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Detecting Hidden Violence: The Spatial Distribution of Excess Mortality in Rwanda

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Abstract

During the nineties, Rwanda experienced several forms of internal violence, including civil war, genocide, reprisal killings and (counter-)insurgency. In addition, the armed conflict triggered of an unprecedented refugee crisis in the Great Lakes region. In order to assess the relative impact of the different forms of violence and the refugee crisis, this article derives a detailed spatial pattern of wartime excess mortality from pre- and post-conflict population census data. In line with previous evidence on the intensity of genocide, civil war and reprisal killings in Rwanda, we find significant high-high excess mortality clusters in the southern province of Butare, in and around Kigali City, and in the eastern province Kibungo. Furthermore, we present the first quantitative evidence to date of high excess mortality in Gisenyi, the northwestern province which was the location of (counter-)insurgency and served as a corridor for more than a million refugees. A regression analysis indicates that both of these events contributed to a high death toll in Gisenyi.

1 Introduction

Armed conflict is often characterized by different forms of violence, e.g. political violence, ethnic violence and random violence (Davenport and Stam (2009), Fearon and Laitin (2003)).

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Each form of violence is likely to be associated with excess mortality, although the affected population might differ by ethnic affiliation, political color or socioeconomic characteristics. Both from a historical point of view and for the sake of post-conflict reconstruction and reconciliation, it is important to recognize the occurrence of different forms of violence and to evaluate their impact on (segments of) the population (Straus (forthcoming)). However, it is more rule than exception that some events in a conflict cycle receive more attention than others (Cramer (2007)). For example, in the aftermath of conflict, victims belonging to the conquering party are more likely to be heard and cared for than victims affiliated with the defeated parties. Furthermore, victims of indirect effects of violence, such as the disruption of health services and refugee streams, may be less visible than direct victims of violence. Finally, areas that are relatively well accessible or areas in which large scale massacres took place may receive more and better coverage compared to less accessible areas and areas where killings were dispersed. Using the case of Rwanda, this paper shows how one can achieve a more complete assessment of a conflict cycle with a balanced view of the impact of distinct forms of violence by relying on widely available data, i.e. population census data, and commonly used data analysis techniques, including Principal Component Analysis (PCA), Local Indicators of Spatial Association (LISA) and regression analysis.

The Rwandan conflict cycle of the nineties included civil war, genocide, reprisal killings, (counter-)insurgency (i.e. rural guerilla warfare) and a major refugee crisis. Civil war broke out in Rwanda at the end of 1990, when the RPF (Rwandan Patriotic Front), a rebel army consisting mostly of Tutsi exiles, started launching attacks from Uganda. These first attacks were followed by a two-year period of intermittent hostilities and negotiations between the government and the RPF, which eventually led to a cease-fire in July 1992 and a power sharing agreement. But on April 6, 1994 the plane carrying President Habyarimana of Rwanda was shot down. Thereafter, Rwanda sunk into chaos. Within hours, the military (FAR - Forces Armées Rwandaises), the Interahamwe militia¹, administrators and ordinary people started to kill Tutsi and moderate Hutu. Simultaneously with the onset of genocide, the civil war between the FAR and the RPF restarted. In areas where the RPF "liberated" the population from the genocidal regime, the RPF allegedly engaged in reprisal killings of Hutu. Late in June 1994, the RPF took power and the massive killings came to an end. However, until the late nineties, violence continued in the Northwest which was the locus of

¹Interahamwe literally means "those who stand together" or "those who attack together". This militia was formed by President Habyarimana's political party in 1992, when the party started giving military training to its youth.

insurgency and counter-insurgency operations on the part of respectively the FAR+ (FAR and Interhamwe militia) - who used Congo as a basis for sporadic attacks, and the RPF - who remained military active close to and across the border with Congo in order to fight the insurgents.

Among the events in the Rwandan conflict cycle, the genocide has by far received most non-scholarly and scholarly attention. Many have tried to understand its causes and consequences from a political, social, anthropological, cultural or economic viewpoint (e.g. André and Platteau (1998), Baines (2003), Des Forges (1999), de Walque and Verwimp (2009), Newbury (1998), Mamdani (2001), Straus (2004), Verpoorten and Berlage (2007), Verwimp (2005)). In addition, several efforts have been made to estimate the genocide's death toll amongst Tutsi (e.g. Prunier (1998), Verpoorten (2005)). Two recent scholarly publications give a more central role to the other forms of violence, including reprisal killings committed by the RPF and the spillover of violence to eastern Congo (Davenport and Stam (2009), Reyntjens (2009)). For several reasons, it is understandable that the genocide received most attention. First, an astonishingly large number of people were killed in a very short time period. Second, the ethnic cleansing campaign of Tutsi was partly executed by ordinary civilians. Third, some of the atrocities committed were of the most extreme brutality one can imagine. Fourth, a clear, large-scale and brutal crime against humanity occurred in front of the public eye without spurring an intervention of the international community. However, a less justifiable reason also plays a role. The western failure to halt the genocidal slaughter left the international community with a legacy of guilt, resulting in donors piling in aid and turning a blind eye to human rights violations committed by the conquering party (the RPF)². Consequently, while the new RPF-led Rwandan government organized up to three different surveys to count the victims and survivors of the genocide (Government of Rwanda (2008)), imprisoned more than 100,000 alleged genocide perpetrators and put in place community level tribunals for judging them, no such efforts were taken to do justice to victims of other forms of violence.

The lack of an open debate on all forms of violence makes it difficult to collect equally accurate information on the different types of violence and assess their relative impact on the population. However, this paper aims to do just that. Relying on both the 1991 and 2002 population census, we construct a detailed spatial pattern of wartime excess mortality by subjecting a series of excess mortality proxies (1991-2002 differences in sector level mor-

²One of the most well-know examples is the Kibeho massacre where the RPA allegedly killed more than 5000 Hutu (Prunier (1998)).

tality of sons and daughters, widowhood and orphanhood, and 2002 disability due to armed conflict) to Principal Component Analysis. The first principal component provides us with a wartime excess mortality index (EMI) on a less to more scale for approximately 1500 administrative sectors, which are, after the cell, the lowest administrative units in Rwanda with an average population size of about 5000 inhabitants³. The significance of local geographic concentration in excess mortality is assessed by Local Indicators of Spatial Association - LISA (Anselin (1995)). In a regression analysis the spatial pattern of excess mortality is related to the spatial determinants of different forms of violence (e.g. distance to Kigali City, distance to Uganda, distance to a main road, the location of alleged extrajudicial killings) as well as to the location and size of refugee camps. The spatial pattern reveals significant high-high excess mortality clusters in some (but not all) provinces affected by the 1994 genocide, as well as in the East, which was the location of heavy fighting between the FAR+ and the RPF in 1994. Moreover, we provide the first quantitative evidence of high excess mortality in the Northwest. This area was not only the place of alleged severe human rights violations on the part of the RPF and FAR+ during the 1995-1998 (counter-)insurgency, but it also served as the corridor for approximately one million refugees in the aftermath of the 1994 genocide. The results of the regression analysis indicate that both the (counter-)insurgency and the refugee crisis contributed to high excess mortality in the Northwest.

