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ABSTRACT

Bombing and the Two Vietnams

The Vietnam War occurred when Vietnam was divided into two states with contrasting institutions. North Vietnam was characterized by a command economy under a stable political regime, whereas South Vietnam experienced a market economy and prolonged political instability. This paper uses this context to investigate the heterogeneous effect of childhood bombing exposure on health in adulthood. On average we found negative long-term effects on adult height and body mass index among the South Vietnamese population, while their counterparts in the North were barely affected. We argue that this heterogeneity is most likely attributable to the interplay of institutions and bombing.

JEL Classification: I15, O15, I31, H56, N35, N45

Keywords: bombing, body mass index, institutions, nutrition transition, Vietnam

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1 Introduction

Many children who are fortunate enough to survive in war zones suffer damage to their physical or mental well-being that is difficult to undo and carried into adulthood (Akbulut-Yuksel, 2014, 2017; Blattman & Miguel, 2010; Singhal, 2019). Yet war experience is never homogeneous. Even the sufferings of children who are exposed to the same war can vary substantially (Akbulut-Yuksel & Yuksel, 2017; Almond, Currie, & Duque, 2018). Children's access to food and shelter, education, and health-care services may differ, with the variation depending to a considerable extent on the political and economic institutions that govern the allocation of resources in the war zone. Hence, the interaction between institutions and the war could lead to heterogeneous life trajectories and outcomes among children exposed to war. However, it is challenging to empirically investigate heterogeneous war impacts because institutions are generally homogeneous within a country.

In this study, we exploited the unique case of the Vietnam War, which featured the most intense bombing campaign in human history in a setting divided between two states with contrasting institutions. North Vietnam was characterized by a command economy and a stable political regime, whereas South Vietnam experienced a market economy and prolonged periods of political instability. The two states used contrasting methods to distribute scarce resources. For instance, both experienced severe shortages of rice during the war period (Dacy, 1987; Tsujii, 1977; Van Dyke, 1972). Limited rice supplies were distributed via ration coupons issued to every citizen in the North (Van Dyke, 1972), whereas in the South, distribution was guided by market prices, which grew exponentially over time (Tsujii, 1977; Tuan, 1987), leading to significant inequalities in access across the population.

It is in this context that we have investigated the heterogeneous effects of U.S. bombing exposure in early life on adult height and body mass index (BMI) in Vietnam. Adult height is a sensitive indicator of the biological standard of living around the birth year (Deaton, 2007; Steckel, 2008), while BMI captures dimensions of long-term health and well-being (Akbulut-Yuksel, 2017). New bombing data from the Theater History of Operations Reports (THOR) database[1] provides the exact date and coordinates of each bombing mission. This has enabled us to calculate bombing exposure in early childhood, from the *in-utero* period to age five, for children born in the same year and commune. The *in-utero* period and the first few years of life are critical for developing the initial health stock (Almond & Currie, 2011; Barker, 1990). To mitigate the potential bias resulting from a likely endogenous bombing strategy, we instrumented the bombing in Vietnam by an interaction between distance to the North-South demarcation line and the concurrent bombing in a parallel war in Laos. Several

[1] This database was released in December 2016 by the U.S. Department of Defense.

studies have used distance to the former North-South border as an instrument to estimate impacts of the Vietnam War (Miguel & Roland, 2011; Palmer, Nguyen, Mitra, Mont, & Groce, 2019; Singhal, 2019). Its validity rests on the fact that this line was determined by a third party without any prior negotiations with the Vietnamese, or based on any prevailing socioeconomic conditions, and that the war became more intense closer to this border. We interacted this distance with the intensity of bombing in Laos over time. As we discuss below, the military strategy of the United States in Laos was linked to Vietnam, and Laos was subject to similar phases of U.S. bombing as Vietnam. The instrument is plausibly exogenous, as the bombing in Laos was driven by world events that arguably did not affect local communes in Vietnam.

We have found that exposure to bombing in early life on average led to lower weight, height, and BMI in adulthood. Nevertheless, significant heterogeneity exists in the bombing effect between the former North and South Vietnam and between men and women. Bombing caused only men in the South to grow up shorter (6-cm difference between the top and bottom quintiles of bombing exposure) but made both men and women in the South weigh less (6.3-kg reduction when individual bombing exposure increases from the bottom to the top quintiles). As for the net effect on BMI, only women in the South experienced a negative effect on BMI. In stark contrast, their counterparts in the North were barely affected by these outcomes.

While the difference in physiological robustness between men and women has been well documented (Low, 2015; van den Berg, Doblhammer, & Christensen, 2009), the striking heterogeneity between the North and the South warrants attention. We examined several mechanisms that may explain why the impact of bombing on adult health differs between the former North and South Vietnam, including selective migration and mortality, and the spraying of military herbicides. However, we have not found strong evidence to fully explain this heterogeneity. Based on a review of the historical literature, we surmise that the different institutional contexts of these former states may have interacted with the bombing and eventually led to different development outcomes.

These findings speak to the small but growing literature on the impact of violent conflict and its dynamics on development outcomes (see Verwimp, Justino, & Brück, 2019 for a review). A limited number of studies in economics have shown that welfare outcomes of a conflict may depend on micro-level dynamics such as the type of targets (Bertoni, Di Maio, Molini, & Nisticò, 2019) and the actions taken by the violent groups (Ibáñez & Vélez, 2008). In the context of the Vietnam War, Dell and Querubin (2018) found that bombing weakened local governance and civil engagement in South Vietnam during the war. We found significantly worse health in cohorts exposed to the bombing in early childhood in the southern regions compared to equivalent cohorts in the northern regions decades after the war had ceased. Taken together, the findings provide suggestive evidence that the relatively weak local governance and supply of public goods in South Vietnam and their interaction with bombing during the war period may have led to poor long-term health outcomes for exposed cohorts in early childhood.

More broadly, we contribute to the literature on the lasting effects of war on health. Among the population in the former South Vietnam, our study corroborates the negative effect of *in utero* and childhood bombing exposure on adult height that has often been reported in the literature (Akbulut-Yuksel, 2014). However, unlike in other studies (Akbulut-Yuksel, 2017; Akresh, Bhalotra, Leone, & Osili, 2017; Atella, Di Porto, & Kopinska, 2018), we have not found that experiencing war *in utero* and during childhood led to a higher likelihood of developing obesity in adulthood. Instead, we found the opposite for the South Vietnamese. A possible explanation is that Vietnam went through a long period of economic deprivation following the end of the Vietnam War. Therefore, by 2002, when the data we used were collected, the war-affected cohorts had not experienced the same sharp improvement in nutrition and energy intake as their counterparts experienced in other countries.

Finally, this study adds to the literature on the impacts of the Vietnam War. Studies have examined the long-term economic impacts (Miguel & Roland, 2011) and effects on mental health (Singhal, 2019) and disabilities (Palmer et al., 2019), but stopped short of a detailed examination of the heterogeneous effects of the war. Our study is the first to focus on the North-South Vietnam dimension, which is of interest given the contrasting institutions subject to the same bombing intervention. We adopt new bombing data and an associated identification strategy, which enabled us to capture time variation in bombing exposure that had not been adopted in previous studies on Vietnam.[2] In addition, our study is the first to use the Vietnam National Health Survey, which offers comparatively large geographic coverage and variation in bombing intensity compared to household survey data used in previous studies.

2 Historical Background

2.1 The Two Vietnams

After years of conflict, the Vietnamese nationalist coalition, known as the Viet Minh, and the French agreed in 1954 to a cease fire in Vietnam with the signing of the Geneva Ac-

[2] Yamada and Yamada (2021) use the same data set of bombing missions to study the impact of Vietnam War bombing on economic development in Laos. Previous studies used an aggregate measure of total bombing intensity over the period 1965-1975 first employed by Miguel and Roland (2011).

cord. According to the conditions of the accord, the Viet Minh would take control of the northern part of Vietnam above the 17th parallel north, under a communist regime. The State of Vietnam would take control of the southern part, which soon became the Republic of Vietnam when U.S.-backed President Ngo Dinh Diem assumed the emperor's power under a referendum. The demarcation line at the 17th parallel north was decided by world powers, including the United States, the Soviet Union, France and the People's Republic of China, without prior consultations with the Vietnamese and was not based on socioeconomic conditions (Miguel & Roland, 2011).

After the division, the two Vietnams began to diverge, both economically and politically. North Vietnam began to implement its first five-year plan, nationalizing and collectivizing private businesses and farms to transit into a command economy. Food was collectively produced and centrally distributed under a food rationing system based on head counts in each family. In contrast, South Vietnam embraced a free market and private ownership, which allowed private firms to continue to operate, resulting in an active and open economy (CIA, 1961).

During the 1965-1975 war period, the North Vietnamese government exerted full control of North Vietnam's politics. The Soviet-style government hierarchy under a single, highly centralized power and military control allowed them to quickly oppress any opposing political forces. When the war intensified and bombing escalated in 1965, coping mechanisms were actively facilitated. By means of mobilization and redistribution, the state aimed to minimize casualties and ensure that civilians had access to a basic ration of food, despite increased scarcity due to the war (Van Dyke, 1972). Rice supply fell dramatically as the bombing intensified but was supplemented by other imported grains, which were also proportionally rationed (Van Dyke, 1972). As a result, the overall calorie intake of North Vietnamese civilians remained relatively stable throughout the war years (Van Dyke, 1972). In addition, while state resources were limited, political stability enabled North Vietnam to establish an extensive health-care network, which may have contributed to remarkably low mortality rates in the 1960s and 1970s (Bryant, 1998).

The capitalist South Vietnam, on the other hand, was politically unstable. As a pluralist state, South Vietnam soon faced insurgencies and civil unrest. Insurgencies in South Vietnam began in 1956 and were worsened by anti-communist and anti-Buddhist policies that fueled violent unrest. In 1965, U.S. President Johnson ordered a military intervention, where, in addition to bombing North Vietnam, the Air Force dropped bombs on South Vietnamese territories to stop the "spread of communism". As the war escalated, rice production stagnated (Dacy, 1987) and inflation rose rapidly (Dacy, 1987; Tsujii, 1977). By 1974, South Vietnam's working-class price index had soared to 1,356 from 100 in the base year 1962 (Dacy, 1987). Meanwhile, the health-care system was underdeveloped due to resources being diverted to the war (Poffenbarger, 1971). South Vietnamese civilians, during this time, had to face not only sustained and intensive bombing but also political instability and uncertainty.

2.2 Aerial Bombing Campaign

Over the war period of 1965-1975, the U.S. Air Force dropped over 6 million tons of bombs and other ordnance in the former Indochina region. Vietnam withstood the worst of this aerial bombing campaign, which is described as the most intense bombing campaign in military history (Dell & Querubin, 2018). Within nine years, bombing had spread to most regions of the country, except the "buffer" area close to the border with China. Figure 1 illustrates the distribution of bombing intensity over 11,023 mainland communes in present-day Vietnam. The most heavily bombed areas were around the 17^{th} latitude demarcation line and the communes to the west of South Vietnam where communist forces entered the country from Cambodia. In North Vietnam, bombing was aimed at destroying infrastructure, production, and supply lines to the south. In South Vietnam, the purpose of the United States and their South Vietnamese ally was to halt communist operations and prevent civilian support for the communists. However, this strategy has been proven to have been ineffective. Bombing weakened civic engagement and cooperation with the government and drove the civilians to the Viet Cong (Dell & Querubin, 2018).

