Explorations in Economic History 84 (2022) 101425

Contents lists available at ScienceDirect

Explorations in Economic History

journal homepage: www.elsevier.com/locate/eeh

Estimating warfare-related civilian mortality in the early modern period: Evidence from the Low Countries, 1620–99 ☆

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ARTICLE INFO

Keywords:
Warfare
Excess mortality
Epidemic disease
Low Countries

ABSTRACT

Early modern warfare in Western Europe exposed civilian populations to violence, hardship, and disease. Despite limited empirical evidence, the ensuing mortality effects are regularly invoked by economic historians to explain patterns of economic development. Using newly collected data on adult burials and war events in the seventeenth-century Low Countries, we estimate early modern war-driven mortality in localities close to military activity. We find a clear and significant general mortality effect consistent with the localized presence of diseases. During years with major epidemic disease outbreaks, we demonstrate a stronger and more widely spreading mortality effect. However, war-driven mortality increases during epidemic years are of similar relative magnitude is those in non-epidemic war years. Given the omnipresence of warfare in the seventeenth-century Low Countries, war-driven mortality was remarkably constant rather than a sharp discontinuity. The economic impact of warfare likely played out over the long term rather than driven by sudden large mortality spikes creating rapid structural change.

1. Introduction

How deadly was warfare in early modern Europe? The ubiquitous episodes of warfare that occurred in Western Europe are often associated with significant death and destruction, despite occurring well before the introduction of mass conscription and industrial armaments radically transformed the scale of conflicts. Indeed, the Thirty Years' War (1618–48) is estimated to have killed about five million out of a population of roughly 15 million people, mostly through war-related disease (Eckert, 1996; Theibault, 1997; Voigtländer and Voth, 2013). Most of these casualties were civilians because the number of soldiers was simply too low to impact aggregate death figures (Outram, 2001; Landers, 2005). The presence of armies exposed civilians to unfamiliar pathogens, brought excessive demands on their food supplies, and sometimes forced civilians to flee from danger (Alfani, 2013a: 43–4).

The hardships and death that accompanied early modern warfare in Europe are regularly invoked by economic historians to explain particular economic outcomes across regions (Lagerlöf, 2003; Voigtländer and Voth, 2013; Dincecco and Onorato, 2017; Siuda and Sunde, 2021). These outcomes include persistent structural changes in economic and demographic patterns as well as institutional transformations. For instance, some episodes of warfare are argued to have contributed to (epidemic) mortality spikes that were severe and widespread enough to curtail demographic and urban recovery for several generations; potentially explaining the relative stagnation of Northern Italy (Alfani, 2013b; Alfani and Percoco, 2019) and parts of central Europe during the seventeenth

☆ We thank the editor (Marianne Wanamaker) and the anonymous reviewers for their excellent suggestions. We are grateful to Erwin Bulte, Bruce Campbell, Matthijs Korevaar, Jordy Meekes, Joel Mokyr, Carlos Molina, Patrick O'Brien, Vincent Schippers and participants at several conferences and seminars for their valuable comments and suggestions. The authors gratefully acknowledge financial support from NWO (VIDI Grant no. 016.Vidi.185.046).

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https://doi.org/10.1016/j.eeh.2021.101425
Received 6 March 2021; Received in revised form 18 August 2021; Accepted 21 August 2021
Available online 26 August 2021
0014-4983/

century (Parker, 1984; Theibault, 1997; Martin, 2002; Wilson, 2009). In contrast, others have argued that warfare entailed different demographic consequences for towns and rural areas. Accordingly, war-driven demographic patterns are said to have increased urbanization rates and economic growth, leading to a divergence between the more war-ridden parts of Europe and those regions that escaped intensive military presence, as well as partially explaining the rise of certain parts of Northwestern Europe relative to the rest of the world (Rosenthal and Wong, 2011; Voigtländer and Voth, 2013; Hoffman, 2015; Dincecco and Onorato, 2016; 2017).[1]

Despite the dominant place of warfare in the literature on economic and demographic change and divergence, estimates of the mortality effects of warfare on civilians during the early modern period are scarce and imprecise. This is the case even for famous episodes of warfare such as the Thirty Years' War, where the above-mentioned numbers are rough estimates for the entire first half of the seventeenth century and include all sorts of demographic deficits such as delayed fertility and migration as well as mortality (Outram, 2002; Landers, 2005). In addition, current knowledge on the intensity and the mechanisms behind the spread of warfare-related mortality derives almost exclusively from anecdotal references—such as the infamous plague outbreak that travelled from La Rochelle to Northern Italy on the back of a French military regiment in 1628 (Prinzing, 1916: 74–6; Voigtländer and Voth, 2013). There are clear reasons for a lack of solid estimates. First, early modern population data are not generally available at high temporal resolution. Second, warfare—at least at the state level—was almost continuous throughout much of western Europe in the early modern period, rendering it difficult to establish a direct association between war and epidemic disease (Tilly, 1992: 72). However, the trajectories of military activity and epidemic outbreaks were usually much more localized within these states (Guttman, 1980; Landers, 2005; Goorts, 2019), which calls for an empirical approach explicitly focused at the local level.

In this paper, we provide new evidence on war-related mortality increases among the civilian population in the Low Countries for the years 1620–99, by using annual and spatially refined data of military activity and locality-specific excess mortality derived from church burial records. Using these records, we calculate locality-specific trends of adult burials and annual deviations from these trends to estimate local mortality increases for 327 localities—ranging from small rural villages to the largest cities.[2] The mortality data are combined with detailed, geo-referenced reconstructions of roughly 800 war events in and around the Low Countries, based on the abundant military and political histories of the seventeenth-century wars within the Low Countries (e.g., Parker, 1972; 1984; Israel, 1982; 1995; Childs, 1991; Lynn, 1999; Satterfield, 2003; van Nimwegen, 2010). Combining both datasets, we provide estimates of the average mortality increase related to nearby warfare.

Mortality increases with substantive consequences for economic development are arguably concentrated in widespread and severe epidemic mortality spikes (Alfani, 2013b; Voigtländer and Voth, 2013; Alfani and Percoco, 2019). Warfare may have had a causal role in the occurrence of these epidemics or at least facilitated their spread, but that question is hard to resolve without appropriate epidemiological data. Accordingly, we investigate the spatial association between warfare and adult mortality during the most severe epidemic disease outbreaks in our sample separately. In doing so, we assess whether the relationship between warfare and excess mortality among adult civilians differs between 'regular' war years and war years during epidemic disease outbreaks.

The Low Countries provide a relevant testcase as one of the major theatres of warfare in early modern Europe: a typical locality in our sample experienced war events within a daily marching distance of 30 km roughly once in every nine years.[3] In addition, the Low Countries experienced several major epidemic disease outbreaks in the seventeenth century. These mortality crises occurred regularly but with different intensities and a high degree of spatial variation Curtis (2016). Similarly, as a result of the complicated political situation of the emerging Dutch Republic and the lack of clear natural borders, the many military conflicts afflicting the region were spatially variable within and across the many different war episodes in the seventeenth-century Low Countries (Parker, 1972; Gutmann, 1980; van Nimwegen, 2010). Furthermore, local mortality outbreaks are unlikely to have influenced the spatial pattern of warfare, because of the timing of both within the calendar year—limiting concerns of endogeneity in our analysis. Weather concerns restricted the military campaign season in the Low Countries to run from the spring to late autumn, while epidemics typically materialized in the late summer and autumn (Curtis, 2016; Francke and Korevaar, 2021). These factors allow for a systematic analysis of the connection between warfare and excess civilian mortality.

Our main findings are as follows. First, proximity to military activity on average results in significantly higher adult mortality. By regressing local mortality deviations on categories of same-year and lagged distance to the nearest war event experienced by that locality in a two-way fixed effects framework, we find that adult burials are on average roughly 45% higher than normal when the nearest military activity occurs within 30 kilometers of a locality—raising normal annual death rates from about 30–40 deaths per 1000 inhabitants, to 45–60 deaths. We find smaller mortality increases up to 60 kilometers consistent with mortality increases

[1] A large literature has documented how interstate warfare in early modern western Europe stimulated increases in state capacity and fiscal centralization—providing states with growing capacities to wage more intense and financially more costly wars (Tilly, 1992; 't Hart, 1993; O'Brien, 2018). This process required new political bargains between elites, taxpayers and creditors, and in some cases, these bargains arguably produced stable, growth-enhancing political and fiscal institutions (Besley and Persson, 2009; 2011; Dincecco and Prado, 2012; Gennaioli and Voth, 2015; Dittmar and Meisenzahl, 2020).

[2] We focus on adults—and thus adult excess mortality—because children were often not systematically recorded in the burial records. Out of an initial sample of about 450 localities, we use only those for which adults and children have been identified and separated (the above-mentioned 327 localities). See Section 3 for more detail.

[3] The major conflict periods in the Low Countries include: the 1600–9 phase of the Eighty Years' War (1568–1648, including the Twelve Years' Truce of 1609–21); the Thirty Years' War of 1618–48 (coinciding with the second half of the Eighty Years' War), extended to 1659 as the Franco-Spanish War; the 1664–8 episode covering the Second Anglo-Dutch War, the First Münster War and the War of Devolution; the Franco-Dutch War of 1672–8; the War of Reunions of 1683–4; and the Nine Years' War of 1688–97. The daily marching distance of seventeenth-century armies in the Low Countries is based on calculations by van Nimwegen (2010: 250, 365).

driven by localized disease outbreaks, and a lagged mortality effect within 60 kilometers consistent with additional hardship-related localized disease in the year following military activity. Second, we find no differences between urban and rural localities in average war-driven mortality effects. Third, we produce a new series of aggregate adult mortality deviations for the Low Countries covering the period 1620–99, based on our sample of localities. The clearest aggregate spike occurs in 1636 with a near quadrupling of aggregate mortality. There are only two other years wherein aggregate mortality doubles—a 2.5 times increase in 1625 and a 2.2 increase in 1676. Fourth, the general link between military activity and raised mortality extends to years with widespread epidemic mortality. In all cases, epidemic mortality is closely spatially associated with warfare but spreads further from military activity.

The mortality increases that we document for the seventeenth-century Low Countries can be contrasted with excess mortality estimates from other European regions. At an individual locality level, there are some similarities in severity. For example, Cummins et al. (2016) document annual deaths at five to six times their normal rates during recurring early modern plague outbreaks in London, which was similarly seen in seventeenth-century cities in our sample, such as Leiden, Utrecht, Bruges, Lille, and others. However, the aggregate intensity of epidemics over a wider territorial area was much smaller in the Low Countries than elsewhere. Even the most severe plague epidemic in 1636 'only' led to an estimated average death rate of 16% in the Low Countries (a quadrupling of normal mortality), whereas average death rates across Northern Italy and Switzerland during the plague of 1629–30 and across the Kingdom of Naples during the plague of 1656–8 were at least 30% (Eckert, 1996; Fusco, 2007; Alfani, 2013b), and at least 20% in large areas of the Spanish interior during the plague of 1598–1600 and the Spanish Mediterranean coast in 1647–52 (Pérez Moreda, 1980).

Recent literature emphasizes the capacity of warfare to structurally affect long-term economic trajectories through severe, but infrequent, mortality crises (Lagerlöf, 2003; Voigtländer and Voth, 2013; Alfani and Percoco, 2019; Siuda and Sunde, 2021). In this article, we show that sharper mortality spikes did indeed occur during years with epidemic diseases and warfare played a role in pushing up mortality further during such years. However, epidemic mortality in the seventeenth-century Low Countries affected localities far removed from warfare, while omnipresent nearby military activity pushed up civilian mortality also in the absence of epidemic disease. Accordingly, our results do not suggest that warfare produced the large civilian mortality spikes or discontinuities needed to cause structural economic divergences. In contrast, the results are more favorable to theories wherein war-driven mortality may affect long-term economic developments more gradually.

Our finding that there are no major differences in mortality effects between villages and larger cities speaks to a recent literature that assesses the role of warfare in shaping the pattern of urbanization in early modern Europe (Rosenthal and Wong, 2011; Voigtländer and Voth, 2013; Dincecco and Onorato, 2016; 2017; Stasavage, 2011; Bosker and Buringh, 2017; Alfani and Percoco, 2019). Whereas Voigtländer and Voth (2013) argue that wars stimulated diseases that disproportionately afflicted cities, thus stimulating urban demand for labor and sustaining high real wages, our results indicate that war-driven mortality was at least as high in rural localities during normal and epidemic years. Although we cannot conclusively study population dynamics, as we lack spatially precise population data across time, this finding suggests that if war did indeed stimulate urbanization, then it more likely did so through refugees seeking shelter in urban 'safe havens' (Rosenthal and Wong, 2011; Dincecco and Onorato, 2016; 2017). However, if direct flight to the cities from the countryside was so substantial, then our calculations of warfare-induced rural mortality are even underestimates—while overestimating (to a smaller extent) the urban effects. An alternative interpretation of the high rural mortality effects of warfare is that rural-to-urban flight was not as prominent as supposed, which is an observation supported by qualitative evidence (Gutmann, 1978; Satterfield, 2003: 260–6). In that case, the results presented in the existing literature might be driven by migration patterns materializing over the longer term.

This paper is organized as follows. Section 2 provides historical background on seventeenth-century warfare in the Low Countries and explains the construction of the war data. Section 3 details the burials data and the construction of our excess mortality estimates. Section 4 presents the estimation strategy and the baseline results. Section 5 reconstructs the link between military activity and excess mortality when focusing on years with widespread epidemic mortality. Section 6 concludes.

2. Historical background and the spatial distribution of war in the Low Countries

The Low Countries consisted of a loose collection of relatively wealthy provinces of the Holy Roman Empire that roughly encompassed modern-day Belgium, Luxembourg, and the Netherlands. Most of the provinces became fiefs of the Dukes of Burgundy during the late Middle Ages but passed into possession of Philip II of Spain with the abdication of Charles V in 1555 (Tracy, 1990; 't Hart, 1993; Israel, 1995). Starting in 1566, a protracted episode of warfare—the Eighty Years' War ('t Hart, 2014)—broke out when most of these provinces rebelled against their Spanish overlords. The rebellion ended up severing the Low Countries into the southern Spanish Low Countries and the newly forged Dutch Republic in the north during the final quarter of the sixteenth century. However, large swaths of the Low Countries remained contested between Spain and the Dutch Republic well into the seventeenth century van Nimwegen (2010). In combination with the flat and open geography of the Low Countries, the result was that almost all corners of the Low Countries were exposed to hostile military activity.