The next section gives an overview of previous assessments of the death toll of the Rwandan conflict cycle. In section 3 we present a measure for wartime excess mortality on a less to more scale for approximately 1500 administrative sectors in Rwanda. Section 4 illustrates and discusses the spatial pattern of excess mortality. Using regression analysis, Section 5 establishes a relationship between the spatial pattern of excess mortality and a set of distinct spatial determinants that are associated with the different events in the Rwandan conflict cycle. Section 6 concludes.

2 The death toll of the Rwandan conflict cycle

Several efforts have been made to estimate the death toll of the 1994 genocide amongst Tutsi. Prunier (1998) makes use of demographic data, starting from the 1991 population census, which reported 596,400 Tutsi living in Rwanda (8.4 percent of the population). Taking into account an annual population growth of three percent, the number of Tutsi would have been

³In the administrative subdivision of Rwanda Anno 1994, "prefectures" are followed by "communes", "sectors" and "cells". In a series of subsequent reforms in 1996 and 2002, prefectures and communes were replaced by respectively provinces and districts.

650,900 at the end of July 1994 (under the no-genocide scenario). Subtracting the number of survivors (an estimated 150,000⁴) from the estimated Tutsi population under the no-genocide scenario, gives an estimate of 500,900 dead, or 77.0 percent of the Tutsi population. This estimate is likely to be at the lower end, because of the alleged under-reporting of Tutsi in the 1991 census. Verpoorten (2005) provides evidence for this allegation, indicating that there was up to 40% under-reporting of Tutsi, either by the Habyarimana regime (in order to keep the school and public employment quotas of Tutsi low), either by Tutsi themselves (in order to avoid discrimination). She demonstrates that, when repeating the same exercise as above with a larger Tutsi population in 1991, the estimated death toll of the genocide increases to a range of 600,000 to 800,000 Tutsi killed, depending on the exact extent of under-reporting.

The most recent estimate of the 1994 killings (among both Tutsi and Hutu) stems from a compilation of data on casualties from different sources: the Rwandan Ministry of Education, the Rwandan Ministry of Youth, Culture and Sports, IBUKA (an association of Tutsi survivors), African Rights (the international human rights organization) and Human Rights Watch (the international human rights organization). Davenport and Stam (2009) apply a Bayesian latent variable model to the data in order to obtain estimates on the number of killings taking place in 164 administrative communes during April-June 1994. The sum of victims in communes under the jurisdiction of the FAR is estimated at approximately 890,000, which adds to the evidence of a high death toll under the jurisdiction of the genocidal regime. Davenport and Stam (2009) use the same approach to estimate the number of killings that took place in 1994 within the zones under RPF control and the zones contested by the RPF and FAR+. They arrive at estimates of respectively 80,000 and 90,000, which confirm previously made allegations of human rights violations, in particular reprisal killings, at the address of the RPF (Des Forges (1999), Prunier (1998), the "Gersony report"⁵).

In contrast to the relatively detailed documentation on the 1994 death toll, the documentation of the death toll of the 1990-1993 civil war and 1995-1998 (counter-)insurgency is much scarcer. The UCDP/PRIODATA battle deaths database details the number of battle deaths in Rwanda for the period 1990-2002, with important omissions for 1994, 1995 and 1996 (Har-

⁴At the end of July 1994, head counting in refugee camps resulted in an estimated 105,000 Tutsi survivors. According to Prunier (1998) one should add 25,000 survivors that did not go to camps. Human Rights Watch adds another 20,000 surviving Tutsi in Zaire and Tanzania (Des Forges (1999)).

⁵The "Gersony Report" is the name given to an unpublished report that identified a pattern of massacres by the RPF. The findings in the report were made by a team under Robert Gersony under contract to the United Nations High Commissioner for Refugees. Gersony's personal conclusion was that between April and August 1994, the RPF had killed "between 25,000 and 45,000 persons, between 5,000 and 10,000 persons each month from April through July and 5,000 for the month of August" Des Forges (1999).

bom and Wallensteen (2007)). Starting at 2,000 battle deaths in 1990, the number increases to 3,200 in 1991 and 1992, and drops to 1,600 in 1993. In 1997 and 1998, respectively 3,000 and 6,000 battle deaths are counted. In 1999 the number of battle deaths does not exceed 1,000 which means an end to civil war according to the definition used⁶. The UCDP/PRIO data is not well suited for assessing the intensity of violence in Rwanda, not only because data is lacking for 1994-1996, but also because violence against civilians, which was by far the most important form of violence in Rwanda, is largely omitted (Restrepo, Spagat, and Vargas (2006)). According to accounts of Amnesty International, in the course of 1995-1998, a large number of Rwandan civilians became victims of the intensifying conflict between the RPF and armed opposition groups believed to be allied to the former FAR+. Both parties are accused of severe human rights violations and large-scale massacres amongst civilians, taking place mainly in the Northwest of the country. However, most of the alleged massacres cannot be investigated because of the Rwandan Government's tight control on the dissemination of information relating to the human rights situation. The accounts of killings therefore remain tentative and incomplete. Amnesty International has probably provided the most complete coverage in four reports with fitting titles "Alarming resurgence of killings", "Civilians trapped in armed conflict", "Ending the silence" and "The hidden violence: disappearances and killings continue" (Amnesty International (1996), Amnesty International (1997a), Amnesty International (1997b), Amnesty International (1998)).