As the bombing campaigns continued in Vietnam, another war was occurring in Laos, a neighboring country that shares a long border with Vietnam to the east – the Laotian Civil War. To support the Royal Lao Government against the communist Pathet Lao, and to prevent communist operations on the Ho Chi Minh trail that passed through Laotian territory, the U.S. Air Force dropped over 2 million tons of bombs in Laos in a covert war operation. Bombing in Laos was correlated with bombing in Vietnam. This is because the military strategy of the United States in Laos was constrained by their objectives in South Vietnam, and was responsive to that of the North Vietnamese (Lamy, 1995). According to then-Colonel Perry L. Lamy (1995, p. 26), *"the fate of Laos did not depend on a military solution in the air or on the ground in Laos and could only be decided by the outcome in Vietnam."*

Overall patterns of bombing intensity over time in Laos and Vietnam were in the same direction, due to both countries being subject to similar phases of U.S. strategies, driven by world events.[3] Bombing in both countries was initiated at nearly the same time by Johnson

[3] An exception is a period after 1968 when a halt in bombing in North Vietnam prompted the United States to switch their focus to Laos (Lamy, 1995).

in late 1964 and early 1965. It then intensified dramatically, especially during the offensive in 1968. After Nixon took over presidency in the United States, his "Vietnamization" policy led to a significant reduction in bombing intensity, which was further constrained by Washington's fiscal decisions in 1971. During the final years of the intervention, bombing again escalated in Laos and Vietnam, following North Vietnam's insurgencies in South Vietnam in March 1972. This military intervention ended in both countries after the Paris Peace Agreement in 1973.

In sum, bombing in Vietnam tended to intensify closer to the demarcation line at the 17^{th} parallel north, and it also shared a similar time trend to bombing in Laos during the covert Laotian Civil War. These geographical and time-variant patterns of bombing are key to our identification strategy.

3 Data

This study combines anthropometric data from the 2002 Vietnam National Health Survey (VNHS) (General Statistics Office, 2002) with a novel, detailed data set of bombing intensity: the Theater History of Operations Reports data set (Air Force Research Institute, 2016), released by the U.S. Department of Defense in December 2016. This data set contains mission-level data of all Vietnam War bombing missions including the exact date and coordinates of each mission.[4] To construct an index of bombing exposure, we used GIS software to calculate the number of bombs dropped in each commune in each year based on each mission's GPS coordinates. We measured individual conflict shocks by calculating the number of bombs dropped in each individual's commune when they were *in utero* and up to the age of five.[5]

The VNHS is a nationally representative survey conducted by the Ministry of Health in collaboration with the General Statistics Office of Vietnam in 2001–2002, covering 1,200 communes and 36,000 households in all regions of the country. One advantage of using this data set is that its large geographical coverage captures significant variations in bombing intensity. Figure A.1 in the Appendix demonstrates the geographical distribution of surveyed communes in the VNHS (right), as compared to those covered by the Vietnam Living Standards Survey 1998 (left) used by Miguel and Roland (2011).[6] As can be seen from Fig-

[4] While being the most detailed record of Vietnam War bombing, the data set does not have full information for all of the entries. Tonnage and bombing damage assessment data is only available for the final years of the bombing.

[5] Note we only measure bombing exposure at the year level, due to the fact that around 20% of individuals in the war cohort did not have full information on their date and month of birth.

[6] Other studies also have similarly small coverage. Palmer et al. (2019) use district-level census data. Singhal (2019) uses data from the 2016 wave of the Vietnam Access to Resources Household Survey (VARHS)

ure 1 which maps bombing intensity, the VNHS has more sampled communes in the most intensely bombed areas around the demarcation line and in the area close to the border with Cambodia. In addition, the poorest regions in the northern mountains and the Central Highlands are also well covered.

Height and weight were measured by trained enumerators as a part of the household anthropometric measurement component of the survey. BMI is calculated from height and weight. The time of day when the enumerator visited the household was also recorded. As an individual's height could vary by 0.98 ± 0.2 cm during the day (Lampl, 1992), the time of measurement enabled us to control for this diurnal variation and thus reduce errors caused by it. This is one of the rare studies with access to this information.

We restricted the sample to the cohorts born between 1960 and 1975, who were at age five or younger when the bombing started, and those born during the conflict until its official end in 1975. The sample size is 31,841 individuals, which excludes 145 entries with missing information.

To control for time and geographic variation in agricultural production in the communes, we obtained rainfall data from Willmott and Matsuura (2009). Rainfall shocks during childhood have been found to have a significant effect on health and human capital via their influences on agricultural production and food security (Maccini & Yang, 2009; Thai & Falaris, 2014). The data was reported by grids of 50 by 50 km for each month. We calculated a rainfall index for each commune in each year by averaging the figures from four nearest grid points and adding up all months.

Table 1 shows descriptive statistics of the sample at national level and for the former North and South Vietnam for cohorts born between 1960 and 1975. On average, cohorts in the North are slightly taller whereas in the South they are heavier particularly the women. Yet both regions average in the normal range for BMI, between 18.5 and 22. Cohorts in southern communes were exposed to a higher level of bombing at an average rate of 4 times the level of cohorts in northern communes, as bombing was concentrated in southern regions. Rainfall in the year of birth was modestly higher in southern than northern communes.

Figure 2 depicts the distribution of adult height in 2002 of men and women in the former North and South Vietnam by the level of exposure to bombing *in utero* and until age five. The sample is restricted to individuals born from 1960 to 1975. As can be seen from the figure, the distribution is relatively normal for all groups. Nevertheless, the adult height of South Vietnamese individuals with bombing exposure in the top quartile has a slightly more right-skewed distribution than those in the bottom quartile.

Figure 3 illustrates the distribution of BMI of the same sample. BMI of all groups has

which is representative of rural households in just 12 of a total 64 provinces.

a slightly right-skewed distribution, with most individuals in the sample having a BMI in the underweight (below 18.5) or normal weight (18.5 to 24.9) ranges. In the former North Vietnam (panels A and B), individuals in the top quartile of bombing exposure tend to have a BMI to the right of the distribution compared to those in the bottom quartile. However, in the former South Vietnam (panels C and D), individuals with high exposure tend to have a lower BMI compared to those with low exposure.

In this sample, we observed a low prevalence of obesity: 5.48% are overweight (BMI from 25 and above) and only 0.71% are obese (BMI from 30 and above), while the underweight rate is many times larger at 21.89%. This could be a result of the persistently low calorie intake of the Vietnamese population after the war (FAO & UN Expert Consultation, 2001; Le, Le, & Nguyen, 2003).[7] Appendix Figure A.2 shows that Vietnam's daily calorie supply per capita also remained almost unchanged until the late 1990s. More context on the postwar nutrition situation in Vietnam is provided in Section A.1 in the Appendix.

This demonstrates the contextual difference between our study in Vietnam and other studies in countries that experienced a high calorie intake. Akbulut-Yuksel's (2017) World War II-exposed sample in Germany had a mean BMI of 26, and 17% were obese. Akresh et al. (2017) used a sample with a mean BMI of 24, where 30.8% were overweight, to assess the Biafran War in Nigeria. Atella et al. (2018) studied World War II's impact in Italy using a female sample with a mean BMI of around 28, which is already in the overweight range. The results of these studies all suggest that exposure to war in early life led to higher BMI and higher overweight or obesity rates in adulthood. Our study shows that this may not necessarily be the case in a country without a dramatic nutrition transition such as Vietnam.

4 Identification Strategy

To identify the causal impact of the Vietnam War bombing on affected cohorts of Vietnamese people, we started from a generalized difference-in-differences strategy that exploits the variation in bombing intensity by commune and birth year:

$$y_{ict} = \beta_0 + \beta ln(B_{ct}) + \theta_i + \gamma_{ct} + \lambda_c + \alpha_t + \epsilon_{ict} \quad (1)$$

where y_{ict} is the outcome of individual i, in commune c, belonging to the cohort born in year t. The treatment variable B_{ct} is a continuous measure of bombing intensity that cohort t in commune c suffered from when they were *in utero* to five years old. In short,

[7] Until 2016, when the latest estimates were made available, Vietnam still had the lowest adult obesity rate in the world, at just 2.1% (WHO, 2017).

$B_{ct} = \sum_{w=t-1}^{t+5} B_{cw}$, where B_{cw} is the bombing intensity in commune c in year w. θ_i is a vector of individual-level controls, including sex, time of measurement of anthropometric health measures, and ethnicity. γ_{ct} is a vector of time-variant and location-variant controls, which include rainfall in the year of birth. λ_c is the commune fixed effects, controlling for differences in commune-level factors that affect the outcome. α_t is the cohort fixed effects, controlling for differences in adult health due to year of birth. ϵ_{ict} is a random, idiosyncratic error term. The standard errors are clustered at the commune level in all specifications to account for within-commune correlations.

The treatment variable enters the model in logarithmic form; hence, the coefficient of interest β captures the change in adult anthropometric health attributable to a proportional change in bombing exposure.[8] For the coefficient to be interpreted as causal it is assumed that changes in adult health across cohorts and communes of varying levels of bombing exposure would have been the same in the absence of the bombing ("common trend" assumption). While the generalized difference-in-differences model controls for fixed characteristics in each commune and cohort, the estimated treatment effect could still suffer from bias if bombing strategies were influenced by both geographical- and time-variant factors that would also affect adult health.

During the Vietnam War, bombing strategies in South Vietnam were partly determined by a set of political and socioeconomic characteristics (Dell & Querubin, 2018).[9] These characteristics, measured at the hamlet level under the Hamlet Evaluation System, included food access and health-care, for example. The Air Force could therefore decide to drop bombs in a certain location and time when food access and the availability of health-care facilities were more favorable for their enemies, the Viet Cong. Directly controlling for these time- and location-variant characteristics in the past would be the most ideal solution. However, the former hamlet boundaries can no longer be identified and even if identified, there would be multiple hamlets in a present-day commune (our smallest possible aggregation level), which complicates the task.

To resolve this potential endogeneity problem, we propose an instrumental variable approach, in which bombing intensity B_{ct} in commune c of cohort t is instrumented by an interaction $D_c \times B_t^L$, which comprises the distance from commune c to the 17$^{\text{th}}$ degree parallel north demarcation line, and bombing intensity in Laos of cohort t. The first-stage

[8] Note 0.1 is added to this bombing measure to retain the zeros after the log transformation.

[9] In North Vietnam, the Air Force's bombing decision was not responsive to measured socioeconomic factors. Bombing in the North was aimed to warn the North Vietnamese government, destroy their infrastructure and prevent them from interfering with the situation in the South. It is possible that bombing in the North was more random and thus exogenous to our outcomes.

equation is as follows:

$$ln(B_c) = \beta_0 + \delta D_c \times B_t^L + \theta_i + \gamma_{ct} + \lambda_c + \alpha_t + \epsilon_{ict} \tag{2}$$

Distance to the demarcation line has been used as an instrument by several studies to estimate the effects of the Vietnam War (Miguel & Roland, 2011; Palmer et al., 2019; Singhal, 2019). Its validity rests on the fact that this line was determined by a third party (world powers, including the United States and the Soviet Union) without any prior negotiations with the Vietnamese, or based on any prevailing socioeconomic conditions, and that the war became more intense closer to this border. We interacted this distance with the time-variant bombing intensity in Laos. This variable is measured for the same number of years as the variable capturing individual exposure at the commune level. The only difference is that instead of capturing exposure in the individual's commune, this variable captures bombing intensity in a neighboring country, which does not affect the local commune. The relationship between individual bombing exposure in Vietnam and bombing in Laos is depicted in Appendix Figure A.3.

