Neol.	Chalc.	EBA	MBA	LBA	IA	Total
Iran	15	127	(2)			209	353
Levant	37	75	297	33	(5)	73	520
Mesopot.	56	(12)	90	66	51	51	326
Turkey	1078	367	786	100	(9)		2340
Middle East	1186	581	1175	199	65	333	3539

Table 1. Number of cases for violence shares by region and period. Regions: Iran; Levant (West Syria, Lebanon, Israel, Jordan); Mesopotamia (Iraq, East Syria); Turkey; Middle East, average. Periods (all BCE): Mesolithic/Neolithic, 12,000-4500; Chalcolithic, 4,500-3,300; EBA, 3,300-2,000; MBA, 2,000-1,550; LBA, 1,550-1,200; IA, 1,200-590. Brackets indicate low number of underlying cases.

Model	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Neolithic	-1.951**	-1.779**	-1.332**	-1.315**	-1.303**	-1.293**	-1.297**
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Early Bronze Age	-1.398**	-1.213**	-0.800**	-0.752**	-0.739*	-0.737*	-0.755**
	(0.000)	(0.000)	(0.001)	(0.007)	(0.011)	(0.010)	(0.007)

Middle Bronze Age	-1.730	-1.417	-1.815*	-1.714*	-1.935*	-1.947*	-1.881*
	(0.051)	(0.075)	(0.011)	(0.018)	(0.013)	(0.015)	(0.027)
Late Bronze Age	-0.704*	0.095	0.715	0.738	0.666	0.665	0.726
	(0.040)	(0.867)	(0.377)	(0.366)	(0.430)	(0.432)	(0.442)
Iron Age	-0.821*	-1.050**	-1.114**	-0.867**	-0.759*	-0.733*	-0.753
	(0.044)	(0.000)	(0.000)	(0.002)	(0.035)	(0.042)	(0.061)
Battle			1.157**	1.260**	1.248**	1.249**	1.182*
			(0.009)	(0.006)	(0.007)	(0.007)	(0.011)
Royal			1.861**	1.610**	1.601**	1.591**	1.674**
			(0.000)	(0.001)	(0.001)	(0.001)	(0.005)
Urban			0.551	0.568	0.524	0.533	0.505
			(0.199)	(0.219)	(0.270)	(0.285)	(0.300)
Climate shock				-0.728	-0.735	-0.752	-0.702
				(0.120)	(0.117)	(0.097)	(0.166)
Iron					0.386	0.400	0.356
					(0.463)	(0.443)	(0.536)
Horse						-0.062	-0.093
						(0.861)	(0.781)
Population size							0.008
							(0.604)
Region FE	NO	YES	YES	YES	YES	YES	YES
Constant	-1.829**	-1.297**	-1.939**	-1.798**	-1.943**	-1.965**	-1.996**
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.001)	(0.001)
Observations	82	82	82	82	82	82	82
p-val (normality)	0.001	0.023	0.369	0.517	0.824	0.824	0.756

Table 2. Regression analysis: were the differences in violence between Chalcolithic and Early and Middle Bronze Age significant? And Neolithic vs. Chalcolithic? Did other potential correlates of violence invalidate the violence decline during the Early and Middle Bronze Age?

Notes: *, **: 5 and 1 percent significance level, respectively, using Huber-White-Sandwich standard errors (hence heteroskedasticity is not an issue). Clustering at region/period level. All p-values are based on two-sided tests. Seven multiple Tobit regressions show coefficients of various variables potentially related to violence. The first line shows seven different coefficients for the Neolithic (vs. Chalcolithic), taking into account other combinations of potential correlates. Potential correlates are listed on the left. If a number and bracket term is in columns 1 to 7, the variable is included in the specific model. Normality of the residuals is given for model 3 to 7 (not 1 and 2), we do not interpret the significance in column 1 and 2. We use logarithmic transformation; following the standard procedure, we added a small constant (0.05; using other small numbers does not change the results notably). Ordinary least square estimation yielded almost the same results. Heteroskedasticity is not an issue, but we tested equality of variances and found no violation of this assumption. A multiple comparison adjustment is not used, as we test only one dependent variable and a small set of theoretically justified covariates (for Holm-Bonferroni adjustments, see Supplementary Information Appendix C, showing almost the same results). The constant always refers to the Chalcolithic period. In column 2 the model considers region-specific effects. In column 3, also royal interments, battle site, and urban/rural differences are accounted for (the constant refers to rural places). In Columns 4 to 7, climate shocks, iron, horse, and population size are added. The variables battle, royal, urban, iron and horse are 1, if their specific characteristic applies (being a battle site etc.), and 0 otherwise.

Climate shock is defined as the share of the period a specific place was affected by droughts and lower temperatures; "size" are estimates of the population size of a specific site during a specific period.

Figure titles and legends:

Title: **Fig. 1. Distribution of Middle Eastern archaeological sites that provided bioarcheological evidence for the present study.**

Legend: In the map, all individual sites are shown, plus the four regions of Anatolia, Mesopotamia, Levant, and Iran. Base map from Global Multi-Resolution Topography Synthesis (GMRT, doi: 10.1594/IEDA.100001)[100].

Title: **Fig. 2. Trends in violent trauma in the study sample**.

Legend: Regions: Iran (N=353); Levant (N=520, includes West Syria, Lebanon, Israel, Jordan); Mesopotamia (N=326: Iraq, East Syria); Turkey (N=2340); Middle East, average. Periods (all BCE): Neolithic (incl. Mesolithic), 12,000-4,500; Chalcolithic, 4,500-3,300; Early Bronze, 3,300-2,000; Middle Bronze, 2,000-1,550; Late Bronze, 1,550-1,200; Iron, 1,200-400. We justify the combination of the two periods of the Mesolithic and the Neolithic by the fact that the violence rate was almost identical for the two. Dropping the Mesolithic would not change the results substantially. For Late Bronze Turkey, the underlying number of cases is 9, all other cases represent more than 30 observations (The other low-number observations in brackets in Table 1 were excluded). We also performed a robustness test of this figure in which we include or exclude cases with low numbers of observations. We discuss the results in the supplement section "Robustness and sensitivity tests". We performed a number of two-sided t-tests to assess the statistical significance, for example, between the violence in the Neolithic and the Chalcolithic, using the number of underlying individuals as weights. For the differences between Neolithic and Chalcolithic for Mesopotamia, Iran, Turkey and the whole Middle East: $p<0.001$. Chalcolithic vs. Early Bronze Age: for Levant $p<0.001$, for Iran and Turkey (small numbers of observations): Iran $p=0.052$, Turkey $p=0.637$, Middle East: $p<0.001$, Early vs. Middle Bronze Age Levant $p<0.001$, Turkey $p=0.789$. The whole Middle East: $p=0.224$. Middle vs. Late Bronze Turkey: $p<0.001$, Middle East $p=0.042$, the others could not be calculated for these periods. Late Bronze vs. Iron Age: Mesopotamia $p<0.001$, whole Middle East $p=0.482$ (see also Supplementary Table 1).

Title: **Fig. 3. Share of violence in the four regions (% of individual human remains)**

Legend: The error bars represent standard errors of cranial trauma and weapon wounds, by region. The bars represent averages of violence by region.

Title: **Fig. 4. The estimates of the number of weapons buried over time between the Chalcolithic (ca. 4,500 BCE) and the Middle Bronze Age (ca. 1,700 BCE).**

Legend: For this figure, we divided the estimate number of weapons by summed population (estimated on the basis of excavation site areas), Source: Weapon estimated adapted from Gernez[93], population: see text. Error bars cannot be provided as we do not have access to the individual observations.

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