Besides the high direct death toll of the Rwandan armed conflict, many may have died prematurely following the collapse of health care, social and economic systems in the mid nineties⁷. Furthermore, the death toll in refugee camps was very high due to the rapid spread of infectious diseases. For example, the cholera epidemic in Goma (at the border of RD Congo and Rwanda) is believed to have taken around 30,000 lives (Prunier (1998)). The indirect death toll of violence taking place in Gisenyi and Ruhengeri may have been higher than elsewhere because these provinces did not only serve as the corridor of approximately one million refugees fleeing to Congo in 1994 and back to Rwanda in 1996/1997, but they also experienced a relatively long period of violence as well as important disruptions in

⁶Civil war is defined as a war between organized groups within a single nation state having more than 1,000 battle deaths in a single year (Gleditsch, Wallensteen, Eriksson, Sollenberg, and Strand (2002)).

⁷There are very few accounts on the indirect death toll of the Rwandan armed conflict. However, the International Rescue Committee (IRC) has tried to assess the impact of war in DR Congo on excess mortality. Based on several national mortality censuses, they report that "Less than 10 percent of deaths were directly attributable to violence. The vast majority of Congolese died from the indirect public health effects of conflict, including higher rates of infectious diseases, increased prevalence of malnutrition and complications arising from neonatal- and pregnancy-related conditions" (Roberts, Ngoy, and Mulumba (2007)).

economic activities. In this respect, Amnesty International reports that, as part of the counter-insurgency strategy, a scorched earth policy was being carried out in many areas in the Northwest, where homes and fields were being burned. In addition, they report that, in an attempt to cut food supplies to armed opposition groups, the RPF prevented farmers from harvesting and marketing their crops (Amnesty International (1997b)).

3 Identifying wartime excess mortality

Excess mortality proxies We derive wartime sector level excess mortality proxies from the 2002 population census, which includes information on approximately 8.1 million individuals living in 1544 administrative sectors (Government of Rwanda (2002)). The sector of residence reported in the 2002 population census may differ considerably from wartime residence given the massive displacement and resettlement in the period 1990-2002. Therefore, we first determine the 1991 sector of residence of all individuals in the 2002 population census, which can be derived from information on the previous residence of migrants. Then, we identify five excess mortality proxies at the sector level:

- (*EM1*) "Mortality of sons" : total number of boys died/number of boys born (for all women who ever gave birth);
- (*EM2*) "Mortality of daughters" : total number of girls died/girls born (for all women who ever gave birth);
- (*EM3*) "Widowhood" : the proportion of widows among women (≥ 30 years);
- (*EM4*) "Double orphanhood" : the proportion of double orphans among children and youngsters (< 30 years);
- (*EM5*) "Disability" : the proportion of the population reporting a handicap due to war or genocide.

The excess mortality proxies (*EM1*) – (*EM4*) may pick up sector level variation in mortality caused by factors other than the intensity of violence, i.e. peacetime characteristics (e.g. climate or health infrastructure). More formally, the variation in EM_{ij} ($i = 1 - 4$) across sectors j ($j = 1 - 1544$) is not only explained by direct and indirect wartime effects of violence, V_j , but also by peacetime sector level characteristics, P_j . We aim to capture only the variation due to V_j . Therefore, we take the difference between EM_{ij} and baseline excess

mortality proxies, EM'_{ij} , taken from the 1991 population census. Due to data limitations, the baseline mortality proxies are defined at the commune level instead of the sector level. The commune still is a very small administrative unit, with an average size of 134 squared km and counting on average only 5.8 sectors. Summary statistics for the excess mortality proxies EM_{ij} and EM'_{ij} , as well as the first differences $(EM_{ij} - EM'_{ij})$, denoted ΔEM_{ij} , are reported in Table 1. It is noteworthy that we find strong evidence for high wartime excess mortality: with markedly higher 2002 excess mortality proxies compared to their 1991 counterparts: compared to 1991, the 2002 mortality proxies of sons and daughters are respectively 21% and 13% higher, the proportion of widows increased by 66% (from 0.19 to 0.31) and the proportion of double orphans more than doubled (from 0.02 to 0.05).

Excess mortality index (EMI) The challenge we face is to aggregate the information embodied in the five wartime excess mortality proxies ($\Delta EM1 - \Delta EM4, EM5$) into a meaningful index of excess mortality. To overcome arbitrariness and safeguard maximum variation, several studies have persuasively argued for the use of principal component analysis (PCA) (Hibbs (1973), Filmer and Pritchett (2001), Alesina and Perotti (1996)). PCA has the desirable property of reducing the dimensionality of a data set while retaining as much as possible of the variation present in the data set. More precisely, from a set of variables, PCA extracts orthogonal linear combinations that capture the common information in the set most successfully. The first principal component (PC) identifies the linear combination of the variables with maximum variance, the second principal component yields a second linear combination of the variables, orthogonal to the first, with maximal remaining variance, and so on⁸. For our objective, i.e. defining an index of excess mortality, we are interested in the first PC, which will be an appropriate summary of excess mortality if it captures a relatively high percentage of the total variance present in the excess mortality proxies set and the

⁸Formally, suppose that x is a vector of p random variables and x^* is a vector of the standardized p variables, having zero mean and unit variance, then the first principal component $PC1$ is the linear function $\alpha_1' x^*$ having maximum variance, where α_1 is a vector of p constants $\alpha_{11}, \alpha_{12}, \dots, \alpha_{1p}$ and $'$ denotes transpose.

$$PC1 = \alpha_1' x^* = \alpha_{11}x_1^* + \alpha_{12}x_2^* + \dots + \alpha_{1p}x_p^*,$$

Mathematically, the vector α_1 maximizes $var[\alpha_1' x^*] = \alpha_1' \Sigma \alpha_1$, with Σ the covariance matrix of x^* , which corresponds to the correlation matrix of the vector x of the original, unstandardized variables. For the purpose of finding a closed form solution for this maximization problem, a normalization constraint, $\alpha_1' \alpha_1 = 1$, is imposed. To maximize $\alpha_1' \Sigma \alpha_1$ subject to $\alpha_1' \alpha_1 = 1$, the standard approach is to use the technique of Lagrange multipliers. It can be shown that this maximization problem leads to choosing α_1 as the eigenvector of Σ corresponding to the largest eigenvalue of Σ , λ_1 and $var[\alpha_1' x^*] = \alpha_1' \Sigma \alpha_1 = \lambda_1$. To interpret the PC in terms of the original variables, each coefficient α_{1l} must be divided by the standard deviation, s_l , of the corresponding variable x_l . For example, a one unit increase in x_l , leads to a change in the 1st PC equal to α_{1l}/s_l . For a detailed exposition of principal component analysis we refer to Jolliffe (2002) and Duntelman (2001).