We discuss the strength and validity of the instrument in the following section.

5 Results

Panel A of Table 2 presents coefficient estimates from ordinary least squares (OLS) estimation of the difference-in-differences specification (Equation 1). Columns 1–3 report on results for the full national sample whereas columns 4–6 and columns 7–9 report on results for the former North Vietnam and South Vietnam samples, respectively. As shown in columns 1–3, we have found highly significant negative impacts of bombing on weight and BMI at the national level. The coefficient on height is negative but statistically insignificant at conventional levels of significance. As shown further in the remaining columns (4–9), populations in the South experience a greater overall reduction in their adult anthropometric health due to bombing exposure in early childhood compared to their counterparts in the North. The coefficient for bombing in the South is negative and significant for all three outcomes–height, weight, and BMI–whereas in the North we observe a significant result only in terms of BMI. Indeed, the coefficient on the height outcome in the northern sample is positive and insignificant.

As discussed in the previous section, the OLS estimates may still be plagued by endogeneity caused by unobserved factors that varied across time and location. We adopted an instrumental variable approach that can address time-variant unobserved heterogeneity and measurement errors associated with lack of birthplace data. Second-stage instrumental variable results are reported in panel B of Table 2 together with first-stage test statistics. More details on the first stage are presented in Appendix Table A.2.

The results indicate that the interaction term between distance to the demarcation line and bombing in Laos has a strong relationship with bombing, demonstrated by consistently high F-statistics in all specifications. However, following Hayashi (2011), failure to reject the null hypothesis in the endogeneity test in the North Vietnam sample (columns 13–15 in panel B of Table 2) shows that bombing can be treated as exogenous. This corroborates our expectation that bombing in the North was not based on the Hamlet Evaluation System and could be more exogenous to the outcomes than bombing in the South. In addition, weak instrument tests have shown that the instrument has the potential to be weak in the North (columns 13–15 in panel B of Table 2). In such case, OLS estimates may be preferred over two-stage least squares (2SLS) estimates because the former is more efficient and consistent. In contrast, the instrument is strong in most specifications for the South, where the endogeneity test indicates that bombing is endogenous.

As shown in columns 10–12 in panel B of Table 2, the pattern of effects across regions is similar to the OLS estimates with effects among exposed populations in the South being higher in both the level of magnitude and significance than those in the North.

We next report on results disaggregated by sex. We present estimates from analogous instrumental variable (IV) specifications on separate male and female samples in Table 3. The OLS estimates are shown in Appendix Table A.1. The pattern of heterogeneous effects of early life bombing exposure on adult anthropometric health based on sex and region for the IV specification is similar to the OLS estimates, with bombing negatively affecting the adult height of South Vietnamese men, and the weight of both South Vietnamese men and women (panel C). The reduction in BMI in the South Vietnam sample is observed only among women, as a result. In the North Vietnam sample, all the coefficients are now statistically indistinguishable from zero (panel B). In sum, the adult anthropometric health of men in the South was most significantly affected by exposure to bombing during early childhood.

The above results establish a negative causal effect of bombing exposure in early life on adult BMI. However, it is unclear whether this implies undernourishment or simply a lower likelihood of being overweight. To investigate this further, we estimated a linear probability model in which the outcome is a binary variable that takes the value of 1 if an individual falls into the low BMI category (BMI < 18.5), and 0 otherwise, using our preferred 2SLS estimation. The results are reported in panel A of Table 4. As shown in columns 1–2, exposure to bombing in early life is associated with a greater likelihood of being undernourished in adulthood (BMI < 18.5) for women in the South and both men and women at the national level, but the effect is larger and statistically more significant among women. Once again, we observe a clear North-South divide with stronger effects in the South and mostly contained to women (columns 3–6).

We investigated this effect of bombing on BMI further by estimating its impact on being overweight (BMI $\geq$ 25). Obesity is the outcome of interest in many other studies in which *in utero* and childhood exposure to violent conflict were found to increase the likelihood of obesity in adulthood (Akbulut-Yuksel, 2017; Akresh et al., 2017; Atella et al., 2018). Nevertheless, as the prevalence of obesity in our sample is just 0.71%, which is too small for identification, we estimated the effect on the likelihood of being overweight instead and report the results in panel B of Table 4. The sign of the effect is negative in most specifications, except for that of northern women. The effect is significant at 10% for women at the national level. The negative sign is consistent with our observation that bombing tends to reduce the BMI of affected populations and is contrary to findings from other studies (Akbulut-Yuksel, 2017; Akresh et al., 2017; Atella et al., 2018).

6 Robustness

Several potential sources of bias should be pointed out in this study. An individual could be included in this research only if they survived the bombing and were alive in 2002. In the absence of location of birth information, we assumed that individuals were born and experienced early childhood in the same 2002 location. If healthier or genetically more resilient children were more likely to survive the bombing, then our results are lower-bound estimates of the true effects. Similarly, if migration out of (or into) heavily bombed areas is systematically related to height, weight, or BMI, the results are biased.

Birth cohort size is a good proxy for both selective migration and mortality, as it encompasses the effects of mortality and movement of people during and after the conflict (Maccini & Yang, 2009). To examine whether birth cohort sizes vary systematically with bombing intensity, we estimated a similar instrumented regression on cohort size using the same specifications with year of birth and commune fixed effects. As shown in panel A of Table 5, exposure to bombing has no significant effect on the size of the cohorts included in the sample. This supports suggestions from other literature that the Vietnam War did not have a sizable effect on infant and child mortality in most locations (Savitz, Nguyen, Swenson, & Stone, 1993). If mortality selection was the main reason for more pronounced effects in the South than the North, we should have observed higher infant and child mortality rates in the North. However, according to Savitz et al. (1993), infant and child mortality was actually slightly higher in the South than in the North.

To examine the issue of selective migration further we drew upon the Vietnam Living

Standard Survey (VLSS) 1998 (General Statistics Office, 1998), which recorded information on district location of birth. We examined first whether migration status has any effects on height, weight, and BMI, and then whether bombing affects the likelihood of migrating. Migration is defined as currently living in a location outside of the district of birth. Panel B of Table 5 reports analogous IV results of the probability of migrating on bombing intensity and shows that bombing is not statistically related to migration at national level and in the former North and South Vietnam regions. Table 6 reports results from the OLS estimation of our anthropometric health outcomes on migration, controlling for commune and cohort fixed effects. As shown in the table, the coefficient on the migration variable is statistically insignificant in all specifications and samples except for a negative effect on height for the northern sample, which is only marginally significant. The result of no significant difference in the anthropometric health of migrant and non-migrant groups holds when disaggregating samples by sex and region (Appendix Table A.6).

Overall, the results suggest that neither mortality selection nor endogenous migration explain our findings. The results are consistent with findings from several other studies that adopted alternate specifications and samples. Dell and Querubin (2018) concluded that bombing generated "at most limited-out migration" from southern hamlets during the active war period, and Miguel and Roland (2011) found no compelling evidence of large inflows of migrants into heavily bombed regions in the post-war period. Singhal (2019) similarly found no statistically significant effect of bombing on cohort size at either district or province level. While collectively these findings cannot rule out sample selection concerns, the leading narrative is that bombing the countryside did not lead to mass migration to cities as strategized. Instead, the Vietnamese went to great lengths to hide from the bombing in underground tunnels and bomb shelters, whereas those that were temporarily displaced by the bombing returned to their homes shortly after the war ended (Dell & Querubin, 2018; Miguel & Roland, 2011).

7 Mechanisms

In this section, we discuss the possible mechanisms underlying our results. One explanation for our findings relating to the North-South Vietnam heterogeneity is that South Vietnam was sprayed with military herbicides, whereas North Vietnam was not. Existing microeconomic studies estimating the long-term effects of bombing in Vietnam have not been able to account for this potential mechanism (Miguel & Roland, 2011; Palmer et al., 2019; Singhal, 2019). An alternative well-established explanation in the conflict literature is that war could disrupt one's education, leading to lower human capital and income, which in turn negatively affects health production in adulthood. Finally, we return to the question of the different institutional environments of the former North and South Vietnam in playing a role in determining the long-term effects of the war.

7.1 Agent Orange

Over the period 1961–1971, more than 70 million liters of herbicides were sprayed by U.S. and Republic of Vietnam forces on an estimated 2.1 million people (and as many as 4.8 million) and 15–16% of land cover of the former South Vietnam (Stellman, Stellman, Christian, Weber, & Tomasallo, 2003). Approximately two-thirds of the herbicides sprayed contained a highly toxic chemical, commonly known as dioxin, with the most common herbicide known as Agent Orange (Stellman et al., 2003). The primary purpose of the herbicides was as a defoliant to remove forest cover to the enemy, but it also aimed to destroy "unfriendly" food crops and supplies (Stellman et al., 2003). It is conceivable that the destruction and destabilization of the nutritional and socioeconomic environment by Agent Orange and other toxic herbicides affected the height of exposed cohorts in early childhood. Furthermore, exposure to dioxin contained in military herbicides is associated with a range of delayed health effects, including cancers and chronic health conditions (Bertazzi, 2001), which could affect height, weight, and BMI in later life.

To the extent that the spraying of military herbicides was correlated with the bombing, it may partially or fully explain our findings relating to the adverse effects of bombing on adult anthropometric health of exposed populations in the former South Vietnam region. We drew upon herbicide data computed by Stellman et al. (2003) and Do (2009), which include information on the total amount of dioxin sprayed in each commune, and constructed a variable of dioxin exposure for cohorts born from 1965 to 1971, which corresponds to the period of most intense spraying.[10]

Table 7 presents results from our IV specification for the South Vietnam sample that includes dioxin exposure of cohorts born from 1965 to 1971 as an additional control variable. As shown in the table, the coefficient on dioxin exposure is very small and statistically insignificant for all anthropometric health outcomes, and the key bombing coefficient remains qualitatively unchanged which suggests that our bombing results are not driven by exposure to dioxin. Similar patterns are observed when the results are broken down by sex, as reported in Appendix Table A.4.

[10] This variable takes a value of zero for other cohorts. Note that data was available for only 56% of the southern communes.

7.2 Human Capital

War experience in early childhood could affect anthropometric health, especially BMI through physiological and socioeconomic channels. Numerous studies have shown that stressful environmental conditions *in utero* could reprogram the human metabolic system.[11] The thrifty phenotype hypothesis proposes that early growth restrictions *in utero* and in early childhood can lead the human body to permanently program itself to have a slow metabolic profile to maximize its chance of survival during difficult times (Hales & Barker, 2001; Prentice, 2001). When faced with more rapid growth and a nutrition-rich diet later in life, individuals with this lower metabolic rate are more prone to obesity and metabolic syndrome (Akbulut-Yuksel, 2017; Akresh et al., 2017; Atella et al., 2018), especially among populations that undergo a fast nutrition transition (Adair, 2002). However, the absence of improvements in nutrition for over 20 years after the Vietnam War might have prevented these metabolic effects from being expressed.