Spain and the Dutch Republic were among the main protagonists in seventeenth-century European political competition, with the result that England, France and the Holy Roman Empire were regularly drawn into the wars in the Low Countries. Alliances among these powers were volatile (Israel, 1997; Lynn, 1999; 't Hart, 2014). France and England initially supported and financed the Dutch Republic in its wars against Spain. However, as the Dutch Republic gradually emerged as an important European power itself by the second half of the seventeenth century, Spain and the Republic even allied in a series of Franco-Dutch and Anglo-Dutch conflicts Lynn (1999). These combined factors resulted in almost continuous military activity with regularly shifting spatial focus points.

The protagonists in the wars that afflicted the seventeenth-century Low Countries were on the forefront of the organizational and military advances of the 'military revolution'. This meant that armies were relatively well-organized and supplied, and towns heavily fortified and stocked to endure long-lasting sieges by the seventeenth century (Parker, 1972: 16–17; Childs, 1991: 178–213). Army sizes, although still far below the standards of the late eighteenth century, had grown too large to feed directly off the land (Parker, 1972: 12–18; Satterfield, 2003; van Nimwegen, 2010). Instead, armies were supplied by a combination of local acquisition of commodities and sophisticated long-distance supply networks (Lynn, 1993; Brandon, 2015). Changes during the seventeenth century in army sizes, logistics and in systematically levied taxes were gradual and monotonic, as armies became ever larger and better organized (Lynn, 1997; van Nimwegen, 2010). Within that setting, the precise location of military events was far from predictable. Whereas generals and political leaders planned annual military campaigns in advance, changing financial and diplomatic situations or practical and acute circumstances on the ground often rendered pre-conceived plans ineffectual (Parker, 1972: 12–18; Childs, 1991; Lynn, 1993; Satterfield, 2003: 272–80).

The economic and political geography of the Low Countries had specific influences on the pattern of warfare. First, the high levels of urbanization and density of fortifications in the Low Countries meant that military success depended predominantly on siege warfare (Parker, 1972: 12–18; Childs, 1991: 32–3; Lynn, 1999: 158). During sieges, success depended on supplying and protecting the surrounding army and its canons rather than starving the civilian inhabitants, who were typically well stocked and protected by fortifications.[4] This limited the possibilities of besieging cities deep into enemy territory. Second, the flat and open topography of the Low Countries imposed few natural limits on army movements, which meant that there were no pre-determined focus points of military activity, and political borders were subject to substantial changes upon shifts in military fortunes (Parker, 1972: 16–18). These combined factors produced a form of warfare in which rapid advances deep into enemy territory were rare and only possible with large and well-organized army segments but, at the same time, provided for long and continuously shifting borders with a high threat of military activity.[5] Third, the northwest European climate restricted military activity in the Low Countries to the period between late spring and late autumn due to the heavy rains and cold of the winter months (Parker, 1972, Gutmann, 1980: 16).

The combination of large and well-organized armies engaging in protracted siege warfare over long and changing frontlines, and the annual pattern of military activity, provides a context for a clear empirical approach to document the spatial pattern of warfare by tracing sequences of military encounters of these armies during the year. Although several studies provide encyclopedic overviews of historical battles and sieges (Clodfelter, 2002; Jacques, 2007) and provide solid starting points, they lean heavily towards renowned events, and to data-rich regions and military episodes. We expand on these references with systematic annual reconstructions of war campaigns using more specific literature focused on the seventeenth-century Low Countries. In the first step we compile annual events—including information on military commanders and armies in the field. In a second step, we use this knowledge to construct sequences of war events per army and year. Third, we use regional literature and detailed military histories to scrutinize specific regions and military episodes for new sequences and isolated military events.[6]

The abundant literature on the military and political history of the early modern Low Countries allows us to compile a comprehensive list of battles, sieges and hostile occupations of towns—'war events'—conducted by armies in the field, and their spatial trajectory. The literature covers all parts of the Low Countries and the entire seventeenth century, limiting concerns of measurement error. Although it is unlikely that we record every single war event, the wide range of literature available yields a highly detailed dataset.

Using these data on annual war locations, we calculate the linear distance to the nearest war event for each burial location in each year of our sample period. Subsequently, we use that distance to the nearest war event in a year as our indicator for the military pressure experienced by a locality. Then, we transform the distances to nearest war event into three binary distance categories of 30 kilometers (0–30, 30–60, and 60–90 km), coding the distance category wherein the nearest war event occurs as 1. The 30kilometers distance roughly corresponds to the daily marching distance of armies in the seventeenth-century Low Countries (van Nimwegen, 2010: 250, 365). Using distance categories directly reduces the measurement error effects of missing war events within dense sequences. Overall, the dataset contains 783 geo-referenced war events in the Low Countries and its direct surroundings between 1620 and 1699.[7]

[4] Canons reduced defensive fortifications long before defending regiments ran out of supplies. A typical siege involved the enemy surrounding the defendant and carefully positioning its canons while building and defending its own outside ring of defenses to protect itself from armies intent on breaking the siege from the outside (van Nimwegen, 2010: 132–45). Consequently, sieges usually ended before the city was taken by force: either by the besieging army forced to back down by a countering army or by the besieging army offering terms of (honorable) surrender when the fortifications of the defending city had crumbled (Israel, 1982: 101; van Nimwegen, 2010: 384–403). There is one clear exception in the seventeenth-century Low Countries: the siege of Breda (1624–5), where the Spanish did commit to endless sieges. The long duration resulted in serious loss of lives on both sides and is generally regarded as a Pyrrhic victory given the depletion of the human and financial resources of the Spanish Army of Flanders (Israel, 1995: 105–8; van Nimwegen, 2010: 207–16).

[5] The Spanish raid on the Veluwe in 1629 is an unrepeated example of the difficulties involved in military advances deep into enemy territory in the context of the seventeenth-century Low Countries. A large Spanish army conducted a well-planned and successful raid into the central part of the Dutch Republic to distract the Dutch army that had laid siege to 's-Hertogenbosch. Although the Spanish army made substantial territorial progress and managed to impose contributions on a large region, it was forced to retreat when a small Dutch force captured the fortress of Wesel, threatening to cut off the Spanish army on the Veluwe from its supply routes (De Cauwer, 2008; van Nimwegen, 2010: 217–33).

[6] For completeness, we incorporate war sequences from regions bordering the Low Countries—a straightforward extension given cross-border interconnectivity of campaigns. The full database and sources are provided in the online supplementary material.

[7] This is a substantial extension of the existing literature. In comparison, the most detailed war encyclopedia compiled by Clodfelter (2002) lists around 800 war events for the whole of Europe for all years between 800 and 1799.

Although warfare spread to all corners of the Low Countries, there was significant variation in war exposure. Fig. 1 presents the spatial distribution of war events, organized by the number of years that localities are within 30kilometers of a war event—the darker the shading, the more years of war events within 30 kilometers. The map underlines the variation in military activity during the seventeenth century. The southern half of the map—roughly the Southern Netherlands—bore the brunt of the fighting, mostly as a consequence of the near-continuous wars between France and Spain from 1635 onward. However, high densities are found in the center and the (north)east of the map too.[8]

The particular variety of seventeenth-century warfare in the Low Countries led to a heavy burden on civilians as a drain on goods and imposition of labor duties. Random acts of violence and arbitrary raiding were, however, limited.[9] The emphasis on siege warfare performed by large well-organized armies rendered raids on local populations ineffective because they could not sustain armies in the field. Nevertheless, raids on enemy supply networks occurred and likely compromised local economic activity and trade. At the same time, armies were reliant on continued supplies from local populations in combination with supply systems over longer distance and, thus, on a degree of cooperation with local populations. To arrange supplies, armies imposed contributions on civilians—a euphemism for forced extraordinary taxes—to arrange those commodities and labor duties that were difficult to supply over long distances (Gutmann, 1980: 41–6; Lynn, 1993). Successful prolongment of military presence, then, depended on sustaining the local population and their economic activities. This was often done through coercive measures by both allied and foreign armies, and more so in the second half of the seventeenth century (Parker, 1972: 15–18; Gutmann, 1978; Lynn, 1993). Perhaps the clearest evidence of the importance of the continuation of local supplies is that armies on opposing sides of conflicts typically respected contributions levied by their enemies, even after the conclusion of wars (Childs, 1991: 34–6; Lynn, 1993; 1997: 301; Satterfield, 2003: 260–6).

Accordingly, the pressure of military activity on local populations remained very high in the seventeenth-century Low Countries. Contributions and other forms of military pressure such as lodging of soldiers were burdensome and could last for several months. These conditions naturally stimulated hardship and, potentially, shortages in food supplies, which in turn, created the circumstances for hardship-related diseases to spread, although famines—excess mortality through a lack of means of subsistence—were rare in the seventeenth-century Low Countries (Curtis et al., 2017; Curtis and Dijkman, 2019).[10] Rather than through food crises, the lengthy contacts between soldiers and civilians facilitated the transmission of diseases through exposure to unfamiliar pathogens. Military encampments were unhygienic and estimates of military casualties in early modern wars typically document disease as a dominant cause of death (Parker, 1972; Outram, 2002; Landers, 2005).

Overall, we focus on clearly identifiable military events. Of course, battles and sieges also differed in their intensity, and accordingly, simple distance measures and indicator variables of events are rough measures of the exposure of individual localities to war. However, since detailed information on military intensity is available only for a small number of high-profile war events in more densely populated areas of the Low Countries, restricting our sample to this small number of war events would undoubtedly create selection bias. Furthermore, while existing literature points to the disruptive consequences of the lodging of soldiers and the 'contributions' mentioned above (Gutmann, 1980: 41–6), detailed evidence of this kind is rare (Childs, 1991; Lynn, 1993; Satterfield, 2003). At the same time, lodgings, impositions of contributions, and military raids on enemy supply systems were concentrated around the large-scale military activity of the type that we measure with battles, sieges, and hostile take-overs of towns (Satterfield, 2003: 155). Accordingly, our measure of war events closely approximates other military activity too.

3. Burials data

Lacking accurate population estimates at high temporal resolution for the early modern period, precise mortality rates (integrating the size of the population at risk) cannot be calculated on an annual basis.[11] Instead, here, we assess the mortality effects of warfare by estimating annual excess mortality for each locality using 327 church burial records from the Low Countries. References to the individual burial records and other data discussed here can be found in the online supplementary material, section F.[12]

Although the burial records do not systematically provide additional information about the deceased, enough do or do so for certain periods to assess the coverage of the burial records. Adult men and women were well recorded, even during mortality crises, and even including the poorest segments of society. People could opt for cheaper burial sites and rituals Curtis (2021b), and funeral costs of 'paupers' were subsidized by the Poor Table (Teeuwen, 2016: 62).

[8] These were the border areas between the Dutch Republic and the Southern Netherlands in the northern parts of Brabant and Limburg, and southern Guelders; and the eastern Dutch Republic bordering on often hostile states in the Holy Roman Empire such as the Bishoprics of Münster and Cologne.

[9] Warfare itself rarely resulted in violent civilian deaths: where such violence occurred, it was usually local and transitory (Gutmann, 1980: 163; De Cauwer, 2008). This does not imply an absence of military violence towards civilians. Burial registers sometimes mention soldiers killing civilians: for instance, in Maulde (Tournai) in 1659 where soldiers killed refugees in the church, or in Goor (Overijssel) in 1665 and in Termunten (Groningen) and Zuidlaren (Drenthe) in 1672 where civilians were killed while fleeing sieges, or in Oostwinkel (Flanders) in 1678 where a citizen was robbed and killed by soldiers despite having a 'safeguard'. Nor should the seventeenth-century Low Countries situation be generalized to other places or periods. The early years of the Dutch Revolt in the second half of the sixteenth century involved some brutal episodes (van Nierop, 1999; Adriaenssen, 2007).

[10] Grain price spikes and high bread prices in cities did occur (de Vries, 2019: 49–64; Dijkman, 2021), despite the fact that food staples were imported into Amsterdam in bulk, although these spikes were only weakly related to excess mortality.

[11] Precise pre-industrial mortality rates are only available for specific and bounded population groups such as personnel in ecclesiastical institutions (Hatcher et al., 2006) or elite groups unrepresentative of society at large (De la Croix and Licandro, 2015; Cummins, 2017).

[12] All replication materials are available from van Besouw and Curtis, 2021.

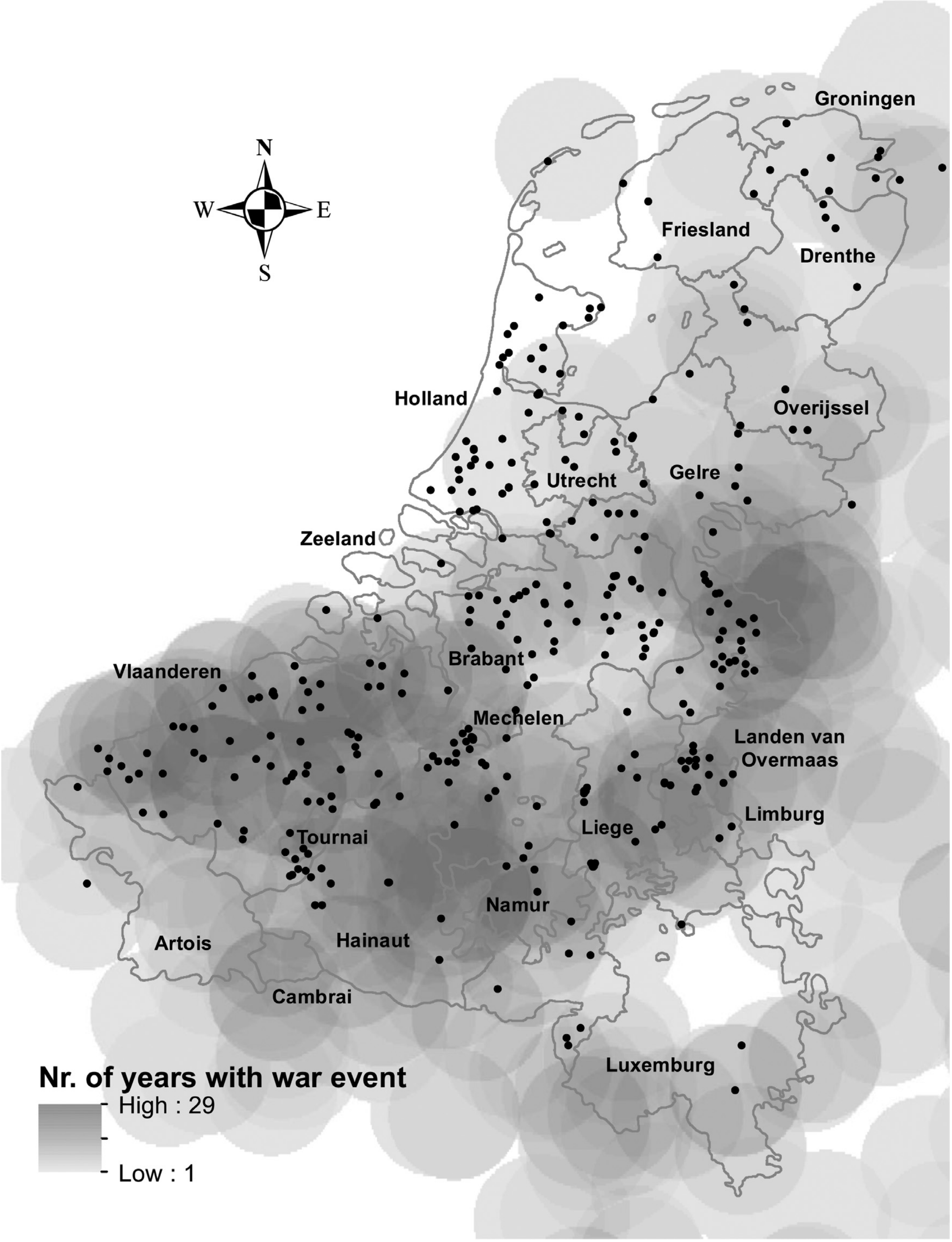

Fig. 1. Distribution of localities with burial records and temporal intensity of war events
Notes: This map of the Low Countries shows the distribution of localities providing burial records and of war pressure over the seventeenth century. We mapped the distribution of war events per annum, drawing concentric rings of 30 kilometers radius around each war event in that year. These maps of annual war events were compiled to create a heatmap showing the number of years wherein any point on the map experienced war events within 30 kilometers—ranging from zero years to 29 years.
Sources: The shapefiles of the Low Countries were provided by Iason Jongepier of GIStorical Antwerp (UAntwerpen). The war events and burial series are based on the authors' own data. See Sections 2 and 3.