"loadings" of that PC have roughly equal values. Subjecting $(\Delta EM1 - \Delta EM4, EM5)$ to PCA results in the following first PC:

$$EMI = 0.45 \times \Delta EM1 + 0.51 \times \Delta EM2 + 0.46 \times \Delta EM3 + 0.44 \times \Delta EM4 + 0.34 \times EM5,$$

which explains up to 57% of the total variation of the variable set $(\Delta EM1 - \Delta EM4, EM5)$ and has significant loadings on all excess mortality proxies.

Robustness checks We perform several robustness tests to check the sensitivity of the excess mortality index to the inclusion of alternative excess mortality proxies. First, we calculate the 2002 excess mortality proxies $(EM1) - (EM4)$ at the commune level instead of the sector level. Then we proceed as above, taking first differences using the commune level 1991 excess mortality proxies. Second, in order to attenuate the effect of survival bias on the excess mortality index, we increase the weight of sectors that are close to sites of large-scale massacres. In these sites, the probability that entire families were exterminated is likely to be relatively high, causing mortality inferred from the surviving population to be under-reported. The proximity to a large-scale massacre is taken into account by adding the natural logarithm of the distance to the nearest mass grave to the set of variables subjected to PCA. This distance is calculated in km at the sector level by overlaying a geo-referenced administrative map with the location of 71 mass graves in Rwanda taken from the Yale Genocide Studies website. The resulting first principal components of these robustness checks are given by the following linear combinations:

$$\begin{aligned} EMI_{COM} &= 0.45 \times \Delta EM1 + 0.49 \times \Delta EM2 + 0.46 \times \Delta EM3 + 0.45 \times \Delta EM4 + 0.38 \times EM5 \\ EMI_{MG} &= 0.44 \times \Delta EM1 + 0.50 \times \Delta EM2 + 0.46 \times \Delta EM3 + 0.44 \times \Delta EM4 + 0.34 \times EM5 \\ &\quad - 0.21 \times EM6 \end{aligned}$$

with $EM6$ "log(distance to mass grave)". The coefficients on the excess mortality proxies $(\Delta EM1 - \Delta EM4, EM5)$ are all very similar to the benchmark EMI . In what follows we demonstrate that neither EMI_{COM} nor EMI_{MG} yields qualitatively different results compared to the benchmark EMI . Besides these robustness checks, we also performed a sensitivity analysis with respect to the age limits for the excess mortality proxies $\Delta EM3$ and $\Delta EM4$. We find that setting the age limits 5 years lower (at 25) or 5 years higher (at 35) does not alter our qualitative results (not reported).

4 The spatial pattern of wartime excess mortality

Table 2 lists the province level average of the different excess mortality proxies ($\Delta EM1 - \Delta EM4, EM5, EM6$) and first *PCs* (EMI, EMI_{COM} and EMI_{MG}). The values of the first *PCs* are all rescaled to fit the interval $[0, 1]$. Gisenyi has the largest value for the excess mortality index EMI , followed by Kibungo, Kigali City and Butare. Cyangugu scores lowest, followed by Gikongoro and Byumba. The ranking of provinces is similar for the alternative excess mortality indices EMI_{COM} and EMI_{MG} . Table 3 compares the EMI ranking of provinces with the ranking of provinces according to the estimated 1994 killings by Davenport and Stam (2009). (The latter was discussed in section 2.) Gisenyi, Kigali City and Ruhengeri are ranked markedly higher according to the EMI , while the reverse is true for Kibuye and Gikongoro (and to a lesser extent Butare, Cyangugu and Gitarama). How do these differences in rankings relate to the location of different forms of violence? The last three columns of Table 3 give a qualitative assessment of the intensity of genocide, civil war and (counter-)insurgency for each province. This information is taken from a study by Justino and Verwimp (2006) who base their assessment on event data from new reports and reports of human rights organizations. We find a clear pattern in the deviations between both rankings: in general, the EMI rank of provinces severely affected by genocide is lower than the 1994 killings rank, while the reverse holds for provinces affected by civil war and (counter-)insurgency. This finding suggests that the focus on 1994 killings does not do justice to (direct and indirect) victims of civil war and (counter-)insurgency.

The province level averages may hide important differences within provincial borders. Figure 1 plots the quintiles of the EMI on a sector level map of Rwanda. We observe a large number of top quintile sectors in Butare, in and around Kigali City, in Gisenyi, in the northwestern corner of Kibungo and in the southwestern corner of Umutara. In addition, we find smaller local clusters in the West of Ruhengeri and Kibuye and in the Southeast of Gitarama and Gikongoro. The significance of these local spatial clusters can be assessed by means of Local Indicators of Spatial Association (LISA). LISA identifies areas with high values of a variable that are surrounded by high values on the neighboring areas, i.e. high-high clusters. Concomitantly, the low-low clusters are also identified (Anselin (1995)). More formally, LISA provides a measure of the extent to which the arrangement of values around a specific location deviates from spatial randomness. A general expression of a LISA statistic

for a variable y_i , observed at location i , is:

$$L_i = f(y_i, y_{J_i}),$$

where f is a function expressing the correlation between y_i and y_{J_i} , and y_{J_i} are the values observed in the neighborhood J_i of location i . The LISA statistic we look at is the local Moran statistic for an observation i :

$$I_i = (y_i - \bar{y}) \sum_{j=1}^n w_{ij} (y_j - \bar{y}),$$

with w_{ij} a spatial weighting matrix indicating the relevant neighbors for the LISA analysis. The weighting matrix w_{ij} can be defined in different ways, although contiguity-based definitions are by far mostly used. We use a first order rook-contiguity based weighting matrix for neighbors, where w_{ij} equals one for sectors with a common boundary and zero otherwise. By looking explicitly at areas instead of individual sectors, we can to a large extent avoid wrong classification of erroneous outliers. Arbitrariness in identifying "high" is avoided by assessing the significance of high-high clusters. The procedure employed to assess statistical significance relies on a Monte Carlo simulation of different arrangements of the data and the construction of an empirical distribution of simulated statistics. Afterwards the value obtained originally is compared to the distribution of simulated values and, if the value exceeds the 95th percentile, it is said that the relation found is significant at 5%.