On the other hand, war could disrupt one's education, leading to lower human capital and income, either of which could negatively affect health production in adulthood (Grossman, 1972). This may provide an explanation for our findings in the context of the Vietnam War bombing such that the human capital or income effects may outweigh those relating to the metabolic effects.[12] To investigate this possible pathway we examined whether bombing affected the accumulation of human capital among exposed cohorts.[13]

Table 8 presents the estimated coefficients of the bombing variable on the likelihood that one completed schooling at each of three levels–-primary, lower-secondary, and upper-secondary schools–using our preferred IV specification. As shown in Table 8, at national level, we observe a positive effect on primary-level education and negative effects on lower- and upper-secondary schooling. However, the secondary schooling effects are statistically insignificant at conventional levels of significance (columns 1–3). We observe further in column 7 that the positive effect on primary schooling derives from the South yet is statistically insignificant, whereas there are negative and statistically significant effects of bombing on the completion of lower and upper secondary school in the South (columns 8–9). The analogous effects in the North are small in magnitude and statistically insignificant. As shown further in Appendix Table A.5 (panel C), both men and women in the South experienced negative

[11] See Rinaudo and Wang (2012) for a review.

[12] The effect of human capital or income on nutritional outcomes like BMI may vary across countries and contexts due to different development stages, food cultures and working conditions (Smith, Shen, Strauss, Zhe, & Zhao, 2012; Strauss & Thomas, 1998).

[13] Our data set does not include individual income, so we are unable to estimate income effects. The Vietnam Household Living Standards Survey does collect income and consumption information, however as noted and shown in Figure 1 and Appendix Figure A.1, the coverage of the survey is limited in areas which were heavily bombed.

effects on secondary school completion. For women, the effects are statistically significant at lower-secondary level, whereas for men they are significant at upper-secondary level.

To strengthen the human capital narrative, we investigated whether exposure to bombing in early life increased people's likelihood to do physically demanding jobs in adulthood and report the results in Table 9. We found a positive, statistically significant effect at 10% among Southern women, who were also the most affected in terms of BMI. It is possible that depleted human capital, as a result of bombing, has led to a lower BMI in the affected population because of their increased energy consumption and lower income from working as low-skilled manual laborers.

Overall, the pattern of bombing effects on human capital is consistent with those we have observed on weight, which aligns with the human capital rather than the metabolic narrative regarding the long-term effects of bombing on weight. We have observed significantly stronger effects in the South among both men and women, which raises the question of why this occurred.

7.3 Institutions

Our results suggest that bombing led to a reduction in the human capital of exposed cohorts in the South but not in the North. Furthermore, we ruled out further any mechanism relating to exposure to military herbicides among populations in the South. The North-South difference is striking given the different institutional and historical contexts of the two former states. Following the framework of Justino (2014), we hypothesize that the overall different institutional environments of the former North and South Vietnam, as previously discussed in Section 2.1 determined its conflict dynamics, which eventually led to different development outcomes.

While we cannot test this hypothesis directly, Dell and Querubin (2018) reported several empirical findings in support. They illustrated that bombing weakened local government, lowering the probability that all village committee positions were filled, and that the local government collected taxes. Since the village committee administered the provision of public goods, which were funded in part by tax revenues, this suggests that bombing directly influenced the ability of local administrations to supply public goods. In further support of this, the authors found that bombing led to a reduction in access to primary and secondary school education. Moreover, Dell and Querubin (2018) found strong negative effects of bombing on civic engagement as measured by individuals participating in non-communist civic organizations and locally organized self-development projects. They also found that bombing made citizens more likely to join the Viet-Cong and engage in the insurgency.

However, this study estimates the effect of bombing on outcomes in this period in South Vietnam only. While providing supporting evidence, the study is unable to confirm or deny our hypothesis that the impact of bombing on governance in the South was more pronounced than in the North which in turn contributed to more adverse long-term health and human capital effects.

Dell, Lane, and Querubin (2018) provided more evidence by examining how South Vietnamese villages with more historical ties to the North Vietnam "Dai Viet" village structure performed better in economic outcomes than those with Khmer roots. The North Vietnam "Dai Viet" village structure is characterized by a strong centralized state in which the village was the fundamental administrative unit compared to villages that were historically rooted in the Khmer Empire with more informal political economy and no village intermediation. Dell et al. (2018) found that historical Dai Viet villages were more likely to collect taxes and provided better access to basic health care, education and law enforcement, and its citizens had higher levels of civic engagement. Given that villages in the North were governed by the Dai Viet structure since the first millennium which gradually expanded southward over time (Dell et al., 2018), the results provide further suggestive evidence that villages in North Vietnam had stronger institutionalized village governance which likely was more resilient to bombing than those in the South.[14]

We have found evidence that bombing caused a reduction in adult anthropometric health and education attainment in the South and no discernible effects in the North. In contrast to Dell and Querubin's (2018) study which relates to populations during the active war period, our results relate to cohorts that were *in utero* or in early childhood during the war. This calls into question whether the heterogeneity was caused by the different institutional environments in North and South Vietnam during the war or due to North and South Vietnam recovering differently after the war. Our results support the former explanation. The heterogeneity is observed not only in the effect of bombing on BMI, but also in its effect on adult height, which is known to be largely determined by net nutrition in early childhood (Deaton, 2007).

8 Conclusion

This study examined the long-term effects of exposure to intense Vietnam War bombing *in utero* and during early childhood on adult anthropometric health. Consistent with the

[14]This is also supported by the colonial literature, which contends that weak village-level institutions in the south were carried over from the Khmer period, while villages in the north were much stronger and could be leveraged by the French for taxation (Dell et al., 2018).

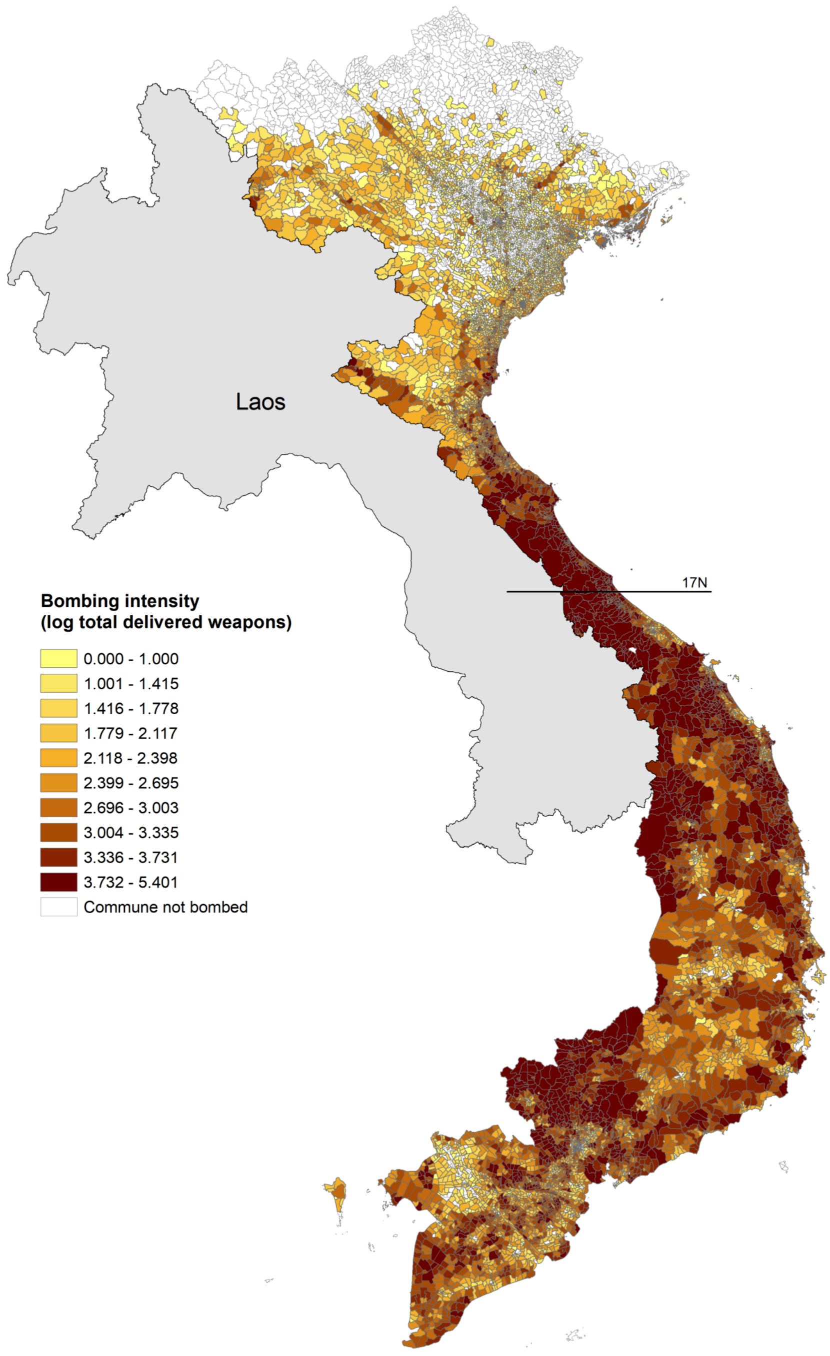
broader microeconomics of conflict literature, we have found that early life exposure to bombing led to a reduction in adult height as a biological marker for childhood conditions. We examined further the impacts on BMI and have found that exposure to bombing in early childhood led to a reduction in BMI and an increased probability of being underweight in adulthood among affected population.

Our results suggest that context matters in the effect of early life shocks on adult BMI. The negative association we identified between childhood bombing exposure and adult BMI contradicts other studies that have found positive effects on BMI and an increased likelihood of being obese in adulthood resulting from early life shocks (Akbulut-Yuksel, 2017; Akresh et al., 2017; Atella et al., 2018; Roseboom, de Rooij, & Painter, 2006). Distinct to these study settings, which experienced relatively high growth in per capita energy intake in the post-conflict period, economic and nutritional conditions did not improve for a long time after the war in Vietnam. We provide evidence that bombing affected the education attainment and employment of exposed cohorts. This suggests a human capital rather than metabolic pathway to long-term effects on BMI in the Vietnam context, where the overall nutrition conditions remained stagnant for two decades after the war.

Our other novel finding relates to the heterogeneous effects of the bombing across populations in the former North and South Vietnam states. We have found evidence consistent with the hypothesis that bombing may have caused a reduction in adult anthropometric health among exposed cohorts in the South with no discernible effects among cohorts in the North. This aligns with the findings of Strauss and Thomas (1998), who observed that some population groups in North Vietnam still experienced height growth during the war, unlike those in the South whose growth at the time was negative. The result is striking given the different institutional environments and political economies during the war years. In light of recent studies on how institutions affected economic and war outcomes in South Vietnam (Dell et al., 2018; Dell & Querubin, 2018), our results offer suggestive evidence that the overall different institutional environments of the former North and South Vietnam may have determined conflict dynamics, which eventually led to heterogeneous war impacts (Justino, 2014).

The findings imply that maintaining a stable political environment and local governance, including the provision of public goods and services and civic engagement, could be key to mitigating the long-term impacts of war on population health. The question of how each of the micro-level institutional dynamics interacted with the bombing and with each other to determine the long-run impacts represents an area for future research.