Even poor recent migrants were recorded—sometimes anonymously, sometimes with their place of origin. Furthermore, the registers allow us to distinguish between civilians and soldiers—important given our aim of assessing the impact of warfare on civilian mortality. Local communities were understandably reluctant to pay for random soldier burials (Gutmann, 1980: 163). Some soldiers were found in church burial registers, but the vast majority ended up in pest house and hospital cemeteries.[13] Pest houses and hospitals are, therefore, excluded from our sample. During epidemic outbreaks, emergency cemeteries were sometimes constructed (Schroor, 2014: 40; Rommes, 2015), though there is no indication from the burial records that those buried in these new sites went unrecorded.

Children, in contrast, were not systematically covered in all series. Although recorded in some, other localities did not record children at all, or more problematically, recorded them unsystematically.[14] However, most series differentiate between children and adults, which allows us to focus on adult mortality specifically. We excluded series where children and adults cannot be separated and drop children from the remaining series. Accordingly, the coverage of adult individuals within the final 327 burial registers is remarkably complete.

The burial records provide clear annual data, although few individual series cover the entire seventeenth century: some start well into the century, some have missing years, and some stop before the end of the century.[15] These sudden start- and end years usually do not cover the full calendar year and are therefore dropped from the data. Many larger towns consisted of several parishes, providing us with multiple series for some localities—as we treat each parish as a unique series.[16] The availability of burial data in the records increases steadily over time for towns of all size categories in a relatively stable pattern from 1620 onward—with few localities yielding burials data before that year, and thus informing our decision to only use data from the period 1620–99.

The localities with adult burials information in our data are shown in Fig. 1. The dataset contains more series for western provinces such as Holland and Flanders, and fewer for eastern provinces, coinciding with known patterns of settlement in the seventeenth-century Low Countries. Nonetheless, burial series are not perfectly randomly spread across the Low Countries. There are fewer burials registers existing for many of the northern rural regions. Burial registration was formally required in the Southern Netherlands from 1614 (Lambrecht, 2014), although most localities start later, and some earlier, than this date. Localities in the Dutch Republic are generally later to start—although there are exceptions. Parishes that changed in denomination (from Catholic to Protestant, for example) often continued with the same burial registration practices. When we have clear breaks in parish denominations, we split the series at that point, continuing with two separate series with the same geo-location. To address imbalances in the availability of original burial records, we concentrated our archival efforts on the rural regions in the northern and eastern parts of the Dutch Republic, instead of on the regions with more forthcoming source availability.

We use existing population estimates to classify the towns with burials data into different size categories as depicted in the upper panel of Table 1. Using conventional categories, our data contain 220 series from rural localities with fewer than 2,000 inhabitants, 40 from small urban localities with 2,000 to 4,999 inhabitants, 33 series from middle-sized urban series with 5,000 to 9,999 inhabitants, and 34 series from large urban localities with 10,000 or more inhabitants.[17] Because several towns contain multiple series, the number of unique localities in our sample is smaller than the number of unique series. In addition, larger towns tend to have slightly longer series of burial records but the average number of burial records for rural localities is still 34 out of 80 years—which closely resembles the coverage of small and medium-sized towns.

The burials sample presented in this paper is unique in its coverage of rural localities in comparison to existing literature on the Low Countries—rural localities comprise 74% of unique localities and 67% of burial series used. Existing literature on a national or super-national level typically concentrates on large towns. In the middle panel of Table 1, we compare the composition of urban localities in the burials sample to what is arguably the most comprehensive dataset on urban localities in the Low Countries by Bosker and Buringh (2017), an expanded version of initial work by de Vries (1984).[18] Comparing the data, the burials sample clearly

[13] For example, the Church of Our Lady hospital in Mechelen recorded 358 out of 853 burials as soldiers in the years 1692–7 (42 per cent) in the worst phases of the Nine Years' War (Curtis and Dijkman, 2019).

[14] By 'unsystematic', we refer to three categories: localities where children are consistently listed but under-recorded, localities where the listing of children is apparently random (occurring in some years but not others), and localities where the series starts by not recording children but later adds them (or vice-versa).

[15] We use annual data because seasonality of epidemic mortality and warfare in the seventeenth-century Low Countries rarely crossed calendar years. Military campaigns were restricted to the period between late spring and autumn due to weather conditions. Epidemic mortality generally peaked in late summer and early autumn, while dropping before winter, although a whole new mortality spike could occur again in the following year (Curtis, 2016). Furthermore, although there was a delay between death and burial, this was usually less than a week (many burial registers list both dates), and during plagues, government ordinances required burial within a maximum of 48 hours (Curtis, 2020).

[16] Aggregating multiple series from one locality into one series is often not an option because the series do not usually overlap fully in time. Using the individual series is also more appealing from an empirical perspective as it provides more datapoints.

[17] Population estimates can be found for most localities in the Low Countries based on infrequent tax lists, censuses, and hearth counts. Classification of size is based on the highest population estimate found during the seventeenth century. Although population size is a crude indicator for urban status, it is a more accurate depiction of the economic and social function of a locality than formal city rights. The population size categories we adopt here are consistent with existing literature on early modern northwest European urbanization (Clark, 1995; de Vries, 1984; Bairoch et al., 1988). In our sample 33 out of 327 localities could not be classified directly. However, all of these 33 localities are small hamlets and thus all classified as rural. Results presented below are all robust to excluding these 33 localities. Sources, method, and population figures can be consulted in the online supplementary material.

[18] The Buringh version of the data extends on de Vries in its focus on smaller towns. This data can be retrieved at https://cgeh.nl/urbanisation-hub-clio-infra-database-urban-settlement-sizes-1500-2000.

Table 1
Overview and coverage of the burial series, 1620–99.

Burials data and series in main sample

	Unique localities	Series used	Avg. years with burials	St. Dev.
Rural	217	220	34.15	20.33
Small urban	39	40	36.43	19.75
Medium urban	18	33	38.42	20.05
Large urban	20	34	46.88	27.14
Total	294	327	36.18	21.40

Proportions of urban localities

	Low Countries		Netherlands		Belgium	
	Count	Proportion	Count	Proportion	Count	Proportion
Burials sample						
Small urban	39	0.51	25	0.52	14	0.48
Medium urban	18	0.23	10	0.21	8	0.28
Large urban	20	0.26	13	0.27	7	0.24
Total	77		48		29	
De Vries/Buringh data						
Small urban	26	0.28	14	0.29	12	0.27
Medium urban	28	0.30	13	0.27	15	0.33
Large urban	39	0.42	21	0.44	18	0.40
Total	93		48		45	

Regional distribution

	Estimated population (1650)	Burial series per 10,000 inhabitants		Estimated population (1650)	Burial series per 10,000 inhabitants
Netherlands			*Belgium*		
Drenthe	23,800	1.68	Brabant	432,000	0.69
Friesland	162,000	0.19	Flanders	650,000	0.68
Gelderland	144,000	1.04	Hainaut	238,000	0.67
Groningen	89,000	1.01	Namur	76,000	1.18
Holland	833,000	0.55	Liège	196,000	0.71
Limburg (NL)	113,000	2.74	Limburg (B)	100,000	1.00
North-Brabant	212,000	2.17	Luxembourg	68,000	0.44
Overijssel	69,000	0.87	Total	1,760,000	0.72
Utrecht	82,000	0.73			
Zeeland	96,000	0.83			
Total	1,823,800	0.95			

Notes: This table provides an overview of the burial series included in the dataset and its representativeness with regard to spatial coverage and coverage of localities of different sizes.
Sources: Authors' own data. See Sections 2 and 3 of the main text.

has fewer cities due to unavailable burial records or records wherein adults and children cannot be properly discerned. However, the burials sample provides a better coverage of smaller towns which were generally more numerous in the early modern Low Countries (Blondé, 1995; Stabel, 1995; 't Hart, 2001)—an advantage that extends naturally to the burials data's coverage of rural localities. Accordingly, the relatively high share of rural localities and small towns suggests a better spatial coverage—one less skewed to regions with a couple of large towns. In terms of population coverage, however, large towns should receive more weight. This is automatically achieved in the burials sample due to the higher average number of series per locality for medium and large towns.

The final panel of Table 1 shows the distribution of burial series across regions in the Low Countries and their respective populations using modern-day borders and provinces and population estimates for circa 1650 from Paping (2014) for the Netherlands and Klep (1991) for Belgium. Coverage per 10,000 inhabitants is slightly higher for the Netherlands, although the provincial population estimates have large margins of error. The spatial distribution of series across provinces is generally even, albeit with a couple of exceptions. The northern coastal province of Friesland stands out for its low coverage driven by the consolidated form of burial registration—where burials for several small rural localities are typically combined into one record. The inland provinces of Limburg and North Brabant have relatively large numbers of series per inhabitant. The results presented in this paper are robust to excluding individual provinces with few or many series per inhabitants.

3.1. Excess mortality

To estimate local excess mortality—or the deviation from the 'normal' rate of burials per annum—we calculate local trend burials as five-year backward-looking moving averages from which the highest and lowest annual numbers are dropped. Series that are too short, have coverage which is too fragmentary, or have too few average burials were dropped.[19] Using these local trends, we calculate mortality $Deviation_{i,t}$ for burial series *i* and year *t* as the local annual number of burials divided by the trend—similar to recent work by Alfani (2013b).[20] This deviation measures the relative increase of local burials:

$$Deviation_{i,t} = Burials_{i,t}/TrendBurials_{i,t}, \quad (1)$$
$$TrendBurials_{i,t} = \left(\sum_{q=1}^{5} Burials_{i,t-q} - \alpha_{i,t} - \beta_{i,t}\right)/3,$$

where $\alpha_{i,t} = \max(\{Burials_{i,t\text{-}1}, \ldots, Burials_{i,t\text{-}5}\})$ and $\beta_{i,t} = \min(\{Burials_{i,t\text{-}1}, \ldots, Burials_{i,t\text{-}5}\})$.

The resulting measure approximates the deviation in the annual local mortality rate, if the proportion of deaths recorded in the burials records is stable, which, as discussed above, is the case. In addition, for an accurate approximation, the calculation of trend burials needs to be sensitive enough to track changes in population size, and mortality rates should be stable over time. While there might have been modest change (van Poppel et al., 2013: 279; van Poppel et al., 2016: 630, 632), which varied across different regional environments (Devos and Van Rossem, 2017), there is little evidence that overall mortality rates among the general population shifted significantly across the seventeenth century (van der Woude, 1982: 62). Indeed, the long-term 'normal' mortality rate is estimated to have been between 3 and 4.5 deaths per 100 inhabitants.[21] Importantly, the five years of burials used to calculate 'trend burials' provides a much better approximation of local population trends than averages over longer periods—given that population sizes of towns could change substantially over long periods. The magnitude of any bias deriving from population trends in 'trend burials' is small, however, even with excessive changes in population growth rates.[22] Accordingly, our 'deviation' measure is a reliable approximation of changes in local mortality. In addition, it is sensitive enough to analyze annual fluctuations and can be directly compared across series.[23]

There are two significant potential sources of short-term shifts in underlying local populations, however. First, there were temporary refugees. Particularly during warfare, it has been argued that people fled to better defended nearby towns (Rosenthal and Wong, 2011: 115–19).[24] If this is the case, the burials trend used to infer the underlying population in localities subject to flight is an overestimation of the actual population, and the estimated 'deviation' underestimates the actual unobserved mortality rate—and vice versa for localities receiving refugees. Nevertheless, the quantitative significance of this process, beyond anecdotal references, is yet to be established. War-driven refugees were not always welcomed and certainly not in towns at risk of an oncoming siege where supplies of food and other resources would be pressured (Outram, 2001; Alfani, 2020: 25–6). In the countryside, peasants were sometimes forcibly kept in place by military commanders to secure the provisioning of armies in the field (Gutmann, 1978; Satterfield, 2003: 260–6). Second, mortality spikes could lead to mortality rates increasing multiple times over the normal rates—decreasing local populations and potentially affecting local age structures. These sudden drops in population create underestimations of the mortality rate in the years directly following a shock. Importantly, this is not through high numbers of burials during the crisis year itself, since the year with the highest number of burials is dropped from the trend-calculation (although less effective for back-to-back mortality crises). To deal with this, we use short backward-looking moving averages to calculate 'trend burials', ensuring that mortality spikes are less likely to influence our estimates over long periods. Using backward—rather than centered—moving averages ensures that the bias introduced here has a clear direction—estimates are downward biased in the years following a mortality shock.