Figure 2 depicts the locations with significant high-high (dark grey) and significant low-low clusters (light grey). We note a very large low-low cluster that covers large parts of northern Cyangugu, eastern Gikongoro and southern Kibuye. Possible explanations of this low-low cluster include the French intervention, "Opération Turquoise", to set up a "safe zone" in the triangle Gikongoro-Cyangugu-Kibuye, and the relatively low concentration of Tutsi in western Gikongoro (in contrast with high concentrations in eastern Gikongoro)⁹. The significant high-high clusters confirm the pattern detected from Table 2 and Figure 1: Butare, Kigali (both City and Rural), Kibungo and Gisenyi stand out, while smaller high-high clusters can be found in parts of Ruhengeri, Umutara, Gikongoro, Gitarama and Kibuye. To complete the description of the spatial pattern, we note that the *EMI* is characterized by global clustering, i.e. the general trend is one of clustering with a rather high value for

⁹With respect to Gikongoro, Verpoorten (2005) provides evidence on the variation of the genocide's death toll within the province and demonstrates that differences in the proportion of Tutsi played a role as well as differences in the attitude of local authorities (either cooperating with the genocidal regime or opposing it).

Moran's I (0.63) indicating significant positive spatial autocorrelation (Moran (1950)).

5 Spatial determinants of excess mortality

Data Now that we have established a detailed spatial pattern of excess mortality in Rwanda, we seek to understand how this pattern relates to the different events of the Rwandan conflict cycle. To this end we identify a set of spatial determinants that are associated with the four major events in the Rwandan conflict cycle, i.e. civil war, genocide, (counter-)insurgency and the refugee crisis. A growing body of literature has pointed to the importance of geography in explaining the location of armed conflict. For example, in Buhaug (2006), a study on the spatial determinants of African civil wars, it is shown that the distance to the capital city, the distance to state borders, road density as well as the geographic concentration of minority ethnic groups play an important role in explaining the location of armed conflict. Furthermore, it is argued that this role depends on the type of conflict. For example, whereas open warfare and conflict over state governance is more likely to be intense near the capital city and main roads, insurgency is favored by local characteristics that are often distant from the capital city and main roads, e.g. rough terrain, sparsely populated hinterland and cross-border sanctuaries.

In accordance with these findings on the role of geography in African armed conflicts, we can identify clear and distinct spatial determinants for the main events in the Rwandan conflict cycle:

1. Civil war started in 1990, in the North of Rwanda at the border with Uganda. In 1994, the RPF moved eastwards to make a circular movement around the capital, Kigali City, which it eventually took over (Justino and Verwimp (2006)). Thus, relevant spatial determinants for civil war are the distance to Uganda and the distance to Kigali City. In addition, since much of the 1990-1994 civil war was open warfare, its intensity is also likely to be higher near main roads.
2. The genocide mainly targeted Tutsi and an estimated 75% of the entire Tutsi population was killed in 1994 (Verpoorten (2005)). A suitable spatial determinant for the intensity of genocide is the distance to Nyanza, which is a sector located in the northwestern corner of Butare. Nyanza was the capital of the Tutsi monarchy, which controlled most of the present-day Rwandan territory from as early as the 14th century. Its importance quickly faded away during colonization and abruptly ended with the 1959 revolution

and subsequent 1962 independence, but the proportion of Tutsi in the sector level population remained closely related to the distance to Nyanza - at least up until 1994 (Des Forges (1999), Verpoorten (2005)).

3. The refugee crisis was nationwide, but more intense at the borders with Congo and Tanzania, which hosted respectively an estimated 1,200,000 and 580,000 refugees. Burundi also hosted a considerable number of refugees (270,000) while Uganda hosted no more than 10,000 refugees (UNHCR (2000)). Both the proximity of a refugee camp and its size are likely to affect excess mortality. Therefore, we distinguish between the distance to a medium camp (25,000-100,000 refugees) and the distance to a large camp (250,000). Small camps (5,000-10,000) are omitted from the analysis.
4. (Counter-)insurgency took place close to the northwestern border with Congo, in the provinces of Gisenyi and Ruhengeri. For these provinces we create separate indicator variables taking one for sectors located in Gisenyi or Ruhengeri and zero otherwise. However, since the Northwest (in particular Gisenyi) also served as a corridor for massive refugee streams, we need to add a finer variable that reflects the intensity of counter-insurgency within the northwestern provinces. To this end, we compile information on the number and location of alleged extrajudicial killings of civilians during (counter-)insurgency from four Amnesty international reports (Amnesty International (1996), Amnesty International (1997a), Amnesty International (1997b), Amnesty International (1998)). This information is used to construct a commune level proxy for the intensity of (counter-)insurgency within the northwestern provinces.

All distance variables are calculated at the sector level using GeoDa (Anselin (1995)). Figure 3 provides an administrative map of Rwandan provinces with indications of borders with neighboring countries, the location of main roads, the sector of Nyanza, and refugee camps. We count four large refugee camps hosting as many as 250,000 refugees. Three of these refugee camps were located at the northwestern border with Congo (near Goma), while one was located close to the southeastern border with Tanzania. Each of these locations was also hosting a medium size refugee camp (25,000 - 100,000 refugees). In addition, there were seven other medium size refugee camps of about 25,000 refugees, of which four were located close to the southwestern border with Congo (near Uvira and Bukavu). Finally, almost all of the remaining 40 small refugee camps - hosting between 1,000 and 10,000 refugees - were located in Burundi and across the southwestern border with Congo, near Uvira and Bukavu (the small camps are omitted from Figure 3). Figure 4 plots the number of alleged

1995-1998 extrajudicial killings of civilians for each of the communes located in Ruhengeri and Gisenyi. The figure reveals a high variation in the number of alleged killings across communes. The communes with the highest figures are Nkuli in Ruhengeri and Kanama in Gisenyi. To illustrate how we compiled the number of extrajudicial executions from the Amnesty International reports, we list two quotes on killings in these communes:

(1430 executions) "Between 9 and 11 May 1997, at least 1,430 civilians were reportedly killed by RPA soldiers in the secteurs of Ryinyo, Kintobo, Gatore, Gatovu, Rukoma, Gitwa, Runigi and Mukamira in Nkuli commune, in Ruhengeri. Amnesty International has received a list, drawn up by local sources, of the names of around 525 victims of these massacres - including at least 90 children - primarily in Ryinyo secteur. In addition to those named, at least 553 were reportedly killed in Kintobo secteur, 127 in Gatovu secteur, 120 in Rukoma secteur and 114 in Runigi secteur. These killings were reportedly preceded by several days of fighting between RPA forces and armed opposition groups around military camps in the area." (Amnesty International (1997b), p.5).