Figure 1: Distribution of Total Bombing Intensity at Commune Level



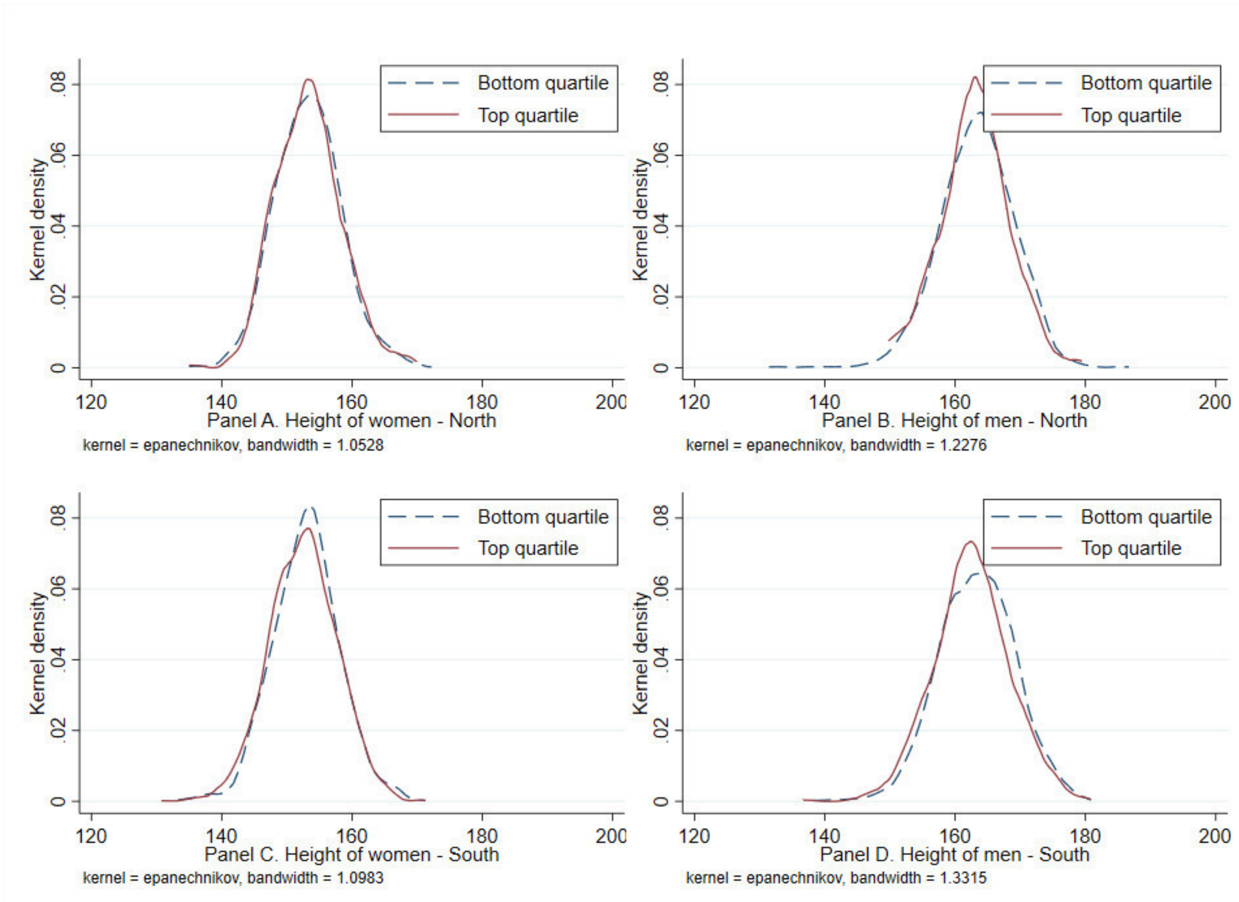
Note: This map shows 10,614 communes on mainland Vietnam and the national borders of the neighboring Laos. Darker colors represent higher bombing density during the 1965–1975 conflict. Data from Theater History of Operations Reports (Air Force Research Institute, 2016).

Table 1: Descriptive statistics

Variables	(1) N	(2) Mean	(3) SD	(4) t-stat	(5) Min	(6) Max
			National			
Female (dummy)	31,970	0.53	0.50		0.00	1.00
Height (male) (cm)	14,871	163.15	5.75		127.20	185.45
Height (female) (cm)	17,003	153.03	5.25		116.20	177.50
Weight (male) (kg)	14,894	54.39	7.52		17.60	99.10
Weight (female) (kg)	17,013	47.77	7.01		22.70	98.80
BMI (male)	14,866	20.41	2.36		7.05	36.95
BMI (female)	17,001	20.38	2.63		10.54	38.47
Number of ordnances exposed to	31,986	792.49	3,847.84		0.00	107,044
Rainfall in year of birth (mm)	31,986	1,808.90	359.12		1,027.93	3,377.85
Time of measurement (hour)	31,921	13.04	3.97		0.00	23.00
Distance to demarcation line (km)	31,986	533.32	201.43		2.04	944.93
			North Vietnam			
Female (dummy)	13,947	0.54	0.50	2.44	0.00	1.00
Height (male) (cm)	6,386	163.22	5.73	1.38	127.20	185.45
Height (female) (cm)	7,530	153.22	5.20	4.17	130.00	177.50
Weight (male) (kg)	6,397	54.06	6.89	4.64	17.60	99.10
Weight (female) (kg)	7,534	47.07	6.16	11.59	23.60	82.60
BMI (male)	6,384	20.27	2.10	6.21	7.05	33.30
BMI (female)	7,529	20.03	2.24	15.32	10.54	33.40
Number of ordnances exposed to	13,952	287.66	2,408.54	20.77	0.00	68,731.00
Rainfall in year of birth (mm)	13,952	1,748.06	292.79	26.95	1,060.75	2,961.82
Time of measurement (hour)	13,927	13.10	4.02	2.12	0.00	23.00
Distance to demarcation line (km)	13,952	441.36	130.78	78.42	4.24	740.09
			South Vietnam			
Female (dummy)	18,023	0.53	0.50	2.44	0.00	1.00
Height (male) (cm)	8,485	163.09	5.77	1.38	132.65	185.35
Height (female) (cm)	9,473	152.88	5.28	4.17	116.20	172.00
Weight (male) (kg)	8,497	54.64	7.94	4.64	23.00	94.30
Weight (female) (kg)	9,479	48.32	7.58	11.59	22.70	98.80
BMI (male)	8,482	20.51	2.53	6.21	9.21	36.95
BMI (female)	9,472	20.65	2.88	15.32	11.03	38.47
Number of ordnances exposed to	18,034	1,183.05	4,628.54	20.77	0.00	107,044.00
Rainfall in year of birth (mm)	18,034	1,855.96	396.68	26.95	1,027.93	3,377.85
Time of measurement (hour)	17,994	13.00	3.93	2.12	0.00	23.00
Distance to demarcation line (km)	18,034	604.47	217.09	78.42	2.04	944.93

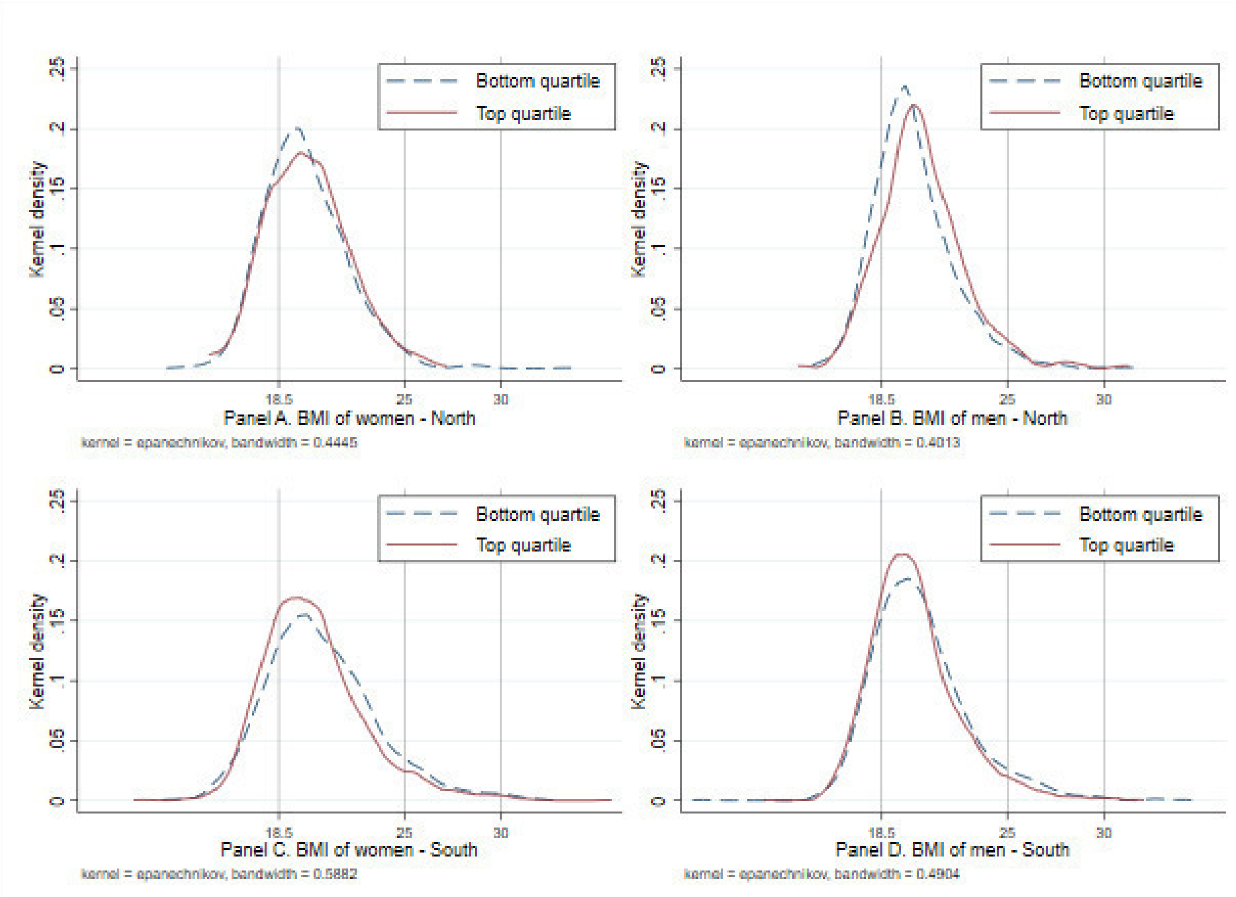
Note: The sample includes cohorts born between 1960 and 1975, who were at age five or younger when the bombing started and those born during the conflict until its official end in 1975. Column 4 reports the absolute value of t-values from two-sample t-tests between North Vietnam and South Vietnam. Data from VNHS 2002.

Figure 2: Distribution of Height in North and South Vietnam, by Sex and Bombing Exposure



Note: These graphs report kernel density estimates of adult height of male and female cohorts born between 1960 and 1975 in North and South Vietnam. Bombing is measured for each individual based on their commune of residence from the *in-utero* period to age five. Data from VNHS 2002.

Figure 3: Distribution of BMI in North and South Vietnam, by Sex and Bombing Exposure



Note: These graphs report kernel density estimates of adult BMI of male and female cohorts born between 1960 and 1975 in North and South Vietnam. Bombing is measured for each individual based on their commune of residence from the *in-utero* period to age five. Vertical lines mark the cutoffs for being underweight (below 18.5), overweight (25 and above) and obese (30 and above). Data from VNHS 2002.