There are two more potential sources of bias in the burials data specific to warfare in the seventeenth-century Low Countries. First, hardship or administrative chaos as a consequence of military activity could, in theory, cause sudden breaks in the registration of parish burials. However, there is no correlation between nearby war events and sudden ends or restarts in our data—not for the end- and start points in the original series that are dropped in our analysis, nor for the subsequent artificial end- and start points.[25]

[19] The temporal coverage per series is assessed after dropping sudden start- and end points. We exclude series with fewer than three calculated estimates of 'deviation' and series with fewer than six average annual burials—thus arriving at a final number of 327 burial series—following a conventional approach in historical demography (for example: Del Panta and Livi-Bacci, 1977; Wrigley and Schofield, 1989).

[20] Unlike Alfani, who estimates mortality increases in a known epidemic year compared to the previous year's trend, we do not skip a year. Our results are robust to changes in the calculation of 'trend burials'—see below.

[21] For the seventeenth-century Dutch Republic (de Vries and van der Woude, 1997: 46); where death rate estimates for individual cities range from 3.5 to 4.5 per cent (Mentink and van der Woude, 1965: 54; Nusteling, 1979: 62–3; van der Woude, 1980: 144–5; Rommes, 1998: 25). Also, similar estimates are used for seventeenth-century England (Wrigley and Schofield, 1989: 531–3; Dobson, 1992: 139; Galley, 1995).

[22] In a hypothetical example, with an excessive compounding annual population growth rate of 10 per cent and a stable mortality rate, this would return a deviation from trend burials of 1.33 each year. The implied compounding annual population growth rate during Amsterdam's massive population expansion from ca. 30,000 inhabitants in 1578 to 206,000 in 1672 is only two per cent—implying a deviation from trend burials of only 1.06 (see Nusteling, 2018 for the Amsterdam population estimates).

[23] Furthermore, it automatically results in trend-stationary series. Dropping the highest and lowest observations limits further unit-root concerns, and results in more stable trends that are less sensitive to short-term deviations through mortality spikes. Stationarity is confirmed by standard unit-root tests.

[24] Scholars also sometimes mention flight (or expulsion: Alfani, 2013a: 104–5) from cities during epidemics, although we find little evidence of that occurring in the seventeenth-century Low Countries, except for a case in Doesburg where 100 residents purchased a 'safeguard' to remain in the countryside for six months during the plague of 1624 (Vermeesch, 2006: 144). Recent literature emphasizes the 'acceptance' of epidemic diseases in cities as an 'ordinary' aspect of urban life (Rommes, 2015: 60; Curtis, 2020).

[25] This is demonstrated in Table A.1 in the appendix, which shows the result of a simple Pooled OLS regression, of the start- and end points on nearby war events—using one lead, one lag, and contemporaneous war events for three distance categories of proximity. See the online supplementary material for more detail.

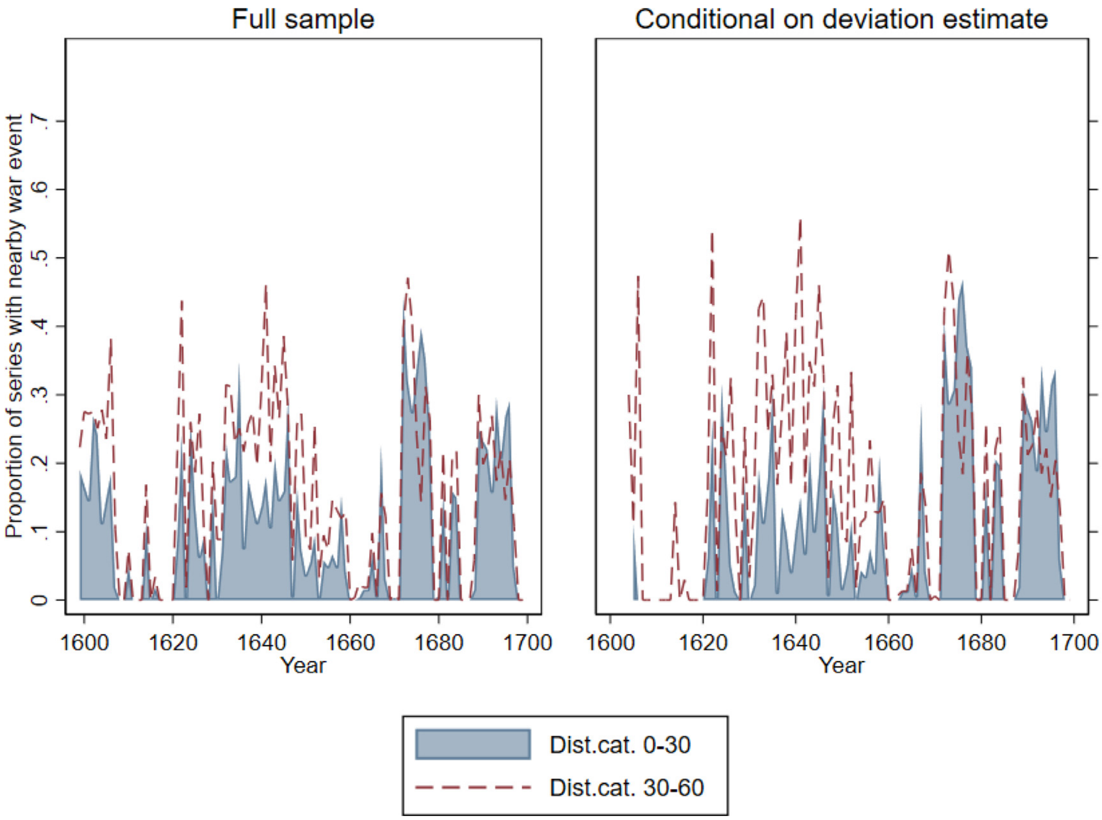

Fig. 2. Proportion of localities with nearby war events over time
Notes: This figure shows the proportion of burial series with nearby war events over time. The left panel shows this proportion for all burials series in each year. The right panel shows this proportion only for those series that provide an estimate of 'deviation' per year.
Sources: Based on the authors' own data. See Sections 2 and 3 of the main text.

Second, qualitative differences in war experiences could exist between regions with many years' worth of burials data and those with less. Fig. 2 depicts the proportion of localities with war events within 30 km distance, and 30–60 km over time, contrasting the full sample (on the left) to the subset of the data that provides an estimate of 'deviation' for each year (on the right)—meaning that the composition of localities in the right panel changes each year. The proportions in the right panel are slightly higher throughout the seventeenth century but the timelines are near identical, except for the first 20 years of the seventeenth century—which are, as already mentioned, excluded from the analysis.

Table 2 gives an overview of the burials and war data for our full sample. The upper part of the table shows the proportion of years wherein war events took place near the localities of the burial series. Using all years of the century and all series, these statistics suggest that localities on average experienced a war event within 30 km roughly once every nine or ten years. Years wherein war events occurred at further distances were just as frequent. In total, localities experienced warfare within 90 km in four out of every ten years. In line with Fig. 2, the statistics for the full sample closely resemble those for the subset of the sample with observations for 'deviation'.

The middle and lower panels of Table 2 provide an overview of the 'deviation' variable. Overall, we have 327 burial series and over 11,800 individual observations of deviation from trend burials for the period 1620–99. A considerable proportion of these series are from rural localities, but there are at least 30 series for each size category of urban localities—see Table 1. The mean of deviation for localities is larger than 1.0 because sudden mortality spikes are more common and larger in magnitude than mortality drops. The mean and standard deviation of our 'deviation' variable decreases with settlement size. This is likely driven by relatively low 'normal' mortality rates in smaller settlements, while a higher baseline mortality often prevailed in larger towns due to overcrowding and poor sanitation.[26] Accordingly, those mortality crises occurring in rural localities resulted in a larger increase over the normal

[26] The negative relation between variability of the deviation measure and settlement size is unlikely to be driven by sensitivity through low absolute numbers of burials. As mentioned before, the smallest rural series are dropped from the analysis—those with fewer than six annual burials on average. In addition, the urban series are not necessarily large in absolute numbers registered because the burial records for towns were often split into different parishes. On high urban early modern mortality in northwest Europe, see Woods (2003) and Clark and Cummins (2009). On poor sanitation in seventeenth-century towns in the Dutch Republic, see van Oosten (2016).

Table 2
Summary statistics of dependent variable and war events, 1620–99.

	(1) Mean	(2) St. dev.	(3) Obs.	(4) Series
Distance to war events-dummies, km.				
Overall				
0-30	0.12	0.33	26,160	327
30-60	0.16	0.37	26,160	327
60-90	0.13	0.34	26,160	327
Conditional on deviations-observation				
0-30	0.14	0.35	11,831	327
30-60	0.17	0.38	11,831	327
60-90	0.13	0.33	11,831	327
Adult burials	39.56	133.23	14,149	327
Deviation from trend burials	1.19	1.07	11,831	327
for Rural (< 2,000)	1.21	1.18	7,512	220
for Small urban (2,000–4,999)	1.18	0.97	1,457	40
for Medium urban (5,000-9,999)	1.18	0.87	1,268	33
for Large urban (> 9,999)	1.13	0.73	1,594	34
Deviation from trend burials and war events				
0-30	1.53	1.41	1,645	257
for Rural (< 2,000)	1.56	1.52	1,031	176
for Small urban (2,000–4,999)	1.47	1.32	218	31
for Medium urban (5,000-9,999)	1.56	1.24	217	27
for Large urban (> 9,999)	1.34	0.93	179	23
30-60	1.23	1.02	2,037	271
for Rural (< 2,000)	1.26	1.05	1,358	185
for Small urban (2,000–4,999)	1.29	1.35	219	31
for Medium urban (5,000-9,999)	1.13	0.72	239	28
for Large urban (> 9,999)	1.16	0.69	221	27
60-90	1.21	1.68	1,504	267
for Rural (< 2,000)	1.26	1.98	974	176
for Small urban (2,000–4,999)	1.17	1.20	191	35
for Medium urban (5,000-9,999)	1.14	0.72	144	31
for Large urban (> 9,999)	1.06	0.69	195	25
>90, or no war event	1.09	0.75	6,645	327
for Rural (< 2,000)	1.09	0.78	4,149	220
for Small urban (2,000–4,999)	1.09	0.60	829	40
for Medium urban (5,000-9,999)	1.08	0.77	668	33
for Large urban (> 9,999)	1.11	0.70	999	34

Notes: This table provides a simple tabulation of the 'deviation' estimates and war data used in this paper as explained in Sections 2 and 3.
Sources: Authors' own data. See Sections 2 and 3 of the main text.

mortality rate. This pattern is also visible from the lower block of Table 2, which presents the average and standard deviation of 'deviation' conditional on distance to war events. Importantly, average 'deviation' is identical for all burial series in the absence of war, regardless of locality size—the standard deviations are similar too. However, the summary statistics of Table 2 already indicate that average 'deviation' increases substantially in the presence of nearby war events—a result we evaluate more systematically in the following sections.

4. Main results

In the previous sections, we discussed the spatially variable and unpredictable patterns of warfare at the local level in the seventeenth-century Low Countries. There are no indications that the presence of warfare might have affected the prevalence of burial registration or that localities with more readily available burial registration somehow had different war experiences. In addition, there is little to suggest that local mortality patterns explain the location of military activity in the Low Countries, because disease-driven mortality became evident months after the start of the military campaign season in the late summer and autumn. Indeed, the spatial variation of war events—in combination with the lack of selection bias in the burials data and limited concern of reverse causality—allow for a straightforward identification strategy.

Accordingly, we estimate the relationship between mortality per locality and nearby military activity in a simple two-way fixed effects regression framework. To do so, we regress local excess mortality, as estimated by our 'deviation' variable, on the distance to the nearest war event for each locality in each year. These distances are captured in three dummy variables of 30-kilometer distance

Table 3
War-driven increases in Deviation, baseline results.

	(1)	(2) Full sample	(3)	(4) 1620–59	(5) 1660–99
Distance category 0-30 km, ***t***	0.534***	0.456***	0.459***	0.691***	0.362***
	(0.107)	(0.096)	(0.098)	(0.211)	(0.086)
Distance category 0-30 km, ***t-1***		0.266***	0.276***	0.288**	0.292**
		(0.084)	(0.081)	(0.120)	(0.112)
Distance category 0-30 km, ***t-2***			-0.063		
			(0.066)		
Distance category 30-60 km, ***t***	0.246***	0.195***	0.193***	0.180	0.218***
	(0.076)	(0.065)	(0.066)	(0.123)	(0.069)
Distance category 30-60 km, ***t-1***		0.198***	0.199***	0.178	0.239***
		(0.066)	(0.061)	(0.127)	(0.071)
Distance category 30-60 km, ***t-2***			0.067		
			(0.071)		
Distance category 60-90 km, ***t***	0.141*	0.114	0.110	0.109	0.135
	(0.076)	(0.072)	(0.070)	(0.131)	(0.098)
Distance category 60-90 km, ***t-1***		0.028	0.023	-0.002	0.060
		(0.038)	(0.035)	(0.049)	(0.051)
Distance category 60-90 km, ***t-2***			0.055		
			(0.053)		
Observations	11,831	11,831	11,831	4,144	7,687
Number of burial series	327	327	327	213	300
Burial series FE	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes
R^2 Adjusted	0.156	0.160	0.161	0.151	0.179

Notes: This table reports the estimated coefficients of several variations to Eq. 2 in the main text. The first three columns estimate the baseline model for the full sample period, extending the number of estimated lags per column. Columns four and five estimate the baseline model for the first and second half of the sample period respectively, including one lagged term for each independent variable. Standard errors are reported in parentheses, while ***, ** and * denote statistical significance at 99, 95 and 90 per cent confidence. All regressions reported in the main text of this article are estimated with burial series and year fixed effects, and with Driscoll-Kraay standard errors.
Sources: Authors' own data. See Sections 2 and 3 of the main text.

categories. We include these dummies for the contemporaneous year as well as the first two lagged years, as formalized in Eq. 2.

$$\text{Deviation}_{\text{i,t}} = \sum_{\text{x}} \left[\sum_{\text{q=0}}^{2} \beta_{\text{x,t-q}} DistCat(x)_{\text{i,t-q}} \right] + \varphi_{\text{i}} + \rho_{\text{t}} + \omega_{\text{i,t}}, \tag{2}$$

where, for notational brevity, $x \in X\{DistanceCategory[0-30), Dist.Cat.[30-60), Dist.Cat[60-90)\}$.