(300 executions) "Sources in Kanama commune, Gisenyi, have reported that on 8 August 1997, several hundred people, including many civilians, were killed in and around a busy marketplace at Mahoko. The killings - most of which have been attributed to the army - reportedly followed the arrival of a group of armed "infiltrators" who looted shops and stalls. The RPA intervened and many civilians were killed in the hours that followed as the RPA reportedly fired towards the market from two military vehicles stationed nearby. Some victims may have been killed in the cross-fire; however, others appear to have been killed indiscriminately by the security forces. The exact number of victims is not confirmed; one source estimated that around 300 bodies were counted. Some were shot in the marketplace, others in nearby streets. The victims included François Munyempame, the family of a trader named Védaste, a representative of a non-governmental organization Emmanuel Tuyisenge, and two inspecteurs de police judiciaire (judicial police inspectors)." (Amnesty International (1997b), p.7).

The dependent variable for the regression analysis is the excess mortality index *EMI* (rescaled to fit the interval 0-1). Since *EMI* is derived from PCA its interpretation is rather cumbersome. Therefore, we provide a second set of results with an alternative dependent variable, i.e. an absolute sector level death toll derived from *EMI*. The derivation is straightforward once we make an assumption on the total nationwide death toll of the Rwandan conflict cycle. For example, assuming a nationwide death toll of 1,000,000, the sector level death toll can be derived from EMI_j as follows:

$$Death_{toll_j} = \frac{EMI_j}{\sum EMI_j} \times 1,000,000$$

One can easily perform a sensitivity analysis with alternative death toll estimates. For example, assuming a nationwide death toll of 1,500,000, the estimated coefficients of the regression analysis should be multiplied by 1.5. To put the absolute death toll in perspective, note that the 1994 Rwandan population amounted to approximately 8.6 million with an average of about 5300 inhabitants per sector. Table 4 provides summary statistics for the sector level death toll, on average 648, and for the explanatory variables used in the regression analysis.

Regression analysis The aim is to test whether all four main events in the Rwandan conflict cycle contribute to explaining the observed spatial pattern in excess mortality. To this end, we formulate testable hypotheses for each of the events by relying on their association with distinct spatial determinants. This approach yields the following set of hypotheses:

1. Civil war

H1a: distance from Uganda is negatively associated with excess mortality

H1b: distance from the nearest main road is negatively associated with excess mortality

H1c: distance from Kigali City is negatively associated with excess mortality

2. Genocide

H2a: distance from Nyanza is negatively associated with excess mortality

3. Refugee crisis

H3a: distance from a refugee camp is negatively associated with excess mortality

H3b: distance from a large refugee camp is more negatively associated with excess mortality than distance from a medium size refugee camp

4. Counter(-insurgency)

H4a: location within Gisenyi or Ruhengeri is positively associated with excess mortality

H4b: the number of alleged extrajudicial killings is positively associated with excess mortality

Panel A and Panel B of Table 5 report the results of the regression analysis for respectively EMI_j and $death_{toll}_j$ as dependent variable. In Model 1 we take up all explanatory variables that allow testing the above hypotheses, except for the distinction between medium and large camps (*H3b*). We find that all but one hypotheses are supported by the data. The exception is *H1a*, which states that -because civil war started at the border with Uganda- distance from Uganda should be negatively associated with excess mortality. Instead of a negative association, we actually find a positive and significant association. A possible explanation for this finding is that the civil war started off at the border with Uganda in (October) 1990, so a couple of months prior to the implementation of the (August) 1991 population census. Our baseline excess mortality proxies, EMI'_{ij} , are therefore affected by civil war for the sectors close to Uganda which biases downwards the impact of the first phase of the civil war on 1991-2002 excess mortality. The spatial determinants associated with later phases of civil war in which the RPF advanced to and took over Kigali (distance to road and distance to Kigali) do show up negative and significant.

In Model 2, we split up the variable "Distance to refugee camp" into "Distance to small or medium refugee camp" and "Distance to large refugee camp". These variables give the distance of a sector to the nearest refugee camp sized respectively 25,000-100,000 and 250,000. We find that the distance to a large camp is more negatively associated with excess mortality than the distance to a small or medium camp, which is evidence in support of *H3b*. In Model 3 we check whether our results are robust to the inclusion of two characteristics that are often included in regressions explaining armed conflict, i.e. population density and rough terrain (proxied by altitude). We find no noteworthy changes in the estimated coefficients. In Model 4, we add controls for all other provinces (besides Gisenyi and Ruhengeri). Also in this case, the results remain qualitatively the same. As a final robustness check, the regressions (1)-(4) were repeated for the alternative $EMIs$ (EMI_{com} and EMI_{mg}). All results remain qualitatively the same (not reported), but it is noteworthy that, in the case of the EMI adjusted for survival bias (EMI_{mg}) the coefficient on "Distance to Nyanza" increases in absolute value, which strokes with the idea that survival bias is larger for the genocide because many Tutsi families were entirely exterminated.

Panel B of Table 5 allows us to give a more tangible interpretation to the estimated coefficients. For example, the estimated additional death tolls in the provinces experiencing

counter-insurgency, Gisenyi and Ruhengeri, vary between respectively 141-186 and 93-123 across the four different models. Furthermore, within these provinces, for every additional 1000 alleged extrajudicial executions within a commune, a sector's death toll is estimated to increase with 43-46. (In Ruhengeri and Gisenyi, each commune counts on average 11 sectors, so the sector level equivalent of 1000 alleged extrajudicial executions within a commune is about 90). A tenfold reduction (e.g. from 10 km to 1 km or from 100 km to 10 km) in the distance to a refugee camp increases the death toll with 91. For medium sized camps the increase varies between 94-106, whereas it varies between 91-130 for large camps. A tenfold reduction in the distance to Nyanza, the former capital of the Tutsi monarchy, leads to a 55-88 rise in the death toll. Finally, a tenfold reduction in the distance to Kigali or a main road increases the estimated death toll respectively by 161-185 and 24-44. Although these coefficient estimates are indicative for the impact of the different forms of violence and the refugee crisis, their absolute values should be taken with caution, due to the unverified assumption of a one million nationwide death toll, multicollinearity between the explanatory variables (e.g. distance to Nyanza and distance to Uganda) as well as the geographic overlap of some events in the conflict cycle (e.g. the 1994 civil war and genocide).