Table 2: Ordinary Least Squares and Two-stage Least Squares Estimates of the Impact of Bombing on Adult Height, Weight and BMI

	National			*North Vietnam*			*South Vietnam*		
Outcome	BMI	Weight	Height	BMI	Weight	Height	BMI	Weight	Height
	Panel A. *OLS results*								
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Exposure to bombing	-0.0186	-0.0617	-0.0241	-0.0226	-0.0538	0.0102	-0.0258	-0.0975	-0.0538
	(0.00701)	(0.0204)	(0.0153)	(0.0109)	(0.0319)	(0.0252)	(0.00991)	(0.0286)	(0.0208)
Controls	Y	Y	Y	Y	Y	Y	Y	Y	Y
Commune fixed effects	Y	Y	Y	Y	Y	Y	Y	Y	Y
Year of birth fixed effects	Y	Y	Y	Y	Y	Y	Y	Y	Y
Observations	31,834	31,872	31,841	13,899	13,917	13,902	17,935	17,955	17,939
	Panel B. *2SLS results*								
	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)
Second-stage results									
Exposure to bombing	-0.2660	-0.9475	-0.4618	-0.0636	-0.2086	-0.059	-0.277	-1.030	-0.5951
	(0.0750)	(0.2470)	(0.1780)	(0.0280)	(0.0980)	(0.1020)	(0.1010)	(0.3490)	(0.2570)
Controls	Y	Y	Y	Y	Y	Y	Y	Y	Y
Commune fixed effects	Y	Y	Y	Y	Y	Y	Y	Y	Y
Year of birth fixed effects	Y	Y	Y	Y	Y	Y	Y	Y	Y
Observations	31,834	31,872	31,841	13,899	13,917	13,902	17,935	17,955	17,939
Test statistics									
First-stage F-statistic	44.40	44.09	44.64	52.67	52.73	52.68	26.48	26.31	26.54
Endogeneity test[a] (C-stat)	13.69	14.08	5.39	2.24	2.22	0.45	7.18	8.02	4.55
Weak IV test[b] (AR, χ^2)	15.34	15.37	5.79	4.43	3.44	0.31	8.49	9.34	5.25

Note: Panel A reports OLS regression results from difference-in-differences models. Panel B reports 2SLS estimates from instrumented difference-in-differences models. Control variables include sex, time of anthropometric measurement, rainfall in the year of birth and ethnicity of the individual. Robust standard errors are reported in parentheses, clustered at the commune level. [a] Tests the null hypothesis that the endogenous variables can in fact be treated as exogenous (Hayashi, 2011). [b] Anderson-Rubin test statistic produced by the command written by Finlay, Magnusson, and Schaffer (2015). The null hypothesis is that all weakly identified coefficients are zero. Data from VNHS 2002.

Table 3: Instrumental Variable Results of the Impact of Bombing on Adult Height, Weight and BMI, by Sex

Outcome	Male BMI	Female BMI	Male Weight	Female Weight	Male Height	Female Height
			Panel A. *National*			
	(1)	(2)	(3)	(4)	(5)	(6)
Second-stage results						
Exposure to bombing	-0.1552	-0.3688	-0.9725	-0.9016	-0.8552	-0.0535
	(0.0925)	(0.1154)	(0.3394)	(0.2856)	(0.2958)	(0.1936)
Controls	Y	Y	Y	Y	Y	Y
Commune fixed effects	Y	Y	Y	Y	Y	Y
Year of birth fixed effects	Y	Y	Y	Y	Y	Y
Observations	14,853	16,981	14,880	16,992	14,858	16,983
Test statistics						
First-stage F-statistic	33.83	33.93	33.58	33.43	34.13	33.93
Endogeneity test[a] (C-stat)	2.24	13.40	6.62	10.18	7.03	0.03
Weak IV test[b] (AR, χ^2)	2.71	14.91	7.24	11.32	7.21	0.07
			Panel B. *North Vietnam*			
	(7)	(8)	(9)	(10)	(11)	(12)
Second-stage results						
Exposure to bombing	-0.0558	-0.0856	-0.2505	-0.1958	-0.1279	0.0194
	(0.0419)	(0.0455)	(0.1768)	(0.1315)	(0.1737)	(0.1096)
Controls	Y	Y	Y	Y	Y	Y
Commune fixed effects	Y	Y	Y	Y	Y	Y
Year of birth fixed effects	Y	Y	Y	Y	Y	Y
Observations	6,379	7,520	6,392	7,525	6,381	7,521
Test statistics						
First-stage F-statistic	35.81	70.29	35.97	70.28	35.81	70.29
Endogeneity test[a] (C-stat)	0.25	2.47	0.91	1.41	0.86	0.05
Weak IV test[b] (AR, χ^2)	1.50	3.20	1.55	1.93	0.48	0.03
			Panel C. *South Vietnam*			
	(13)	(14)	(15)	(16)	(17)	(18)
Second-stage results						
Exposure to bombing	-0.1441	-0.3383	-1.0160	-0.9038	-1.0151	-0.1972
	(0.1225)	(0.1456)	(0.4515)	(0.3763)	(0.4222)	(0.2423)
Controls	Y	Y	Y	Y	Y	Y
Commune fixed effects	Y	Y	Y	Y	Y	Y
Year of birth fixed effects	Y	Y	Y	Y	Y	Y
Observations	8,474	9,461	8,488	9,467	8,477	9,462
Test statistics						
First-stage F-statistic	19.20	20.97	19.15	20.55	19.24	20.97
Endogeneity test[a] (C-stat)	1.15	5.46	4.11	5.26	5.08	0.45
Weak IV test[b] (AR, χ^2)	1.31	7.01	4.61	6.64	5.66	0.61

Note: This table reports 2SLS estimates from instrumented difference-in-differences models. Control variables include time of anthropometric measurement, rainfall in the year of birth and ethnicity of the individual. Robust standard errors are reported in parentheses, clustered at the commune level. [a] Tests the null hypothesis that the endogenous variables can in fact be treated as exogenous (Hayashi, 2011). [b] Anderson-Rubin test statistic produced by the command written by Finlay et al. (2015). The null hypothesis is that all weakly identified coefficients are zero. Data from VNHS 2002.

Table 4: Instrumental Variable Estimates of the Impact of bombing on the likelihood of being underweight and overweight

	National		*North Vietnam*		*South Vietnam*	
	Male	Female	Male	Female	Male	Female
	Panel A: *Outcome is BMI < 18.5 - Underweight*					
	(1)	(2)	(3)	(4)	(5)	(6)
Exposure to bombing	0.0348	0.0432	0.0138	0.0060	0.0334	0.0489
	(0.0192)	(0.0209)	(0.0088)	(0.0099)	(0.0252)	(0.0282)
Controls	Y	Y	Y	Y	Y	Y
Commune fixed effects	Y	Y	Y	Y	Y	Y
Year of birth fixed effects	Y	Y	Y	Y	Y	Y
Observations	14,909	17,012	6,398	7,529	8,511	9,483
First-stage F-statistic	33.76	33.49	36.02	70.28	19.20	20.62
	Panel B: *Outcome is BMI ≥ 25 - Overweight*					
	(7)	(8)	(9)	(10)	(11)	(12)
Exposure to bombing	-0.0079	-0.0123	-0.0003	0.0025	-0.0099	-0.0140
	(0.0067)	(0.0065)	(0.0031)	(0.0017)	(0.0089)	(0.0089)
Controls	Y	Y	Y	Y	Y	Y
Commune fixed effects	Y	Y	Y	Y	Y	Y
Year of birth fixed effects	Y	Y	Y	Y	Y	Y
Observations	14,909	17,012	6,398	7,529	8,511	9,483
First-stage F-statistic	33.76	33.49	36.02	70.28	19.20	20.62

Note: This table reports 2SLS estimates from instrumented difference-in-differences models. Control variables include time of anthropometric measurement, rainfall in the year of birth and ethnicity of the individual. Robust standard errors are reported in parentheses, clustered at the commune level. Data from VNHS 2002.

Table 5: Instrumental Variable Estimates of the Impact of Bombing on Cohort Size and Migration Status

	National	*North Vietnam*	*South Vietnam*
	Panel A. *Outcome is cohort size*		
	(1)	(2)	(3)
Exposure to bombing	-0.0521	-0.0223	-0.0425
	(0.0350)	(0.0149)	(0.0495)
Controls	Y	Y	Y
Commune fixed effects	Y	Y	Y
Year of birth fixed effects	Y	Y	Y
Observations	21,294	9,468	11,826
	Panel B. *Outcome is migration*		
	(4)	(5)	(6)
Exposure to bombing	-0.0065	0.0011	0.0198
	(0.024)	(0.007)	(0.035)
Controls	Y	Y	Y
Commune fixed effects	Y	Y	Y
Year of birth fixed effects	Y	Y	Y
Observations	5,972	2,483	3,489

Note: Panel A reports 2SLS estimates from instrumented difference-in-differences models. Control variables include sex, rainfall in the year of birth and ethnicity. Robust standard errors are reported in parentheses, clustered at the commune level. Data source is VNHS 2002. Panel B reports 2SLS estimates from instrumented difference-in-differences models. The dependent variable takes a value of one if the individual's place of residence at the time of data collection is in a different district from their birth district and zero otherwise. Control variables include sex and ethnicity. Bombing is measured at the district level. Robust standard errors are reported in parentheses, clustered at the district level. Data from VLSS 1998.

Table 6: Ordinary Least Squares Estimates of the Association Between Migration and Anthropometric Measures

	National			*North Vietnam*			*South Vietnam*		
Outcome	BMI	Weight	Height	BMI	Weight	Height	BMI	Weight	Height
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Migrant	0.0818	0.146	-0.111	0.0272	-0.302	-0.643	0.111	0.331	0.0851
	(0.0869)	(0.260)	(0.226)	(0.144)	(0.432)	(0.358)	(0.108)	(0.317)	(0.281)
Controls	Y	Y	Y	Y	Y	Y	Y	Y	Y
Commune fixed effects	Y	Y	Y	Y	Y	Y	Y	Y	Y
Year of birth fixed effects	Y	Y	Y	Y	Y	Y	Y	Y	Y
Observations	5,692	5,693	5,692	2,372	2,372	2,372	3,320	3,321	3,320

Note: This table reports OLS estimates from difference-in-differences models. The explanatory variable of interest takes a value of one if the individual's place of residence at the time of data collection is in a different district from their birth district and zero otherwise. Control variables include sex and ethnicity. Robust standard errors are reported in parentheses, clustered at the district level. Data from VLSS 1998.

Table 7: Instrumental Variable Estimates Controlled for Dioxin

		South Vietnam	
Outcome	BMI	Weight	Height
	(1)	(2)	(3)
Exposure to bombing	-0.2764	-1.0255	-0.5915
	(0.1017)	(0.3512)	(0.2577)
Dioxin exposure	-0.000158	-0.001571	-0.001237
	(0.001488)	(0.004756)	(0.002360)
Controls	Y	Y	Y
Commune fixed effects	Y	Y	Y
Year of birth fixed effects	Y	Y	Y
Observations	17,935	17,955	17,939
First-stage F-statistic	26.51	26.34	26.56

Note: This table reports 2SLS estimates from instrumented difference-in-differences models. Total dioxin exposure of cohorts born from 1965 to 1971 is included as a control variable, measured by Stellman et al. (2003) and computed for each commune by Do (2009). This variable takes a value of zero for other cohorts. Dioxin exposure is reported in 100,000 gallons. Control variables include sex, time of anthropometric measurement, rainfall in the year of birth and ethnicity of the individual. Robust standard errors are reported in parentheses, clustered at the commune level. Data from VNHS 2002.