The lagged effects capture the potential follow-up impact of military activity on adult mortality in subsequent years through the occurrence of new hardship-induced diseases. Burial series fixed effects, φ_i, capture local variation in sensitivity to mortality shocks. Year fixed effects, ρ_t, capture aggregate yearly fluctuations—resulting from, for instance, widespread disease outbreaks that cover many localities in any particular year—that might artificially drive up the estimated effects if the mortality effect of warfare is concentrated in such years. The model is estimated using Driscoll-Kraay standard errors, $\omega_{i,t}$, that correct for spatial autocorrelation and other standard error concerns.[27] In doing so, this regression model estimates the isolated effect of military activity on adult mortality. Furthermore, the results presented here are robust to different specifications of the lag structure of the model, to different distance categories, alternative town-size categories, region or province-specific time fixed effects, and to slight modifications in the construction of 'deviation'—such as longer and shorter moving averages, and variations in the exclusion of the highest and lowest observations.[28]

In the model presented in Eq. 2, the regression estimates are average marginal effects within localities. They compare the deviation in burials of a locality in years with nearby military activity to the same locality in years when it was more than 90 kilometers (three marching days) away from a war event. The reported coefficients quantify the increase in 'deviation' relative to 'deviation' in normal years, where deviation in normal years is approximately one.

The first column of Table 3 presents the regression results using the full sample, covering the years 1620–99, and estimates for three distance categories without any lagged terms. Localities encountering a war event within 30 kilometers experience an increase in 'deviation' of 0.53, or a 53% increase of deviation over trend burials. Accordingly, assuming a mortality rate of 4% in normal

[27] Driscoll-Kraay standard errors correct for cross-sectional dependence of a variety of forms, and for heteroskedasticity and auto correlation (Driscoll and Kraay, 1998; Vogelsang, 2012). The long time-dimension increases the precision of the standard error corrections, while making alternative corrections for spatial dependence computationally unfeasible.
[28] Results of these robustness checks are provided in the online supplementary material.

times, localities with a war event within 30 kilometers experienced on average an increase to 6.1 deaths per hundred adults. The effect is sizeable given that this is an average effect of a regular occurrence—recall from Table 2 that the average locality was within 30 kilometers of a war event every nine years.

Raised mortality is also seen in localities at a further distance of 30–60 and 60–90 kilometers, although the effect beyond 60 kilometers disappears once lagged terms are included in columns two and three. Columns two and three show a statistically significant effect of war-driven mortality in the one year following military activity for military events occurring within 60 kilometers distance. The lagged effect is roughly half the contemporaneous effect within 30 km distance and comparable to the contemporaneous effect at 30–60 kilometers distance. In addition, including these lagged terms reduces the contemporaneous effects within 60 kilometers, and renders the 60–90 kilometers estimate statistically insignificant. More specifically, the contemporaneous effect at 0–30 kilometers drops to 0.46, implying an increase from 4 to roughly 5.8 deaths per hundred adults. Further lagged terms, as reported in column three, are not statistically significant and do not change the estimated coefficients—compare the coefficients in columns two and three. Accordingly, we proceed with estimating only one lag term in subsequent estimations.

The fourth and fifth columns of Table 3 present the results of the same regression model but based on subsamples of the data. Column four uses the years from 1620 to 1659, covering the second half of the Eighty Years' War and its extension as the Franco-Spanish War. The fifth column uses the period from 1660 to 1699, defined by the wars of Louis XIV Lynn (1999). Although changes in seventeenth-century warfare were limited in the Low Countries because of the continued dominance of siege warfare (Parker, 1972; Childs, 1991), our results do point to a change in its effects on local mortality. Larger mortality increases are seen in localities close to military activity in the period before 1660, while the mortality effects at a further distance of 30–60 kilometers are less visible. The disappearance of plague after the final outbreak in the 1660s is likely to partly explain more intense mortality increases before 1660 (Noordegraaf and Valk, 1988), although this is not necessarily an explanation for the further spread of excess mortality after 1660. The gradual changes in the scale of warfare, involving larger and more maneuverable armies, might explain the larger spatial effect of warfare after 1659. Arguably, the less disciplined, smaller-scale military activity before 1660 put more prolonged pressure on local communities. However, the larger armies and protracted military campaigns were more conducive for a wider territorial spread and durability of mortality effects.

The positive lagged effects in Table 3 are intriguing. Clearly, civilians are unlikely to die as a result of direct violence from soldiers a year—or several months—down the line. In addition, and as discussed in Sections 2 and 3, disease-driven mortality rarely crossed over from one calendar year to the next. Accordingly, raised mortality in the subsequent calendar year is more likely to be explained through continued hardship induced by the military activity of the preceding year. Indeed, extraordinary taxes imposed by armies could be levied for several years, and even if just for one year, could leave localities heavily indebted for years (Gutmann 1978; Goorts, 2019: 271–303). Communities often petitioned urban or provincial authorities, testifying to the inhabitants' inability to pay dues, taxes, and rents. Enduring hardship could, in turn, pave the way for new or resurfacing diseases to strike the populations of localities. The larger lagged mortality effects of warfare seen in the second half of the seventeenth century supports this 'hardship interpretation', since the burden of contributions on communities in the Low Countries increased over the course of the century (Gutmann, 1980; Lynn, 1993; 1997).

4.1. Differences between urban and rural localities

In light of an established literature that emphasizes the differential impact of warfare on cities and the countryside (Rosenthal and Wong, 2011; Voigtländer and Voth, 2013; Dincecco and Onorato, 2016; 2017), we assess the mortality effect of warfare for localities of different size in our sample. To do so, we interact all terms of Eq. 2 with dummies for each different urban-size category, and including one lagged term for each independent variable. Accordingly, the normal regression coefficients should be read as conditional main effects, presenting the estimated effects for rural localities, whereas the estimates of interaction terms should be read as marginal effects for the differently sized cities compared to the effects in rural localities.

The results of this exercise are visualized in Fig. 3, where lagged terms are excluded for readability.[29] The results show that there are no differences between rural and urban localities. The conditional main effects, presenting the mortality increase in rural localities, remain statistically significant and are slightly larger than the estimates reported in Table 3. The estimate at 0–30 kilometers increases to 0.50 compared to 0.46 in Table 3 above.[30] The coefficients of the interaction terms are noisy due to the smaller number of observations underlying some of the urban categories. The point estimates suggest that urban localities, if anything, suffered slightly less raised mortality than rural ones, which is surprising given that the rural death-tolls are likely to be conservative estimates in the event of flight to cities.

The lack of a differential mortality effect between urban and rural localities has important implications because it contradicts a prominent view linking early modern warfare with heightened urban mortality Voigtländer and Voth (2013). The large effects reported for rural localities close to war events also speak to a literature stressing rural flight during war and cities' roles as 'safe havens' (Rosenthal and Wong, 2011; Dincecco and Onorato, 2016). Our finding that rural excess mortality was at least as high as in urban environments suggests that many people stayed in place. Indeed, if rural flight was a quantitatively important phenomenon, then our results underestimate rural excess mortality; the actual death toll was much higher than reported here. However, our finding

[29] Table A.2 in the appendix presents the regression results in table form.

[30] The unreported lagged terms and the results of splitting the sample into an early and later part of the seventeenth century are virtually identical to those reported in Table 3.

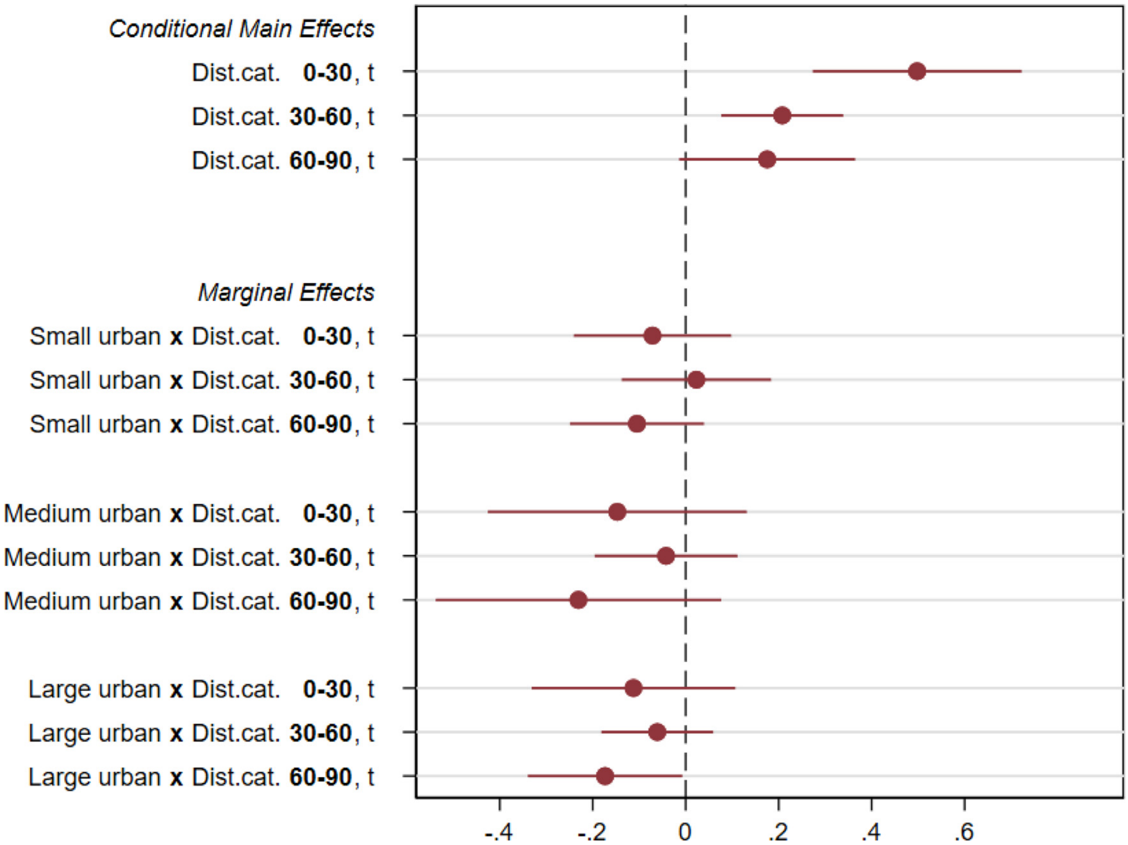

Fig. 3. Urban-rural differences in war-driven mortality increases
Notes: This figure reports the estimated coefficients of Equation 2 extended with interactions terms for the different urban size categories discussed in the main text. Point estimates are shown by the markers, whereas the horizontal bars indicate confidence intervals around these point estimates (at 95 per cent statistical significance). The model is estimated with an additional lag term for each reported coefficient, but these are omitted to improve readability. Table A.2 in the Appendix reports the results in table form (the full-size table including the coefficients of the lagged terms can be found in the online supplementary material). All regressions reported in the main text of this article are estimated with burial series and year fixed effects, and with Driscoll-Kraay standard errors.
Sources: Authors' own data. See Sections 2 and 3 of the main text.

is in line with the attempts of military commanders to stimulate or force peasants to stay put (Gutmann, 1978; Satterfield, 2003: 42–88; Goorts, 2019: 285), and resonates with recent literature on seventeenth-century mortality crises that emphasize the strong rural profile of many disease outbreaks (Alfani, 2013b; Curtis, 2016). These explanations imply that direct rural flight might be a smaller phenomenon than suggested in the literature. This would mean that increased urbanization in response to warfare, documented in that literature (Dincecco and Onorato, 2016), was driven by migration over the longer term. This interpretation might, however, be specific to the seventeenth-century Low Countries.

4.2. *Magnitude of the mortality increases*

The results presented in this section point to a clear and significant spatial and temporal relationship between military activity and raised mortality. However, the magnitude of the average mortality increase does not seem spectacular when compared to known mortality spikes associated with epidemic disease outbreaks that could lead to mortality rates five or six times higher than normal—as discussed in the introduction (Alfani, 2013b; Cummins et al., 2016). However, warfare was a recurring phenomenon, with the average locality in the sample experiencing a war event within 30 kilometers distance in 12% of the years between 1620 and 1699—see Table 2. In addition, localities experienced their nearest war event between 30 to 60 kilometers distance in 16% of the years, meaning that the average locality experienced its nearest war event within 60 kilometers distance in 28% of the years.

To put the estimated mortality effects of warfare in perspective, we can use the average number of years with nearby warfare in combination with the estimated excess mortality effects reported in Table 3 to calculate the average number of years needed for warfare to produce a total mortality deficit comparable to that of a severe epidemic disease outbreak. For this, we use a 'deviation' of 6.0 as a benchmark for an epidemic outbreak and a normal mortality rate of 3 deaths per 100 inhabitants, and restrict war-driven mortality to the first two distance categories and one lag. Assuming that excess mortality is recovered within a year and does not change demographic trends within a locality, a deviation of 6.0 from a normal rate of 3 deaths per 100 inhabitants would mean the epidemic killing a further 15 people (18 deaths in total). The mortality effect of warfare estimated above, in contrast, would produce an excess deviation score of 1.52 over 10 years, meaning 4.6 additional deaths (7.6 in total).[31] Put differently, it would take roughly 33 years for average warfare to produce a total death toll comparable to that of a serious seventeenth-century epidemic outbreak.

There are several major caveats to the back-of-the-envelope calculation presented above, three of which are particularly noteworthy. First, the assumption that excess mortality does not affect underlying demographics is a strong one. Serious excess mortality could well result in lower absolute numbers of births in subsequent years, while the recurrent effects of warfare would be slightly underestimated when populations do not recover their population losses from one year to the next. Second, by focusing on the effects of warfare and epidemic disease on one locality, we ignore potential differences in the spatial scope of their effects. Early modern plague outbreaks, for example, regularly spread over large territories killing large numbers of people Alfani (2013b), while it would require a large spread and density of war events to reproduce a mortality effect on similar scale. These first two caveats suggest that the effects of epidemics such as plague outbreaks are arguably more dramatic than the calculations above indicate. However, the third caveat relates to possible connections between warfare and epidemics, with warfare as a catalyst for epidemic disease-related mortality, an issue we now turn to.

5. War and major epidemics

In this section, we investigate the relationship between warfare and civilian adult mortality specifically for periods and localities where high mortality was evident (i.e., years with large-scale epidemic disease). Epidemic diseases are the natural point of departure in the early modern period to explain very high local mortality rates. Since the burial registers did not record cause of death systematically, and the terminology used to describe conditions and symptoms is not straightforward to interpret, no epidemiologic data exists to systematically identify epidemic disease-driven mortality for the early modern Low Countries.[32] Accordingly, it is not possible to study whether warfare played a causal role in the emergence of epidemic diseases. We can assess whether warfare contributed to epidemic mortality, however, by considering whether the relationship between warfare and civilian mortality was different during years of very high (epidemic) mortality.