6 Conclusion

During the nineties, Rwanda experienced a sequence of different interrelated forms of violence: civil war, genocide, reprisal killings and (counter-)insurgency. In addition, in the aftermath of massive killings in 1994, Rwanda faced a massive refugee crisis. Among these events in the Rwandan conflict cycle, the 1994 genocide has by far received most non-scholarly and scholarly attention. The challenge taken in this study is to provide a more balanced view of the impact of the different events, by studying the spatial distribution of excess mortality in Rwanda.

We develop a fine spatial measure for wartime excess mortality in Rwanda relying on information from the 1991 and 2002 population census. In particular, we subject five excess mortality proxies (1991-2002 differences in sector level mortality of sons and daughters, widowhood and orphanhood, and 2002 disability due to armed conflict) to principal component analysis. The first principal component provides us with an index of sector level excess mortality on a less to more scale. The spatial pattern of the excess mortality index confirms a high death toll of genocide, especially in Butare province. In addition, significant high-high excess mortality clusters are located in and around Kigali City and in the eastern province

Kibungo. These clusters may be explained by different events, since these areas were the scene of genocide, civil war as well as reprisal killings.

The main contribution of this study is the finding of a large and significant high-high excess mortality cluster in Gisenyi. This finding cannot be explained by genocide since Gisenyi counted very few Tutsi among its population (2.9%). It neither can be explained by the open warfare between the RPF and FAR(+) in 1990-1994 since civil war took place at the border of Uganda, in the East and around Kigali City. Instead, Gisenyi served as a corridor for approximately one million refugees and was the scene of fierce fighting between the RPA and remains of the FAR+ during the 1995-1998 (counter-)insurgency. The regression analysis indicates that both the refugee stream and the 1995-1998 extrajudicial killings contributed to high excess mortality in Gisenyi.

The detection of high excess mortality in Gisenyi and its demonstrated association with (counter-)insurgency is controversial, because the (counter-)insurgency's direct and indirect death toll among civilians has been minimized by the Rwandan government. Human rights watch organizations have tried to draw attention to large-scale massacres among the civilian population as well as other severe human rights violations including the burning of houses and crops, but they were hampered in their efforts by restricted access to information and to the battle zones. Partly due to a lack of hard evidence, the UN and large western donors have failed to acknowledge the real extent of suffering on the part of the Gisenyi population.

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Table 1: Sector level excess mortality proxies (1486 administrative sectors)

Variable	Description	2002 census		1991 census		First difference	
		EM _{ij}		EM' _{ij}		ΔEM _{ij}	
		Mean	St. Dev.	Mean	St. Dev.	Mean	St. Dev.
Mortality of daughters	Total number of girls died/number of girls born	0.27	0.05	0.24	0.03	0.03	0.04
Mortality of sons	Total number of boys died/number of boys born	0.32	0.05	0.26	0.03	0.05	0.05
Widowhood	Widows among women (>=30 years) (%)	0.31	0.07	0.19	0.03	0.12	0.07
Double orphanhood	Double orphans among children (<30years) (%)	0.05	0.02	0.02	0.01	0.03	0.02
Disability	Disabled due to war or genocide (%)	0.004	0.004				

Table 2: Province level average of excess mortality proxies and first principal components

Province	ΔEM1	ΔEM2	ΔEM3	ΔEM4	EM5	EM6	EMI	EMI _{com}	EMI _{mg}
Butare	0.05	0.08	0.14	0.03	0.004	1.88	0.47	0.55	0.47
Byumba	0.02	0.04	0.10	0.02	0.002	3.20	0.34	0.33	0.31
Cyangugu	0.00	0.02	0.06	0.02	0.003	2.12	0.29	0.25	0.29
Gikongoro	0.02	0.03	0.07	0.02	0.003	2.07	0.33	0.31	0.33
Gisenyi	0.04	0.08	0.20	0.06	0.005	2.28	0.54	0.66	0.53
Gitarama	0.03	0.06	0.10	0.03	0.003	2.31	0.40	0.44	0.39
Kibungo	0.06	0.08	0.14	0.05	0.005	2.12	0.51	0.60	0.50
Kibuye	0.02	0.05	0.12	0.03	0.005	1.98	0.40	0.44	0.39
Rural Kigali	0.04	0.05	0.11	0.04	0.005	2.47	0.44	0.52	0.43
Kigali City	0.02	0.04	0.15	0.07	0.007	1.44	0.49	0.57	0.51
Ruhengeri	0.02	0.05	0.15	0.04	0.004	2.62	0.42	0.47	0.40
Umutara	0.04	0.05	0.13	0.02	0.005	3.37	0.42	0.52	0.39
Total	0.03	0.05	0.12	0.03	0.004	2.34	0.42	0.47	0.41

Notes: For definitions of ΔEM1-ΔEM4 and EM5 see Table 1; EM6 = Log(distance to nearest mass grave); EMI is the first principal component of (ΔEM1-ΔEM4, EM5); EMI_{mg} is the first principal component of (ΔEM1-ΔEM4, EM5, EM6)); EMI_{com} is the first principal component of (ΔEM1-ΔEM4, EM5) at the commune level instead of the sector level; EMI, EMI_{mg} and EMI_{com} are rescaled to fit the interval [0,1].

Table 3: Comparison of EMI and 1994 killings across provinces

Province	EMI		Estimated 1994 death toll as % of 1994 population (Davenport and Stam (2009))		Difference in ranking (1) & (2)	Qualitative assessment of the impact of different forms of violence on population decline (Justino and Verwimp (2006))		
	Values	Ranking (1)	Values	Ranking (2)		Genocide	Civil war	Counter- insurgency
Butare	0.47	9	0.50	12	-3	2	0	0
Byumba	0.34	3	0.00	1	2	0	1	0
Cyangugu	0.29	1	0.02	4	-3	2	0	0
Gikongoro	0.33	2	0.05	6	-4	2	0	0
Gisenyi	0.54	12	0.02	3	9	0	0	1
Gitarama	0.40	5	0.09	8	-3	1	0	0
Kibungo	0.51	11	0.18	9	2	1	1	0
Kibuye	0.40	4	0.34	11	-7	2	0	0
Rural Kigali	0.44	8	0.22	10	-2	1	1	0
Kigali City	0.49	10	0.04	5	5	NA	NA	NA
Ruhengeri	0.42	6	0.01	2	4	0	1	1
Umutara	0.42	7	0.08	7	0	NA	NA	NA

Notes: For the definition of EMI, see tables 1 and 2; Davenport and Stam (2009) apply a Bayesian latent variable model to data on 1994 casualties (see Section 2 for details); Justino and Verwimp (2006) use event data for their qualitative assessment of the location of genocide, civil war and (counter-)insurgency, corresponding respectively to the ethnic cleansing of Tutsi in 1994, the invasion and early advancement of RPF in 1990-1994, and the 1995-1998 fighting between the RPA and the remains of the FAR+. Justino and Verwimp (2006) provide no separate assessment for Kigali City and Umutara Province, a province which was created only after 1994 by joining parts of Kibungo and Byumba.