Table 8: IV Estimates of the Impact of Bombing on School Completion

	National			*North Vietnam*			*South Vietnam*		
Outcome	Primary	Lower secondary	Upper secondary	Primary	Lower secondary	Upper secondary	Primary	Lower secondary	Upper secondary
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Exposure to bombing	0.0250	-0.0104	-0.0135	0.0023	0.0034	0.0055	0.0240	-0.0385	-0.0326
	(0.0115)	(0.0128)	(0.0118)	(0.0045)	(0.0067)	(0.0053)	(0.0147)	(0.0177)	(0.0173)
Controls	Y	Y	Y	Y	Y	Y	Y	Y	Y
Commune fixed effects	Y	Y	Y	Y	Y	Y	Y	Y	Y
Year of birth fixed effects	Y	Y	Y	Y	Y	Y	Y	Y	Y
Observations	31,921	31,921	31,921	13,927	13,927	13,927	17,994	17,994	17,994
First-stage F-statistic	44.35	44.35	44.35	52.75	52.75	52.75	26.44	26.44	26.44

Note: This table reports 2SLS estimates from instrumented difference-in-differences models. Control variables include sex, rainfall in the year of birth and ethnicity of the individual. Robust standard errors are reported in parentheses, clustered at the commune level. Data from VNHS 2002.

Table 9: Instrumental Variable Estimates of the Impact of Bombing on the Likelihood of Doing Manual Labor

	National		*North Vietnam*		*South Vietnam*	
	Male	Female	Male	Female	Male	Female
Outcome	Simple labor	Simple labor	Simple labor	Simple labor	Simple labor	Simple labor
	(1)	(2)	(3)	(4)	(5)	(6)
Exposure to bombing	0.0090	0.0238	0.0046	-0.0096	0.0075	0.0509
	(0.0228)	(0.0203)	(0.0082)	(0.0075)	(0.0324)	(0.0298)
Controls	Y	Y	Y	Y	Y	Y
Commune fixed effects	Y	Y	Y	Y	Y	Y
Year of birth fixed effects	Y	Y	Y	Y	Y	Y
Observations	14,556	15,966	6,252	7,393	8,304	8,573
First-stage F-statistic	32.83	36.23	34.73	62.61	18.26	22.01

Note: This table reports 2SLS estimates from instrumented difference-in-differences models. The outcome variable takes a value of one if the individual has an occupation in the "simple laborer" category in agriculture, forestry, fishery, mining, construction and industry or processing. This variable takes a value of zero if their occupation is classified under "leader or manager", "professional occupation", "office worker", "service provider", "trader", "machinery operator" or "driver". This classification is provided by the General Statistics Office of Vietnam in the 2002 Vietnam National Health Survey. Control variables include rainfall in the year of birth and ethnicity of the individual. Robust standard errors are reported in parentheses, clustered at the commune level. Data from VNHS 2002.

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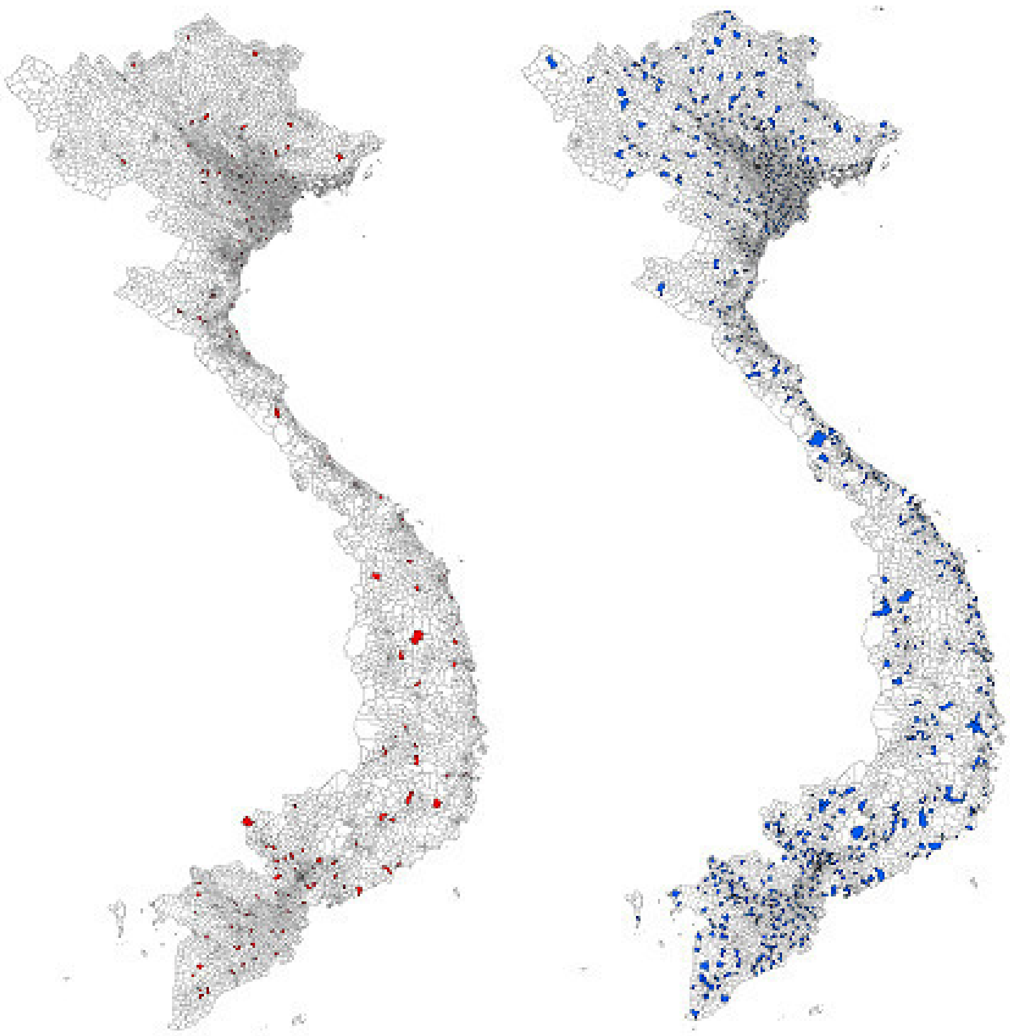
A Appendix

Figure A.1: Maps of Surveyed Communes in 1998 and 2002 Surveys



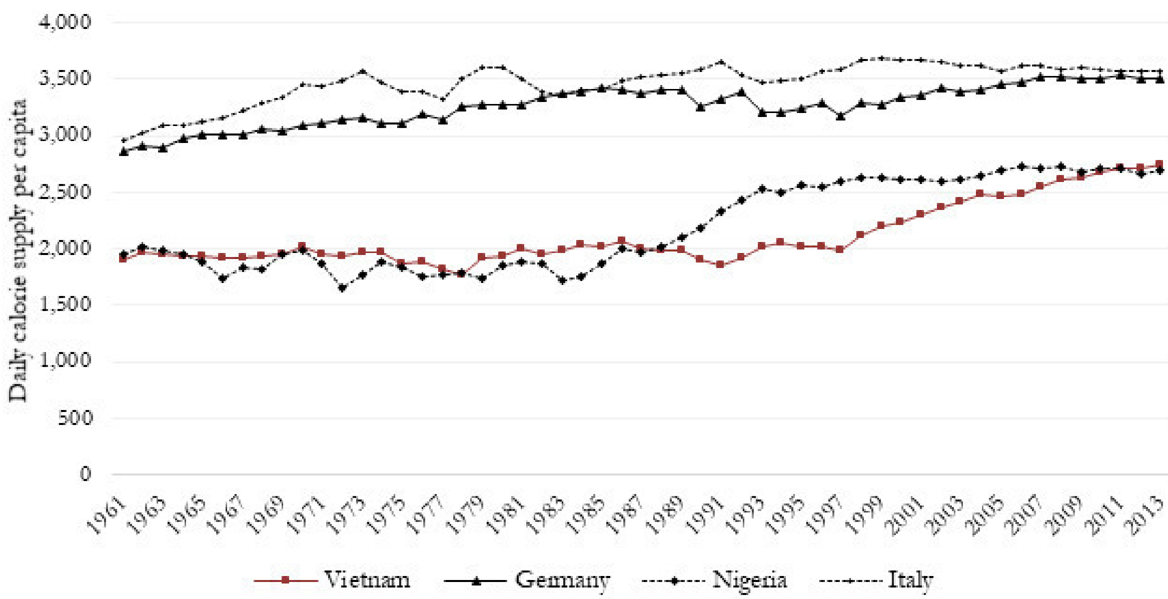
Panel A: VLSS 1998 *Panel B*: VNHS 2002

Note: Each panel shows 10,614 communes on mainland Vietnam. Colored polygons highlight the communes included in each survey.

A.1 Post-war Nutrition Situation in Vietnam

After the end of the war and reunification under communist rule in 1975, Vietnam fell into a prolonged socioeconomic crisis. Central planning caused countrywide stagnation in production. In addition, economic sanctions imposed by the United States, which lasted until 1994, and the cessation of international relations with China between 1979 and 1991 contributed to the worsening situation of an already exhausted economy. Most economic support to Vietnam came from its allies in the Eastern Bloc and the Soviet Union, which was also suffering from a crisis and eventually collapsed in 1991.

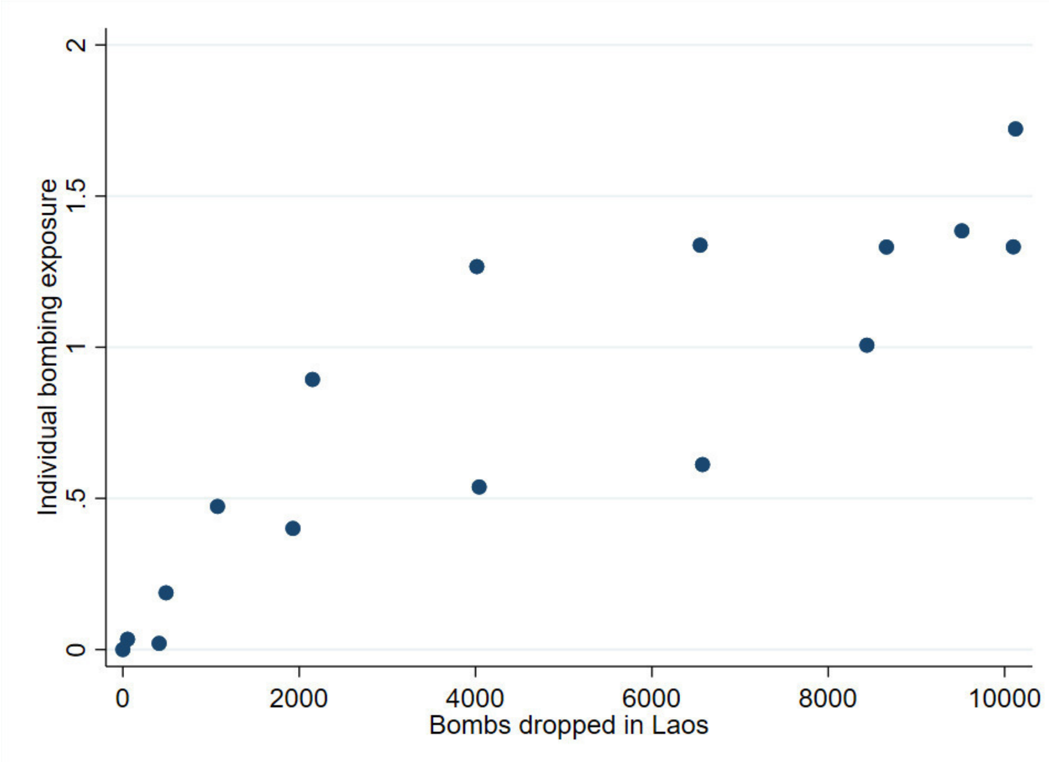
Figure A.2: Daily Calorie Supply per Capita in Vietnam and Selected Countries, 1961–2013



Note: This graph reports daily calorie supply per capita in Vietnam, Germany, Nigeria and Italy from 1961 to 2013. The oldest data point that we could obtain is for year 1961. Data from Food and Agriculture Organization (2020)

Poor economic conditions resulted in the stagnation in nutrition conditions for a prolonged period after the Vietnam War. As depicted in Figure A.2 which is based on data from the Food and Agriculture Organization (2020), daily calorie supply per capita in Vietnam remained low at just or below 2,000 calories for at least two decades after the war. Other data sources have reported even lower figures at just above 1,900 calories (Le et al., 2003). Although the ideal energy intake is subject to physiological factors and energy consumption, a person of healthy body weight usually needs a calorie intake in the low- to mid-2,000s calories (FAO & UN Expert Consultation, 2001). Figure A.2 therefore indicates Vietnam's persistently low level of daily energy intake after the war. This contrasts with Nigeria, which witnessed a dramatic increase in its calorie consumption in the late 1980s, and Germany and Italy, both of which have experienced a high energy intake of greater than 3,000 calories per capita per day since the 1960s (Food and Agriculture Organization, 2020).