To illustrate the occasional magnitude of local mortality increases throughout the seventeenth century, Table 4 lists the highest 'deviation' estimates among all localities in our sample, combined with information on the distance to nearest war events in the second and third columns. The upper panel of the table presents the top-ten highest deviations overall. The highest local mortality found had a deviation over trend burials of 46.2 in Ciergnon (1636), which should be interpreted as a 4520% increase in deviation over the normal rate (or a regression coefficient of 45.2). That increase suggests the village was left virtually depopulated.[33] Although such increases are clearly exceptional, 'deviations' of 10—suggesting adult death rates of roughly one-third of the population—are more common. Still, mortality increases of the size discussed in Cummins et al. (2016) and Alfani (2013b) are rare in our data; there are only 109 instances of a mortality deviation of 5.0 or larger (68 instances of 6.0 and larger), or 0.9% out of a total of 11,831 deviation estimates for the years 1620–99.[34]

An intriguing finding in Table 4 is that four localities in the top-ten of highest deviation experienced a war event within 30 km in the same or previous year. Although the proportion of localities with links between military activity and extreme local mortality deviations might not seem spectacular (40%), it is notably higher than the proportion of localities experiencing (same-year) military activity reported in Table 2; 14% among the subset of locality-year combinations with a mortality deviation estimate. Furthermore, 44 out of 109 cases (40%) of mortality deviation 5.0 or higher experienced same-year military activity within 30 km. These results indicate that incidences of very high local mortality were relatively often connected to warfare.

To test the connection between warfare and extreme mortality deviations more systematically, we focus on the connection between warfare and epidemic disease-related mortality in high mortality years. Lacking comprehensive studies on the occurrence of epidemic disease covering the Low Countries as a whole—or a large part of it—we approximate the chronology of major outbreaks of epidemic disease in the seventeenth-century Low Countries using the burials sample, and then check this against the existing secondary literature.[35] To do so, we construct an indicator of the aggregate adult mortality within our entire sample. This 'aggregate

[31] This figure is calculated by taking the number of years with warfare within 0–30 and 30–60 kilometers per 10 years (1.2 and 1.6 years respectively) and multiplying these with the contemporaneous and lagged excess mortality numbers: 1.2(0.46+0.27) + 1.6(0.20+0.20)=1.52 as excess deviation, or 2.52 as annualized deviation. These numbers can be combined in this simple fashion by assuming that population recovers within the calendar year.

[32] Even where conditions and symptoms are recorded, that information is difficult to use given issues regarding 'retrospective diagnosis' of diseases through historical sources (Thoen and Devos, 1999). Terms such as '*peste*' or '*pestilentia*' appear frequently, but we should not assume that this is definitive reference to plague (caused by *Yersinia pestis*), in the absence of confirmative aDNA evidence.

[33] Early modern mortality rates in northwest Europe may have been 1.8 times higher in large cities than in the countryside. An annual urban mortality rate of 4 per cent would, therefore, correspond to 2.2 per cent in rural areas (Clark and Cummins, 2009: 244). In Ciergnon, burials cease to be recorded after the hyper-mortality of 1636, suggesting total or almost total depopulation for a period of time.

[34] The highest percentage found in a single year is 18 per cent of localities with a mortality deviation of at least 5.0 in the year 1636. See more on this below.

[35] Although literature has identified epidemic diseases occurring in parts of the Low Countries at particular points in time, the geographical and temporal scope is never wide enough and the source material never allows for a straightforward methodology of identification. Accordingly, we cannot take "epidemics in the secondary literature" as a starting point. By way of example, the most comprehensive work on epidemic disease in the

Table 4
Highest local deviations over trend burials.

	(1) Mortality deviation	(2) Distance to nearest war event in km, same year	(3) Distance to nearest war event in km, previous year
Town (year)			
Largest local mortality deviations			
Ciergnon (1636)	46.2	68.6	31.4
Gierle (1636)	29.4	88.2	31.6
Rijsbergen(1625)	17.3	8.4	9.6
Nijkerk (RK) (1636)	15.9	59.1	59.1
Lille (BE) (1636)	14.9	92.4	28.2
Kropswolde(1666)	13.6	111.9	20.8
Fressin (1636)	13.4	60.1	151.5
Oudewater (1636)	13.1	81.7	84.2
Louches (1665)	13.0	321.0	444.9
Huy (St. Pierre-en-Outremeuse) (1636)	12.5	103.6	0.0
Largest local mortality deviations, given war event within 30 kilometers in same or previous year			
Rijsbergen(1625)	17.3	8.4	9.6
Lille (BE) (1636)	14.9	92.4	28.2
Kropswolde(1666)	13.6	111.9	20.8
	12.5	103.6	0.0
Huy (St. Pierre-en-Outremeuse) (1636)			
Minderhout (1625)	12.2	16.8	18.6
Gentbrugge (1646)	12.0	4.8	4.8
Izegem (1694)	11.9	25.1	22.0
Asperen (1672)	11.8	10.7	-
Schriek (1693)	10.9	16.8	47.4
Bottelare (1646)	10.7	10.7	10.7

Notes: The upper half of this table lists the ten highest local deviations over trend burials, including the name of the burial series and the year of occurrence. The lower half lists the highest ten deviations among localities that had a war event within 30 kilometers in the same or previous year. Burial locations that occur in both lists in the same year are underlined. RK refers to the Catholic church burial series (distinct from the Dutch Reformed series), and BE refers to Belgium—Lille in this table is a village in Brabant and not the city in northern France.
Sources: Authors' own data. See Sections 2 and 3 of the main text.

deviation' is calculated as the simple average of all local deviations for each year for the subset of burial series with a deviation estimate—which implies that the subset of burial series underlying the aggregate deviation-estimate varies across years. This aggregate deviation is presented in the left panel of Fig. 4 where the shaded background refers to the main war episodes, and with the five highest 'aggregate deviations' marked by vertical lines (the years 1625, 1636, 1646, 1676, and 1693).

The years identified as major aggregate mortality years in our data closely correspond with existing secondary literature on known epidemics in the seventeenth-century Low Countries. The years 1624–5 and 1635–7 have been identified as plague outbreaks in a substantial literature (Noordegraaf and Valk, 1988; Rommes, 2015; Curtis, 2016).[36] The year 1676, furthermore, has been clearly identified as a dysentery outbreak on account of the very distinctive symptoms of bloody diarrhea (Kappelhof, 1973; Bruneel, 1977: 213–317; Dings, 1986), and these same symptoms, alongside general references to fevers, have been recorded for 1693 during the period of exceptionally high grain prices (Curtis and Dijkman, 2019).

For the year 1646 we have less supporting documentary evidence, likely because it mainly centered itself on Flanders and Hainaut and is thus not mentioned in the classic work by Noordegraaf and Valk (1988).[37] There are also two episodes of epidemic

early modern Low Countries, only focuses on plague, concentrates on the first half of the century, and mainly corresponds to the County of Holland (Noordegraaf and Valk, 1988).

[36] Besides spiked mortality, there is other evidence such as plague ordinances and resolutions (Kerkhoff, 2020: 26–51), medical treatises and religious tractates (Dijstelberge and Noordegraaf, 1997), pest house admissions (Buwalda and Buwalda-Prey, 1939; Brunner, 1946), payments for medicines and financial support to plague-afflicted families (de Brouwer, 1995; Jacquet-Ladrier, 2007), contracts for comforters, cleaners and care-givers (Curtis, 2021a), inheritance disputes (de Brouwer, 2000), the construction of isolation huts (van Zalinge-Sporen, 1994), and direct observations from diaries (Beck, 1993).

[37] There are ample references to this disease episode, however. See, for instance, the plague ordinances announced in Bruges, Douai and Mons (Anon, 1647; Wion, 1647; Lacroix, 1844: 26). Also, the remedies noted in the "*temps pestiféré*" in Lille (Du Gardin, 1646; reprinted from the 1617 original in Douai), and the payments made to those suffering from the "*contagieuse sieckte*" and isolating in their houses in the coastal village of Lissewege, near Bruges (Vandepitte, 1962: 89). "*Peste*" and "*contagion*" are mentioned in various burial registers in the years 1646 and 1647, but also "*febris*" (fevers), "*variola*" and "*pokken*" (smallpox), "*dissenteria*" (dysentery), "*hydropica*" (dropsy), and "*phthysis*" (tuberculosis).

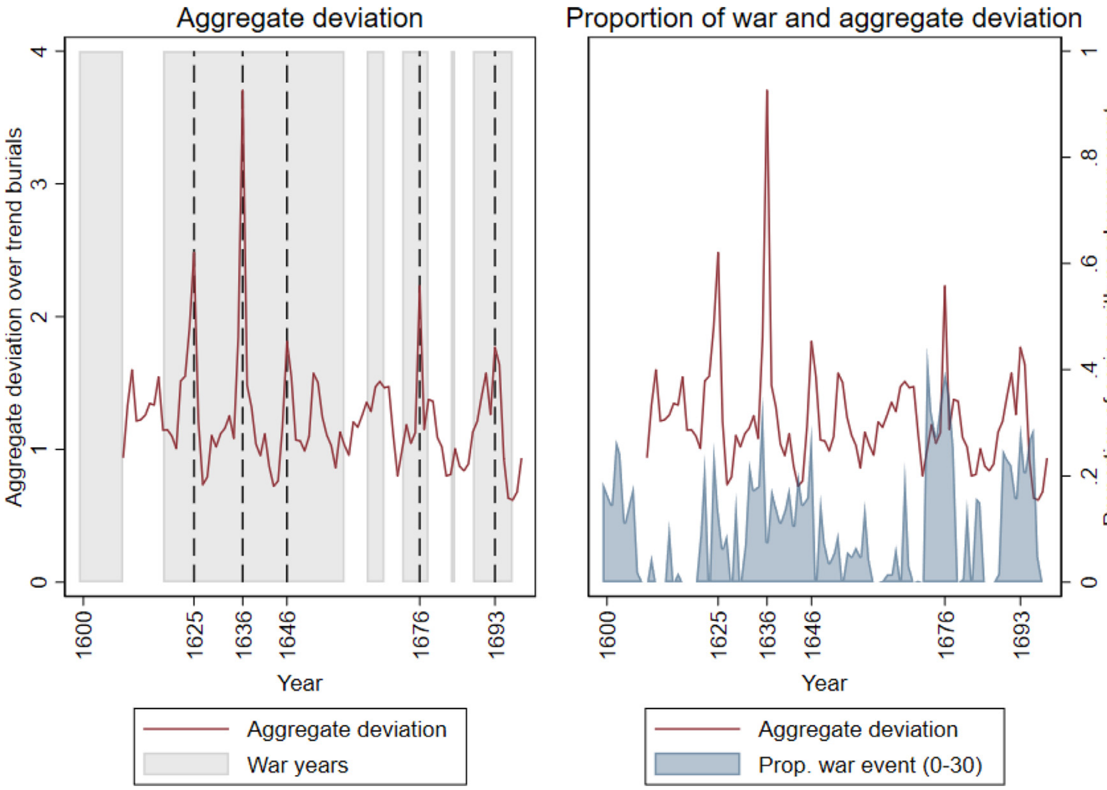

Fig. 4. Aggregate deviation over trend burials
Notes: This figure shows aggregate deviation over trend burials over time. The left panel shows aggregate deviation, with vertical lines indicating the five highest deviation years and the shaded part of the graph indicating 'war years'. The right panel shows aggregate deviation—reproduced from the left panel of Figure 2—in comparison to the proportion of burials locations with a war event within 30 kilometers.
Sources: Based on the authors' own data. See Sections 2 and 3 of the main text.

disease established in the literature that do not appear conclusively in the aggregate deviation shown in Fig. 4: 1655–6 and 1664–9 (Noordegraaf and Valk, 1988; Rommes, 2015; Curtis, 2016). The 1655–6 plague outbreak was mainly restricted to Holland (leading to embargoes of ships leaving from Meuse ports: Kerkhoff, 2020: 95) and Utrecht. The 1664–9 outbreak was spread over such a long period, affecting different regions at different times, that it did not create a sharp spike in one single year in the aggregate burial deviations, but a gradual increase over a number of years is visible in Fig. 4. As these two episodes are less prominent in our burials data, we focus our analysis on the five epidemic years shown in Fig. 4.

Two aspects of Fig. 4 stand out. First, all the main aggregate mortality spikes occur during episodes of warfare, displayed by the shaded parts of the left panel. Since this is unsurprising given that most years in the seventeenth century were war years, the right panel of Fig. 4 overlays the aggregate mortality deviation with the proportion of localities in the full dataset with a war event within 30 kilometers (unconditional on localities yielding a deviation estimate in a given year, as seen in the left panel of Fig. 2), as a more meaningful marker of annual variation in the spatial spread of military pressure. Although only indicative, all mortality spikes are seen in and around years wherein large proportions of the localities experience nearby warfare. Furthermore, all temporal concentrations of widespread military activity coincide with peaks in aggregate mortality deviations, and none of the aggregate mortality spikes are found in years with a small spread of military activity. At the same time, and concentrating on the main mortality episodes, there is no apparent relation between the size of the mortality spike and the spread of military activity.

Second, the magnitude of the aggregate mortality spikes in Fig. 4 is substantial, though less substantial than noted for other areas of Western Europe. The aggregate deviation of close to four for 1636 particularly stands out, as this implies an average adult death rate of 16% among all localities when assuming a normal death rate of 4 per cent.[38] To further scrutinize the relationship between military activity and civilian mortality in the spike years specifically indicated in Fig. 4 at the local level, we employ a regression model similar to that of Eq. 2 in Section 4. However, here we estimate a fixed effects model, using the three distance categories and including one lagged term as in Eq. 2, but adding a dummy variable for the epidemic years specified above—the years 1625, 1636, 1646, 1676 and 1693. In addition, we add a second specification with interaction terms for the aggregate epidemic dummy and the

[38] Excluding Ciergnon and Gierle, the massive outliers in Table 5, reduces the magnitude of 'aggregate deviation' in 1636 to three, but it remains the highest aggregate mortality year in our data period.