Table 4: Summary statistics for spatial determinants

Variable	Description	Mean	St. Dev.
EMI	Excess mortality index = first principal component of ($\Delta EM1 - \Delta EM4$, EM5)	0.4	0.1
Death toll	An estimate for the sector level absolute death toll, derived from EMI assuming a nationwide death toll of 1,000,000	647.7	226.5
Distance to Uganda	All distance variables are expressed in km and calculated at the sector level using GeoDa	69.3	42.2
Distance to Kigali		63.6	29.8
Distance to main road		7.9	5.8
Distance to Nyanza		64.2	30.9
Distance to medium size refugee camp (25,000-100,000)		57.3	26.2
Distance to large refugee camp ($\geq 250,000$)		70.2	29.8
Executions in Northwest	Alleged extrajudicial executions in the communes of Ruhengeri and Gisenyi, taken from four Amnesty International reports	79.1	353.9
Executions in Northwest	(Mean for the Provinces of Gisenyi and Ruhengeri)	398.3	710.1
1991 population density	Source: 1991 population census	502.3	862.1
Sector altitude (m)	Own estimate of altitude in m based on spatial nearest neighborhoods estimates of approximately 150 sector level values taken from the Michigan state University Rwanda Project	1794.4	289.2

Table 5: Spatial determinants of excess mortality in Rwanda

PANEL A: EMI	(1)		(2)		(3)		(4)	
Distance to Uganda ^a	0.02	(2.90)***	0.01	(2.31)**	0.01	(1.64)	0.02	(2.59)***
Distance to Kigali ^a	-0.10	(-11.11)***	-0.10	(-10.78)**	-0.11	(-11.32)***	-0.12	(-8.44)***
Distance to main road ^a	-0.02	(-2.74)***	-0.02	(-3.37)***	-0.03	(-5.09)***	-0.03	(-4.65)***
Distance to Nyanza ^a	-0.04	(-5.39)***	-0.05	(-6.96)***	-0.05	(-8.10)***	-0.06	(-7.16)***
Distance to refugee camp ^a	-0.06	(-6.79)***						
Distance to medium refugee camp ^a			-0.06	(-6.27)***	-0.07	(-6.88)***	-0.06	(-4.97)***
Distance to large refugee camp ^a			-0.08	(-7.95)***	-0.08	(-8.37)***	-0.06	(-5.00)***
Executions in Northwest ^b	0.03	(3.33)***	0.03	(3.14)***	0.03	(3.04)***	0.03	(3.32)***
1991 population density					0.00	(-4.76)***	0.00	(-4.08)***
Sector altitude (m)					0.00	(-5.56)***	0.00	(-0.56)
Gisenyi	0.12	(7.61)***	0.09	(5.21)***	0.10	(5.44)***	0.10	(3.76)***
Ruhengeri	0.06	(5.13)***	0.06	(4.40)***	0.08	(5.80)***	0.07	(2.53)**
Dummies for other provinces ^c	No		No		No		Yes	
Constant	1.15	(13.52)***	1.54	(12.95)***	1.81	(14.96)***	1.62	(11.69)***
R ²	0.20		0.21		0.24		0.32	
Obs	1544		1544		1520		1520	
PANEL B: death toll^d	(1)		(2)		(3)		(4)	
Distance to Uganda ^a	23.69	(2.90)***	18.88	(2.31)**	13.39	(1.64)	30.82	(2.59)***
Distance to Kigali ^a	-161.09	(-11.11)***	-155.09	(-10.78)**	-165.63	(-11.32)***	-185.33	(-8.44)***
Distance to main road ^a	-23.64	(-2.74)***	-28.68	(-3.37)***	-44.00	(-5.09)***	-38.85	(-4.65)***
Distance to Nyanza ^a	-55.15	(-5.39)***	-69.39	(-6.96)***	-78.33	(-8.10)***	-87.68	(-7.16)***
Distance to refugee camp ^a	-91.13	(-6.79)***						
Distance to medium refugee camp ^a			-95.38	(-6.27)***	-106.06	(-6.88)***	-94.15	(-4.97)***
Distance to large refugee camp ^a			-119.71	(-7.95)***	-130.52	(-8.37)***	-90.74	(-5.00)***
Executions in Northwest ^b	43.73	(3.33)***	43.22	(3.14)***	45.06	(3.04)***	46.17	(3.32)***
1991 population density					-0.04	(-4.76)***	-0.03	(-4.08)***
Sector altitude (m)					-0.10	(-5.56)***	-0.01	(-0.56)
Gisenyi	186.23	(7.61)***	141.36	(5.21)***	152.12	(5.44)***	159.06	(3.76)***
Ruhengeri	98.45	(5.13)***	92.93	(4.40)***	123.43	(5.80)***	104.59	(2.53)**
Dummies for other provinces ^c	No		No		No		Yes	
Constant	1766.44	(13.52)***	2371.24	(12.95)***	2790.05	(14.96)***	2484.10	(11.69)***
R ²	0.20		0.21		0.24		0.32	
Obs	1544		1544		1520		1520	

Notes: Regression estimates with robust t scores in parenthesis. *p < 0.10; **p < 0.05; ***p < 0.01.

^a Logged; ^b Expressed in 1000 alleged executions/commune; ^c Butare is the excluded province

^d The dependent variable of Panel B is an absolute sector level death toll, derived from EMI, assuming a total nationwide death toll of 1 million.

Figure 1: Quintiles of EMI (top quintiles are in darkest grey)

Figure 2: Significant high-high (dark grey) and low-low clusters (light grey) of EMI

Figure 3: Administrative map of Rwanda with location of main refugee camps, main roads and Nyanza sector

Figure 4: number of alleged 1995-1998 extrajudicial killings of civilians for administrative communes located in Ruhengeri and Gisenyi