Figure A.3: Average Individual Bombing Exposure and Bombing in Laos



Note: This scatter plot shows the relationship between average individual bombing exposure in each birth cohort and bombing in Laos. The sample contains people born between 1960 and 1975. The unit of measure is per thousand pieces of ordnance.

Table A.1: Ordinary Least Squares Estimates of the Impact of Bombing on Adult Height, Weight and BMI, by Sex

Outcome	Male BMI	Female BMI	Male Weight	Female Weight	Male Height	Female Height
			Panel A. *National*			
	(1)	(2)	(3)	(4)	(5)	(6)
Exposure to bombing	-0.0152	-0.0223	-0.0579	-0.0620	-0.0226	-0.0195
	(0.0100)	(0.0100)	(0.0309)	(0.0269)	(0.0232)	(0.0208)
Controls	Y	Y	Y	Y	Y	Y
Commune fixed effects	Y	Y	Y	Y	Y	Y
Year of birth fixed effects	Y	Y	Y	Y	Y	Y
Observations	14,853	16,981	14,880	16,992	14,858	16,983
			Panel B. *North Vietnam*			
	(7)	(8)	(9)	(10)	(11)	(12)
Exposure to bombing	-0.0347	-0.0158	-0.0687	-0.0406	0.0412	-0.00411
	(0.0152)	(0.0148)	(0.0472)	(0.0411)	(0.0397)	(0.0343)
Controls	Y	Y	Y	Y	Y	Y
Commune fixed effects	Y	Y	Y	Y	Y	Y
Year of birth fixed effects	Y	Y	Y	Y	Y	Y
Observations	6,379	7,520	6,392	7,525	6,381	7,521
			Panel C. *South Vietnam*			
	(13)	(14)	(15)	(16)	(17)	(18)
Exposure to bombing	-0.00998	-0.0426	-0.0786	-0.114	-0.0748	-0.0282
	(0.0142)	(0.0144)	(0.0433)	(0.0383)	(0.0308)	(0.0283)
Controls	Y	Y	Y	Y	Y	Y
Commune fixed effects	Y	Y	Y	Y	Y	Y
Year of birth fixed effects	Y	Y	Y	Y	Y	Y
Observations	8,474	9,461	8,488	9,467	8,477	9,462

Note: This table reports OLS regression results from difference-in-differences models. Control variables include time of anthropometric measurement, rainfall in the year of birth and ethnicity of the individual. Robust standard errors are reported in parentheses, clustered at the commune level. Data from VNHS 2002.

Table A.2: First-stage Instrumented Difference-in-differences Results, by Sex

Outcome	*National* Bombing exposure (1)	*North Vietnam* Bombing exposure (2)	*South Vietnam* Bombing exposure (3)
Distance # Bombing in Laos	-0.0638	-0.272	-0.0540
	(0.00416)	(0.00819)	(0.00478)
Controls	Y	Y	Y
Commune fixed effects	Y	Y	Y
Year of birth fixed effects	Y	Y	Y
Observations	31,921	13,927	17,994

Note: This table reports first stage 2SLS results from instrumented difference-in-differences models, controlling for fixed effects at the commune and year of birth levels. Control variables include time of anthropometric measurement, rainfall in the year of birth and ethnicity of the individual. Robust standard errors are reported in parentheses, clustered at the commune level. Data from VNHS 2002.

Table A.3: First-stage Instrumented Difference-in-differences Results, by Sex

	North Vietnam		*South Vietnam*	
Outcome	Male Bombing exposure (1)	Female Bombing exposure (2)	Male Bombing exposure (3)	Female Bombing exposure (4)
Distance # Bombing in Laos	-0.264	-0.279	-0.0518	-0.0550
	(0.0125)	(0.0112)	(0.00675)	(0.00706)
Controls	Y	Y	Y	Y
Commune fixed effects	Y	Y	Y	Y
Year of birth fixed effects	Y	Y	Y	Y
Observations	6,398	7,529	8,511	9,483

Note: This table reports first stage 2SLS results from instrumented difference-in-differences models, controlling for fixed effects at the commune and year of birth levels. Control variables include time of anthropometric measurement, rainfall in the year of birth and ethnicity of the individual. Robust standard errors are reported in parentheses, clustered at the commune level. Data from VNHS 2002.

Table A.4: Instrumental Variable Estimates Controlled for Dioxin, by Sex

	National		*North Vietnam*		*South Vietnam*	
	Male	Female	Male	Female	Male	Female
Outcome	BMI	BMI	Weight	Weight	Height	Height
	(1)	(2)	(3)	(4)	(5)	(6)
Exposure to bombing	-0.1412	-0.3384	-1.0020	-0.9073	-1.0061	-0.2032
	(0.1239)	(0.1459)	(0.4567)	(0.3773)	(0.4262)	(0.2414)
Dioxin exposure	-0.000793	0.000066	-0.003806	0.001702	-0.002458	0.002929
	(0.001385)	(0.002000)	(0.005090)	(0.005713)	(0.003468)	(0.002762)
Controls	Y	Y	Y	Y	Y	Y
Commune fixed effects	Y	Y	Y	Y	Y	Y
Year of birth fixed effects	Y	Y	Y	Y	Y	Y
Observations	8,474	9,461	8,488	9,467	8,477	9,462
First-stage F-statistic	19.12	20.98	19.08	20.56	19.16	20.98

Note: This table reports 2SLS estimates from instrumented difference-in-differences models. Total dioxin exposure of cohorts born from 1965 to 1971 is included as a control variable, measured by Stellman et al. (2003) and computed for each commune by Do (2009). This variable takes a value of zero for other cohorts. Dioxin exposure is reported in 100,000 gallons. Control variables include time of anthropometric measurement, rainfall in the year of birth and ethnicity of the individual. Robust standard errors are reported in parentheses, clustered at the commune level. Data from VNHS 2002.

Table A.5: Instrumental Variable Estimates of the Impact of Bombing on School Completion, by Sex

Outcome	Male Primary	Female Primary	Male Lower secondary	Female Lower secondary	Male Upper secondary	Female Upper secondary
			Panel A. *National*			
	(1)	(2)	(3)	(4)	(5)	(6)
Exposure to bombing	0.0179	0.0371	-0.0074	-0.0105	-0.0307	0.0006
	(0.0154)	(0.0164)	(0.0180)	(0.0201)	(0.0179)	(0.0183)
Controls	Y	Y	Y	Y	Y	Y
Commune fixed effects	Y	Y	Y	Y	Y	Y
Year of birth fixed effects	Y	Y	Y	Y	Y	Y
Observations	14,909	17,012	14,909	17,012	14,909	17,012
First-stage F-statistic	33.76	33.49	33.76	33.49	33.76	33.49
			Panel B. *North Vietnam*			
	(7)	(8)	(9)	(10)	(11)	(12)
Exposure to bombing	-0.0008	0.0032	-0.0029	0.0045	-0.0066	0.0147
	(0.0064)	(0.0062)	(0.0084)	(0.0089)	(0.0088)	(0.0072)
Controls	Y	Y	Y	Y	Y	Y
Commune fixed effects	Y	Y	Y	Y	Y	Y
Year of birth fixed effects	Y	Y	Y	Y	Y	Y
Observations	6,398	7,529	6,398	7,529	6,398	7,529
First-stage F-statistic	36.02	70.28	36.02	70.28	36.02	70.28
			Panel C. *South Vietnam*			
	(13)	(14)	(15)	(16)	(17)	(18)
Exposure to bombing	0.0170	0.0385	-0.0148	-0.0562	-0.0416	-0.0294
	(0.0203)	(0.0204)	(0.0246)	(0.0275)	(0.0253)	(0.0241)
Controls	Y	Y	Y	Y	Y	Y
Commune fixed effects	Y	Y	Y	Y	Y	Y
Year of birth fixed effects	Y	Y	Y	Y	Y	Y
Observations	8,511	9,483	8,511	9,483	8,511	9,483
First-stage F-statistic	19.20	20.62	19.20	20.62	19.20	20.62

Note: This table reports 2SLS estimates from instrumented difference-in-differences models. Control variables include rainfall in the year of birth and ethnicity of the individual. Robust standard errors are reported in parentheses, clustered at the commune level. Data from VNHS 2002.

Table A.6: Instrumental Variable Estimates of the Association Between Migration Status and Anthropometric Measures, by Sex

Outcome	Male BMI	Female BMI	Male Weight	Female Weight	Male Height	Female Height
			Panel A. *National*			
	(1)	(2)	(3)	(4)	(5)	(6)
Migrant	0.156	0.0117	0.192	0.166	-0.337	0.198
	(0.141)	(0.112)	(0.456)	(0.316)	(0.397)	(0.256)
Controls	Y	Y	Y	Y	Y	Y
Commune fixed effects	Y	Y	Y	Y	Y	Y
Year of birth fixed effects	Y	Y	Y	Y	Y	Y
Observations	2,690	3,002	2,691	3,002	2,690	3,002
			Panel B. *North Vietnam*			
	(7)	(8)	(9)	(10)	(11)	(12)
Migrant	0.389	-0.168	0.234	-0.560	-1.192	-0.293
	(0.307)	(0.144)	(1.131)	(0.408)	(0.749)	(0.405)
Controls	Y	Y	Y	Y	Y	Y
Commune fixed effects	Y	Y	Y	Y	Y	Y
Year of birth fixed effects	Y	Y	Y	Y	Y	Y
Observations	1,095	1,277	1,095	1,277	1,095	1,277
			Panel C. *South Vietnam*			
	(13)	(14)	(15)	(16)	(17)	(18)
Migrant	0.0836	0.0996	0.171	0.498	-0.0880	0.403
	(0.157)	(0.149)	(0.491)	(0.418)	(0.465)	(0.334)
Controls	Y	Y	Y	Y	Y	Y
Commune fixed effects	Y	Y	Y	Y	Y	Y
Year of birth fixed effects	Y	Y	Y	Y	Y	Y
Observations	1,595	1,725	1,596	1,725	1,595	1,725

Note: This table reports OLS estimates from difference-in-differences models. The explanatory variable of interest takes a value of one if the individual's place of residence at the time of data collection is in a different district from their birth district and zero otherwise. Control variables include sex and ethnicity. Robust standard errors are reported in parentheses, clustered at the district level. Data from VLSS 1998.