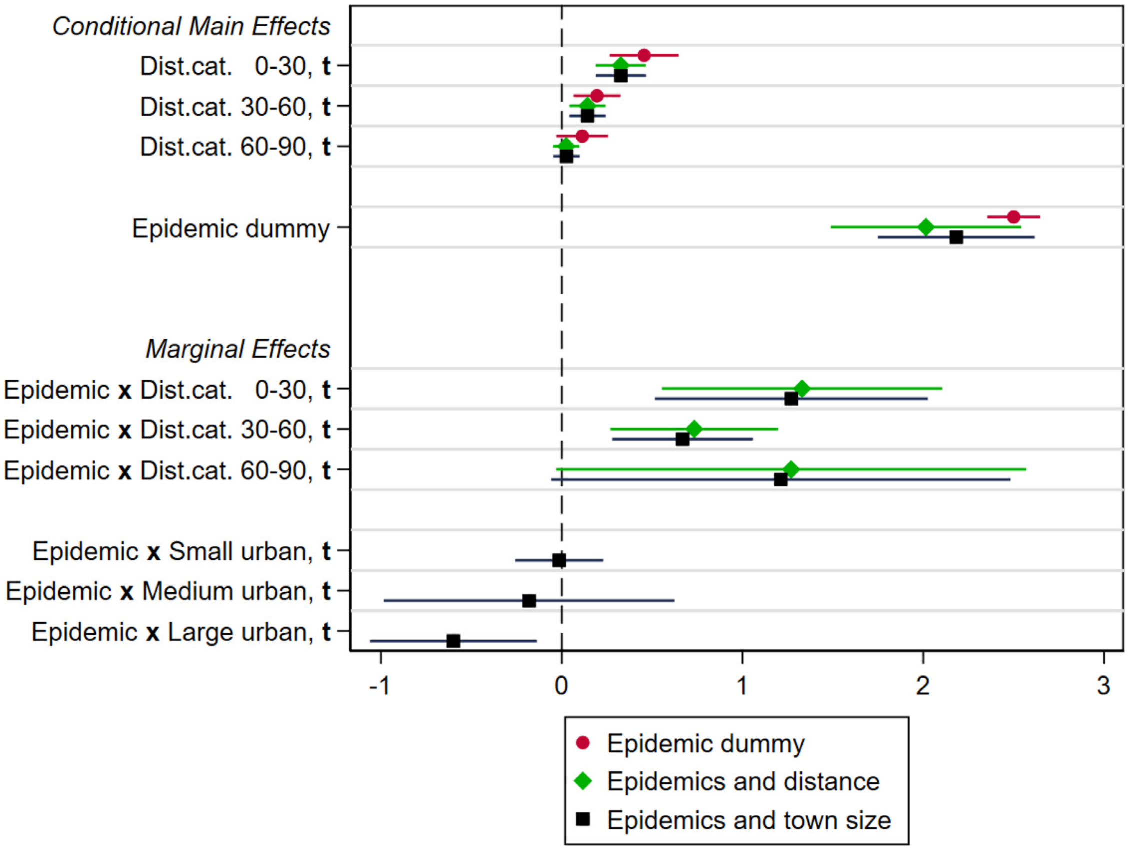

Fig. 5. War-driven mortality increases during epidemic years

Notes: This figure presents the estimated coefficients of Equation 2 extended with a dummy variable for the epidemic years, as specified in the main text, and reported in red circles. Point estimates are shown by the markers, whereas the horizontal bars indicate confidence intervals around these point estimates (at 95 per cent statistical significance). A first extended specification of this model adds interaction terms of the distance categories of the baseline model with epidemic years, shown in green diamonds. A further extended specification adds interactions of the urban size dummies and the epidemic dummy (in black squares). The model is estimated with an additional lag term for each reported coefficient, but these are omitted to improve readability. Table A.3 in the Appendix reports the results in table form (the full-size table including the coefficients of the lagged terms can be found in the online supplementary material). All regressions reported in the main text of this article are estimated with burial series and year fixed effects, and with Driscoll-Kraay standard errors.

Sources: Authors' own data. See Sections 2 and 3 of the main text.

locality-specific distance categories, and a third specification with further interaction terms for the epidemic dummy and each of the urban categories. The results of this exercise are visualized in Fig. 5. [39]

The first specification of this regression model is shown in red in Fig. 5. The estimated regression coefficients for the distance categories are identical to those reported in the second column of Table 3 and are reported here for comparison and to highlight three important takeaways. The first comparison, also in red, is to the much larger size of the epidemic dummy (with a point estimate of 2.50), which presents the average mortality effect of all localities during epidemic years. The second comparison, in green, is to the effect of locality-specific war-driven mortality during epidemic years. These effects are much larger than the conditional main effects. The mortality deviation corresponding to war events at 0–30 km distance during epidemic years is 1.33, compared to the general effect of warfare at 0–30 km of 0.46 (in Table 3). Including these interaction terms also reduces the conditional main effects of distance from war events slightly but, importantly, they remain statistically significant.[40] Third, the inclusion of these interaction terms reduces the magnitude of the epidemic dummy somewhat—from 2.50 to 2.02. This shows that nearby military activity was not a necessary condition for local mortality spikes during epidemic years: localities far removed from warfare experienced very large mortality increases too. Finally, war-driven mortality during epidemic years spread further from the location of warfare, indicated

[39] The estimated lagged terms are excluded from Fig. 5 to improve readability. The figure is shown in table form in the appendix in Table A.3.

[40] These conditional main effects, once including interaction terms for epidemic years, capture the effect of nearby warfare on mortality during non-epidemic years.

by the large point estimate of war-driven mortality at 60–90 km during epidemic years (significant at the 0.1 level). However, these estimates of war-driven mortality during epidemic years are quite noisy, shown by the large confidence intervals in Fig. 5.

Fig. 5 reveals a strong spatial and temporal connection between military activity and civilian mortality during epidemic years. The main estimates are slightly reduced compared to those presented in Table 3, although the results are qualitatively similar. Note, however, that the excess mortality attributable to warfare during epidemic years is comparable to war-driven mortality in non-epidemic years in a relative sense. Although much higher in absolute terms, nearby warfare (using the contemporaneous effect of warfare at 0–30 km distance) pushed the deviation score up by 0.33 from roughly 1.00 in normal years, and by 1.33 from 3.02 in epidemic years—a 33% increase versus a 44% increase.

A further comparison depicted in Fig. 5 comes from the interaction terms of the epidemic dummy and the urban size categories (depicted in blue). Including these interaction terms leads to a small increase in the size of the epidemic dummy, while the interaction terms of epidemic years and the large urban category is negative and statistically significant. In line with the results presented in Section 4, this suggests that rural localities were at least as heavily affected by mortality spikes as urban localities.[41]

The results presented in this section indicate that war played a sizeable role in driving up civilian mortality during epidemic disease periods. Localities close to warfare saw substantially more raised mortality during the main epidemic years of the seventeenth-century Low Countries. Importantly, this epidemic role is additional to the ‘normal’ link between warfare and mortality in years without significant epidemic diseases, documented in the previous section. During epidemic years, however, war-driven mortality tended to spread over larger distances than in non-epidemic years .

6. Conclusion

Using two newly compiled large datasets of adult burials and war events in the seventeenth-century Low Countries, we estimate the relationship between early modern warfare and civilian mortality with greater precision than seen in the existing literature. We show that military activity within 30 kilometers pushed up annual civilian mortality from roughly 3–4 to 4.5–6% of the adult population. Smaller mortality increases are found at distances between 30 and 60 kilometers and as lagged effects (within 60 kilometers distances). These results are consistent with mortality driven by local and mainly modest disease outbreaks.

Although it has been suggested that war-induced diseases particularly affected cities, thereby stimulating urbanization in the long term (Voigtländer and Voth, 2013), we find no differences in mortality effects between urban and rural localities. War-driven urbanization might also have had its roots in rural flight (Rosenthal and Wong, 2011; Dincecco and Onorato, 2016; 2017), but relatively high rural excess mortality, in combination with limits imposed on the mobility of people from the countryside (Gutmann, 1978; Satterfield, 2003: 260–6), suggest that war-driven urbanization documented in the literature may have had its roots in long-term migration rather than sudden or short-term rural flight—at least in the seventeenth-century Low Countries.

Existing literature that attributes an important role to warfare in engendering structural consequences to early modern western European economies concentrates on its capacity to produce incidental but extreme increases in mortality (Lagerlöf, 2003; Alfani, 2013b; Alfani and Percoco, 2019; Siuda and Sunde, 2021). Analyzing the relationship between military activity and excess mortality for epidemic outbreaks specifically, we show that the connection between war events and mortality spikes is stronger during most epidemic years and spreads over larger distances. However, the war-driven mortality increases during epidemic years are of similar relative magnitude as those in non-epidemic years. Overall, given the omnipresence of warfare in the seventeenth-century Low Countries, war-driven mortality was remarkably constant rather than a sharp discontinuity. Therefore, the economic implications of warfare also likely played out over the long term rather than driven by sudden large mortality spikes creating rapid structural changes .

Supplementary materials

Supplementary material associated with this article can be found, in the online version, at doi:10.1016/j.eeh.2021.101425.

References

Adriaenssen, L., 2007. Staatsvormend geweld: Overleven aan de frontlinies in de Meierij van Den Bosch, 1572–1629. Stichting Zuidelijk Historisch Contact, Tilburg.
Alfani, G., 2013a. Calamities and the Economy in Renaissance Italy: The Grand Tour of the Horsemen of the Apocalypse. Palgrave Macmillan, Basingstoke.
Alfani, G., 2013b. Plague in seventeenth-century Europe and the decline of Italy: An epidemiological hypothesis. Eur. Rev. Econ. History 17 (4), 408–430.
Alfani, G., 2020. The economic history of poverty, 1450–1800. In: Hitchcock, D., McClure, J. (Eds.), The Routledge History of Poverty, c. 1450–1800. Routledge, Abingdon, pp. 21–38.
Alfani, G., Percoco, M., 2019. Plague and long-term development: The lasting effects of the 1629–30 epidemic on the Italian cities. Econ. History Rev. 72 (4), 1175–1201.
Anon., Ordonnantiën tegen de pest te Brugge. Aengaende het suyveren, reynigen ende rooken van de gheinfecteerde huysen, Sept. 1647. Bruges.
Bairoch, P., Batou, J., Chèvre, P., 1988. La population des villes européennes, 800–1850. Droz, Geneva.
Beck, D., 1993. Spiegel van mijn leven. Haags dagboek 1624. Verloren, Hilversum.
Besley, T., Persson, T., 2009. The origins of state capacity: Property rights, taxation, and politics. Am. Econ. Rev. 99 (4), 1218–1244.
Besley, T., Persson, T., 2011. Pillars of Prosperity: The Political Economies of Development Clusters. Princeton University Press, Princeton NJ.
Blondé, B., 1995. Domestic demand and urbanisation in the eighteenth century: demographic and functional evidence for small towns of Brabant. In: Clark, P. (Ed.), Small Towns in Early Modern Europe. Cambridge University Press, Cambridge, pp. 229–249.
Bosker, M., Buringh, E., 2017. City seeds: geography and the origins of the European city system. J. Urban Econ. 98, 139–157.

41 Although not estimated in this figure, the war-driven mortality effects during epidemic years for urban localities do not differ from those in rural localities. See the online supplementary material for the results of a regression that incorporates triple interaction effects between the epidemic dummy, distance categories, and different urban categories.

Brandon, P., 2015. War, Capital, and the Dutch State (1588–1795). Brill, Leiden.
de Brouwer, L., 1995. 'De aenclevende sieckte': De pest in Tilburg voor 1630. Tilburg: Tijdschrift voor Geschiedenis, Monumenten en Cultuur 13 (1), 3–13.
de Brouwer, L., 2000. Erfenisperikelen ten tijde van pest. De Brabantse Leeuw 49, 74–82.
Bruneel, C., 1977. La mortalité dans les campagnes: Le duché de Brabant aux XVIIe et XVIIIe siècles. La mortalité dans les campagnes: Le duché de Brabant aux XVIIe et XVIIIe siècles, Vol. I. Presses universitaires de Louvain, Louvain.
Brunner, H., 1946. Pest-epidemieën van de 15e tot de 17e eeuw te Rotterdam. Nederlands Tijdschrift voor Geneeskunde 90 (2), 620–624.
Buwalda, J., Buwalda-Prey, E., 1939. Eenige gegevens over de pest te Gouda in de zeventiende eeuw. Nederlands Tijdschrift voor Geneeskunde 83 (4), 5663–5671.
Childs, J.C.R., 1991. The Nine Years' War and the British Army, 1688–1697: The Operations in the Low Countries. Manchester University Press, Manchester.
Clark, G., Cummins, N., 2009. Urbanization, mortality, and fertility in Malthusian England. Am. Econ. Rev., P. & P. 99 (2), 242–247.
Clark, P., 1995. Small Towns in Early Modern Europe. Cambridge University Press, Cambridge.
Clodfelter, M., 2002. Warfare and Armed Conflicts: A Statistical Reference to Casualty and Other Figures, 1500–2000. McFarland, Jefferson NC.
Cummins, N., 2017. Lifespans of the European elite, 800–1800. J. Econ. History 77 (2), 406–439.
Cummins, N., Kelly, M., Ó Gráda, C., 2016. Living standards and plague in London, 1560–1665. Econ. History Rev. 69 (1), 3–34.
Curtis, D.R., 2016. Was plague an exclusively urban phenomenon? Plague mortality in the seventeenth-century Low Countries. J. Interdiscipl. History 47 (2), 139–170.
Curtis, D.R., 2020. Preserving the ordinary: social resistance during second pandemic plagues in the Low Countries. In: Gerrard, C., Brown, P., Forlin, P. (Eds.), Waiting for the Ends of the World: Perceptions of Disaster and Risk in Medieval Europe. Routledge, London, pp. 280–297.
Curtis, D.R., 2021a. The female experience of epidemics in the early modern Low Countries. Dutch Crossing: J. Low Countries Stud. 45 (1), 3–20.
Curtis, D.R., 2021b. From one mortality regime to another? Mortality crises in late medieval Haarlem, Holland, in perspective. Speculum 96 (1), 127–155.
Curtis, D.R., Dijkman, J., 2019. The escape from famine in the Northern Netherlands: a reconsideration using the 1690s harvest failures and a broader Northwest European Perspective. The Seventeenth Century 34 (2), 229–258.
Curtis, D.R., Dijkman, J., Lambrecht, T., Vanhaute, E., 2017. The Low Countries. In: Alfani, G., Ó Gráda, C. (Eds.), Famine in European History. Cambridge University Press, Cambridge, pp. 119–140.
De Cauwer, P., 2008. Tranen van bloed: Het beleg van 's-Hertogenbosch en de oorlog in de Nederlanden, 1629. Amsterdam University Press, Amsterdam.
de la Croix, D., Licandro, O., 2015. The longevity of famous people from Hammurabi to Einstein. J. Econ. Growth 20 (3), 263–303.
Del Panta, L., Livi-Bacci, M., 1977. Chronologie, intensité et diffusion des crises de mortalité en Italie: 1600–1850. Population 32 (1), 401–445.
Devos, I., Van Rossem, T., 2017. Oud, ouder, oudst. Regionale en lokale verschillen in sterfte in het graafschap Vlaanderen tijdens de zeventiende en achttiende eeuw. De Zeventiende Eeuw 33, 39–53.
Dijkman, J., 2021. Managing food crises: Urban relief stocks in pre-industrial Holland. Past and Present 251 (1), 41–74.
Dijstelberge, P., Noordegraaf, L., 1997. Plague and Print in The Netherlands. A Short-Title Catalogue of Publications in the University Library of Amsterdam. Erasmus Publishing, Rotterdam.
Dincecco, M., Onorato, M.G., 2016. Military conflict and the rise of Europe. J. Econ. Growth 21 (3), 259–282.
Dincecco, M., Onorato, M.G., 2017. From Warfare to Wealth. Cambridge University Press, Cambridge.
Dincecco, M., Prado, M., 2012. Warfare, fiscal capacity, and performance. J. Econ. Growth 17 (3), 171–203.
Dings, M.P.H.M., 1986. Een dysenterie-epidemie in Limburg, 1676. De Maasgouw: Tijdschrift voor Limburgse Geschiedenis en Oudheidkunde 105 (3), 105–114.
Dittmar, J.E., Meisenzahl, R.R., 2020. Public goods, institutions, human capital, and growth: evidence from German history. Rev. Econ. Stud. 87 (2), 959–996.
Dobson, M.J., 1992. Contours of Death and Disease in Early Modern England. Cambridge University Press, Cambridge.
Driscoll, J.C., Kraay, A.C., 1998. Consistent covariance matrix estimation with spatially dependent panel data. Rev. Econ. Stat. 80 (4), 549–560.
Du Gardin, L., 1646. Le chasse peste ou les remèdes des familiers dont chacun pourra se servir pour se préserver en temps pestiféré et se guérir soi-même s'il est atteint de la peste. Lille.
Eckert, E.A., 1996. The Structure of Plagues and Pestilences in Early Modern Europe: Central Europe, 1560–1640. S. Karger Ag, Basel, pp. 1560–1640.
Francke, M., Korevaar, M., 2021. Housing markets in a pandemic: evidence from historical outbreaks. J. Urban Econ. 123, 103333.
Fusco, I., 2007. Peste, demografia e fiscalità nel regno di Napoli del XVII secolo. Franco Angeli, Milan.
Galley, C., 1995. A model of early modern urban demography. Econ. History Rev. 48 (3), 448–469.
Gennaioli, N., Voth, H.-J., 2015. State capacity and military conflict. Rev. Econ. Stud. 82 (4), 1409–1448.
Goorts, R., 2019. War, State and Society in Liège: How a Small State of the Holy Roman Empire Survived the Nine Years' War (1688–1697). Leuven University Press, Louvain, pp. 1688–1697.
Gutmann, M., 1978. Why they stayed: the problem of wartime population loss. Tijdschrift voor Geschiedenis 91 (3), 407–428.
Gutmann, M., 1980. War and Rural Life in the Early Modern Low Countries. Princeton University Press, Princeton NJ.
Israel, J.I., 1982. The Dutch Republic and the Hispanic World. Oxford University Press, Oxford.
Israel, J.I., 1995. The Dutch Republic: Its Rise, Greatness, and Fall, 1477–1806. Clarendon Press, Oxford, pp. 1477–1806.
Israel, J.I., 1997. Conflict of Empires: Spain, the Low Countries and the Struggle for World Supremacy, 1585–1713. Hambledon Press, London, pp. 1585–1713.
Jacques, T., 2007. Dictionary of Battles and Sieges, 3 vols. Greenwood Press, Westport CT.
Jacquet-Ladrier, F., 2007. Les épidémies de peste aux XVIe-XVIIe siècles: L'exemple de Namur. Cahiers de Sambre et Meuse 83 (4), 122–141.
't Hart, M., 1993. The Making of a Bourgeois State: War, Politics and Finance during the Dutch Revolt. Manchester University Press, Manchester.
't Hart, M., 2001. Town and country in the Dutch Republic, 1550–1800. In: Epstein, S.R. (Ed.), Town and Country in Europe, 1300–1800. Cambridge University Press, Cambridge, pp. 80–105.
't Hart, M., 2014. The Dutch Wars of Independence: Warfare and Commerce in the Netherlands 1570–1680. Routledge, London, pp. 1570–1680.
Hatcher, J., Piper, A.J., Stone, D., 2006. Monastic mortality: Durham Priory, 1395–1529. Econ. History Rev. 59 (4), 667–687.
Hoffman, P.T., 2015. Why Did Europe Conquer the World?. Princeton University Press, Princeton NJ.
Kappelhof, A., 1973. Pest en rode loop in de Baronie van Breda in de tweede helft van de 17e eeuw (1660–1680). Jaarboek van de Geschied- en Oudheidkundige Kring van Stad en Land van Breda 26, 75–90.
Kerkhoff, A.H.M., 2020. Per Imperatief Plakkaat. Overheid en pestbestrijding in de Republiek der Zeven Verenigde Nederlanden. Verloren, Hilversum.
Klep, P.M.M., 1991. Population estimates of Belgium, by province (1375–1831). In: Société Belge de Démographie (Ed.), Historiens et populations. Liber Amicorum Étienne Hélin. Academia, Louvain-la-Neuve, pp. 485–507.
Lacroix, A., 1844. Notice chronologique et analytique sur les épidémies et les épizooties qui ont régné en Hainaut, à diverses époques, de 1006 à 1832. Wouters, Brussels.
Lagerlöf, N.P., 2003. From Malthus to modern growth: can epidemics explain the three regimes? Int. Econ. Rev. 44 (2), 755–777.
Lambrecht, T., 2014. Geboorte, huwelijk en dood: parochieregisters als bron voor je historisch artikel. Bladwijzer 12, 15–26.
Landers, J., 2005. The destructiveness of pre-industrial warfare: political and technological determinants. J. Peace Res. 42 (4), 455–470.
Lynn, J.A., 1993. How war fed war: The tax of violence and contributions during the Grand Siècle. J. Modern History 65 (2), 286–310.
Lynn, J.A., 1997. Giant of the Grand Siècle: The French Army, 1610–1715. Cambridge University Press, Cambridge.
Lynn, J.A., 1999. The Wars of Louis XIV, 1667–1714. Routledge, London.
Martin, P., 2002. Une guerre de Trente Ans en Lorraine 1631–1661. Serpenoise, Metz.
Mentink, G.J., van der Woude, A., 1965. De demografische ontwikkeling te Rotterdam en Cool in de 17e en 18e eeuw. Gemeentearchief, Rotterdam.
van Nierop, H., 1999. Het verraad van het Noorderkwartier: Oorlog, terreur en recht in de Nederlandse Opstand. Amsterdam University Press, Amsterdam.
van Nimwegen, O., 2010. The Dutch Army and the Military Revolutions, 1588–1688. Boydell & Brewer, Woodbridge.
Noordegraaf, L., Valk, G., 1988. De Gave Gods. De pest in Holland vanaf de late Middeleeuwen. Octavo, Bergen.
Nusteling, P.H., 1979. Binnen de vesting Nijmegen: Confessionele en demografische verhoudingen ten tijde van de Republiek. Walburg, Zutphen.

Nusteling, P.H., 2018. De homeostatische bevolkingsreeks voor Amsterdam in 1586–1865 toegelicht en getoetst. Tijdschrift voor Sociale en Economische Geschiedenis 15 (1), 31–65.
O'Brien, P., 2018. The costs and benefits of mercantilist warfare. Financ. History Rev. 25 (1), 97–112.
van Oosten, R., 2016. The Dutch great stink: the end of the cesspit era in the pre-industrial towns of Leiden and Haarlem. Eur. J. Arch. 19 (4), 704–727.
Outram, Q., 2001. The socio-economic relations of warfare and the military mortality crises of the Thirty Years' War. Medical History 45 (2), 151–184.
Outram, Q., 2002. The demographic impact of early modern warfare. Social Science History 26 (2), 245–272.
Paping, R., 2014. General Dutch Population Development 1400–1850: Cities and Countryside. 1st ESHD Conference Paper http://hdl.handle.net/11370/d057464a-dbb1-4d50-a217-762403c1a3e2.
Parker, G., 1972. The army of Flanders and the Spanish Road, 1567–1659. The Army of Flanders and the Spanish Road, 1567–1659: The Logistics of Spanish Victory and Defeat in the Low Countries' Wars. Cambridge University Press, Cambridge.
Parker, G., 1984. The Thirty Years' War. Routledge, London.
Pérez Moreda, V., 1980. Las crisis de mortalidad en la España interior (siglos XVI-XIX). Siglo Veintiuno de España, Madrid.
van Poppel, F.W.A., Bijwaard, G.E., van Lieburg, M., van Lieburg, F., Hoekstra, R., Verkade, F., 2016. The life expectancy of medical professionals in the Netherlands, sixteenth to twentieth centuries. Population 71 (4), 619–640.
van Poppel, F.W.A., van Kaa, D.J., Bijwaard, G.E., 2013. Life expectancy of artists in the Low Countries from the fifteenth to the twentieth century. Pop. Stud. 67 (3), 275–292.
Prinzing, F., 1916. Epidemics Resulting from Wars. Clarendon Press, Oxford.
Rommes, R., 1998. Oost, west, Utrecht best? Driehondert jaar migratie en migranten in de stad Utrecht (begin 16e–19e eeuw). Stichting Amsterdamse Historische Reeks, Amsterdam.
Rommes, R., 2015. Plague in Northwestern Europe. The Dutch experience, 1350–1670. Popolazione e Storia 16 (2), 47–71.
Rosenthal, J.-L., Wong, R.B., 2011. Before and Beyond Divergence. Harvard University Press, Cambridge MA.
Satterfield, G., 2003. Princes, Posts and Partisans: The Army of Louis XIV and Partisan Warfare in the Netherlands (1673–1678). Brill, Leiden.
Schroor, M., 2014. Rurale metropool: Bevolking, migratie en financiën van de stad Groningen ten tijde van de Republiek (1595–1795). Nederlands Agronomisch Historisch Instituut, Groningen.
Siuda, F., Sunde, U., 2021. Disease and demographic development: the legacy of the plague. J. Econ. Growth 26, 1–30.
Stabel, P., 1995. Demography and hierarchy: the small towns and the urban network in sixteenth-century Flanders. In: Clark, P. (Ed.), Small Towns in Early Modern Europe. Cambridge University Press, Cambridge, pp. 206–228.
Stasavage, D., 2011. States of Credit: Size, Power and the Development of European Polities. Princeton University Press, Princeton NJ.
Teeuwen, D., 2016. Financing Poor Relief through Charitable Collections in Dutch Towns, c. 1600–1800. Amsterdam University Press, Amsterdam.
Theibault, J., 1997. The demography of the thirty years war revisited: Günther Franz and his critics. German History 15 (1), 1–21.
Thoen, E., Devos, I., 1999. Pest in de Zuidelijke Nederlanden tijdens de Middeleeuwen en de Moderne Tijden. In: De pest in de Nederlanden. Koninklijke Academie voor Geneeskunde van België, Brussels, pp. 19–43.
Tilly, C., 1992. Coercion, Capital, and European States, AD 990–1992. Oxford University Press, Oxford.
Tracy, J.D., 1990. Holland under Habsburg rule, 1506–1566: The Formation of a Body Politic. University of California Press, Berkeley CA.
Vandepitte, G., 1962. Over Lissewegenaren en Lisseweegse parochietekeningen uit de eerste helft van de XVIIe eeuw - Deel 1. Rond de Poldertorens 3, 82–93.
Vermeesch, G., 2006. Oorlog, steden en staatsvorming. De grenssteden Gorinchem en Doesburg tijdens de geboorte-eeuw van de Republiek (1570–1680). Amsterdam University Press, Amsterdam.
Vogelsang, T.J., 2012. Heteroskedasticity, autocorrelation, and spatial correlation robust inference in linear panel models with fixed-effects. J. Econometrics 166 (2), 303–319.
Voigtländer, N., Voth, H.-J., 2013. The three horsemen of riches: plague, war, and urbanization in early modern Europe. Eur. Rev. Econ. Stud. 80 (2), 774–811.
de Vries, J., 1984. European Urbanization 1500–1800. Routledge, London.
de Vries, J., 2019. The Price of Bread: Regulating the Market in the Dutch Republic. Cambridge University Press, Cambridge.
de Vries, J., van der Woude, A., 1997. The First Modern Economy: Success, Failure, and Perseverance of the Dutch Economy, 1500–1815. Cambridge University Press, Cambridge, pp. 1500–1815.
Wion, G., 1647. Traicté politique et médical touchant la préservation des villes, qui sont dans l'appréhension de la Peste. Douai.
Wilson, P.H., 2009. Europe's Tragedy: A History of the Thirty Years War. Allen Lane, London.
Woods, R., 2003. Urban-rural mortality differentials: an unresolved debate. Pop. Dev. Rev. 29 (1), 29–46.
van der Woude, A., 1980. In: Blok, D.P. (Ed.). In: Algemene Geschiedenis der Nederlanden, vol. V.. Fibula-Van Dishoeck, Haarlem, pp. 102–168.
van Besouw, B., Curtis, Daniel R., 2021. Replication Files for 'Estimating Warfare-Related Civilian Mortality in the Early Modern Period: Evidence from the Low Countries, 1620–99. Inter-university Consortium for Political and Social Research [distributor], Ann Arbor, MI 2021-08-18 doi:10.3886/E147721V2.
van der Woude, A., 1982. Population developments in the Northern Netherlands (1500–1800) and the validity of the "urban graveyard" effect. Annales de Démographie Historique 55–75.
Wrigley, E.A., Schofield, R., 1989. The Population History of England, 1541–1871. Cambridge University Press, Cambridge, pp. 1541–1871.
van Zalinge-Spooren, C., 1994. 'Die contageuse sieckte der peste is grasserende…': De pest in Helmond in 1636. De Vlasbloem 14, 57–92.