Motivation & Background

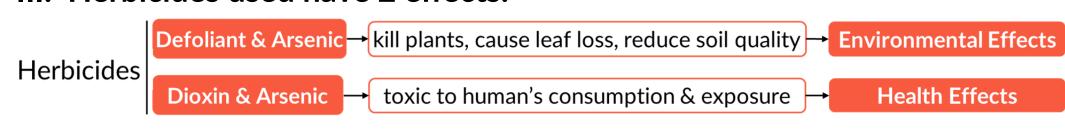
- Second Indochina War 1955 1975:
- . South Vietnam & the US: South Vietnam as an independent political entity – away from communist influence
- North Vietnam & National Liberation Front (NLF)/Viet Cong: a unified Vietnam under communism
- . National Liberation Front (NLF) (a.k.a. Viet Cong) is a group of procommunist South Vietnamese

II. Operation Ranch Hand 1961 - 1971: Spraying of herbicides and defoliants Goal: Derive NLF/Viet Cong's and North Vietnamese Army's vegetation coverage and food sources

Outcomes:

- . 20 millions gallons of herbicides were sprayed on South Vietnam
- · 2.1 4.8 million Vietnamese civilians directly affected
- . At least 20% of forests in South Vietnam were sprayed at least once

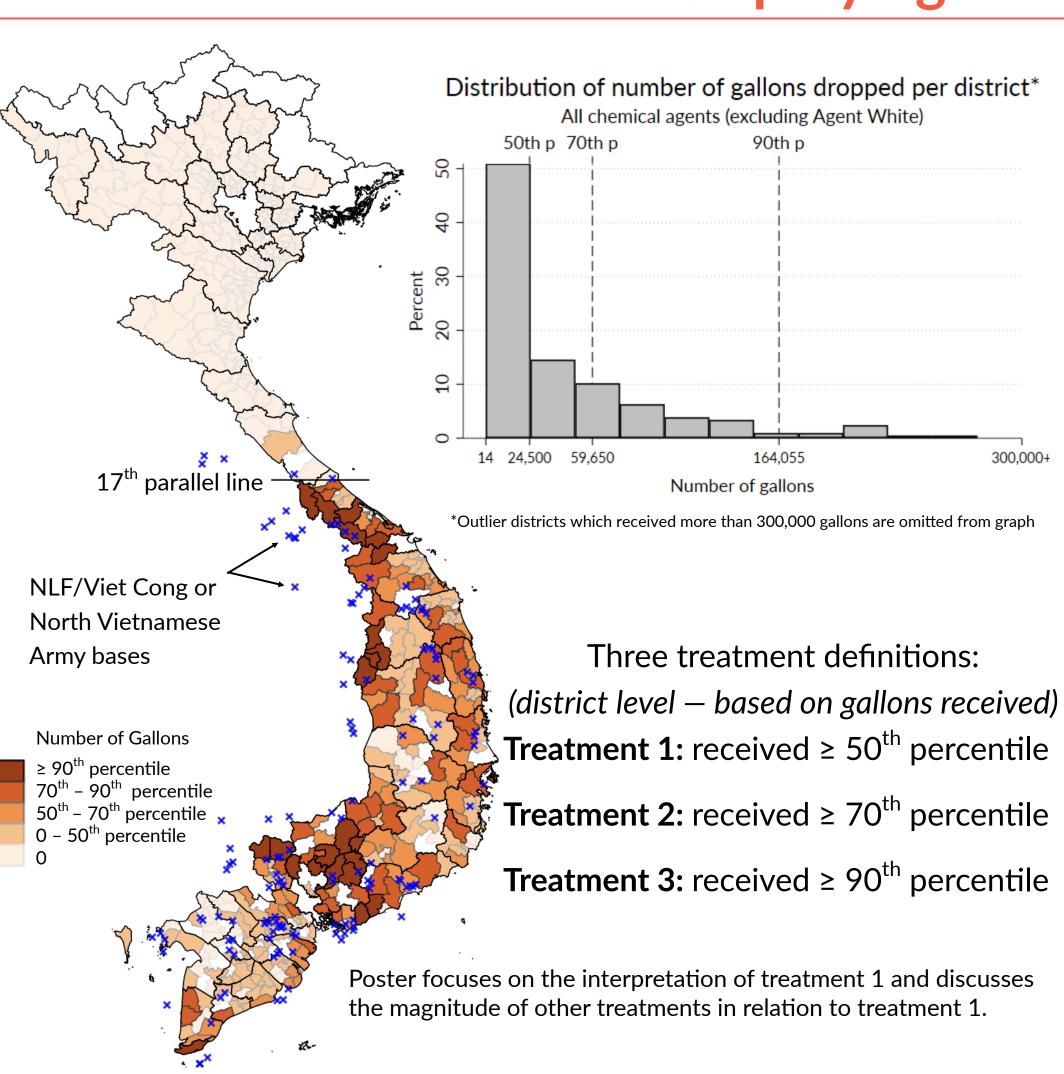
III. Herbicides used have 2 effects:



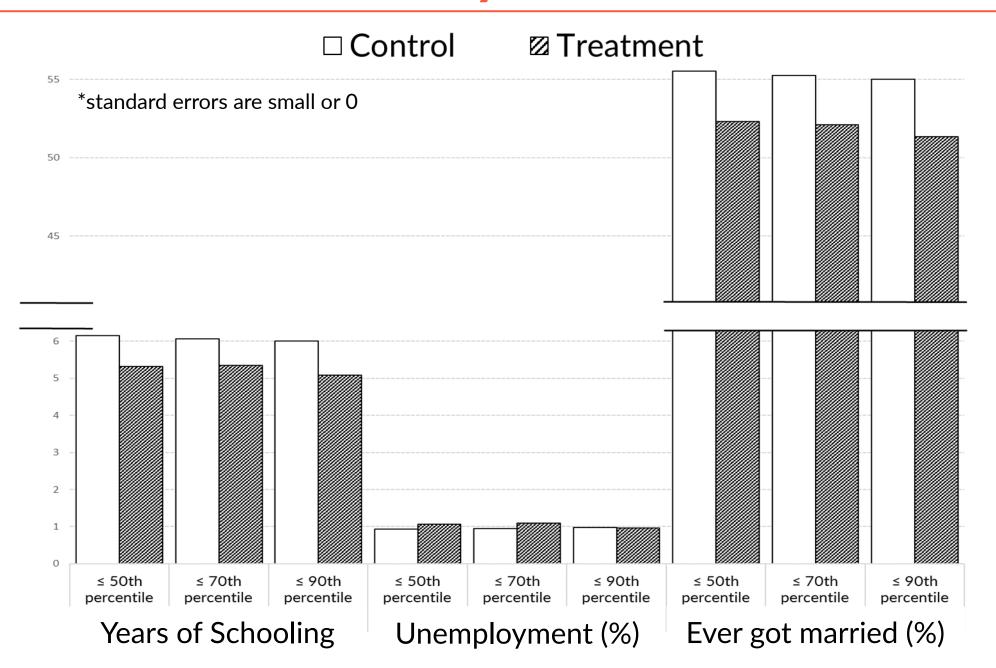
Data

- . **Spraying mission**: Herbicide Reporting System
- . Individual characteristics: 2009 Vietnam Population and Housing Census
- . Bombing Intensity: (Miguel and Roland, 2011)
- . Land use data: Advanced Land Observing Satellite Science Project
- Elevation and soil types: (Hawker and Neal, 2021) & Food and Agriculture Organization of the UN
- Location of NLF/Viet Cong or North Vietnamese Army bases (instrument): Department of Defense, United States

Variation in Herbicides Spraying



Summary Statistics



Reference

Miguel, E., & Roland, G. (2011). The long-run impact of bombing Vietnam. Journal of Development Economics, 96(1), 1-15.

Fortune Sons, Unfortunate People: The Legacy of Herbicidal Warfare in Vietnam

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Advisors: Nicole Fortin & Felipe Valencia Caicedo

Research Questions & Literature

- 1. Does herbicide spraying have long-term effects on current years of schooling, and employment outcomes?
- Nguyen (2023) Agent Orange lowers years of schooling, increases unemployment rate, and (direct exposure) increases mobility disability.
- 2. Are both the environmental and health effects persistent?
- · Le, Pham, and Polachek (2022); Yamashita and Trinh (2022) direct exposure to Agent Orange increases mobility disability.
- Appau et. al. (2021) Agent Orange and negative household rice production.

Research Design — IV

Instrument: Distance from a district centroid to an NLF/Viet Cong or North Vietnamese Army base (Le, Pham, and Polachek, 2022)

• Exclusion Restriction: Base locations are designed to be mobile and unpredictable. On average, a base is active for about 2 years before being abandoned or destroyed.

First-stage regression: Treated_d = $\alpha_0 + \alpha_1 Dist_base_d + \alpha_2 X_{id} + v_d$

Second-stage regression: $Y_{id} = \beta_0 + \beta_1 Treated_d + \beta_2 X_{id} + u_{id}$

Dist_based — Distance between a district centroid and an NLF/Viet Cong or a NVA base (in km)

 $Treated_d$ — Indicating variable if a district receives more gallons of herbicides than the cutoff at 50th, 70th, and 90th percentile

 Y_{id} — outcome of interests for individual i residing in district d

 X_{id} — a set of controls at the individual level, including demographic characteristics, disability status; and at the district level, including rural, elevation, soil composition, and bombing intensity.

*District level regression looks at the proportion of land use for agriculture

Main Results: Unemployment

Individuals in 50th treated districts are **200% more likely to be unemployed**.

Dependent Variable	Unemployed				
	OLS	2SLS			
	(1)	(2)	(3)		
Treated (≥ 50 th percentile)	0.004***	0.018***	0.020***		
	(0.001)	(0.003)	(0.004)		
Mean in the control group _	0.010	0.010	0.010		
Treated (≥ 70 th percentile)	0.004***	0.031***	0.035***		
	(0.001)	(0.006)	(800.0)		
Mean in the control group	0.010	0.010	0.010		
Treated (≥ 90 th percentile)	0.002	0.111***	0.153***		
	(0.002)	(0.032)	(0.050)		
Mean in the control group	0.011	0.011	0.011		
Geographical characteristics	Yes	Yes	Yes		
Bombing Intensity	Yes	No	Yes		

6,920,278 observations and 447 clusters All columns include demographic characteristics, education and disability status control.

Key Findings

- 1. People in treated districts have fewer years of schooling and are more likely to be unemployed.
- → Long-term negative effects on educational and employment outcomes
- 2.a. Health effects: No conclusive evidence
- 2.b. Environmental effects: Treatment groups are less likely to work in agriculture and allocate less land for agricultural products.
- → Evidence that the environmental effects are persistent

First Stage Results

One km closer to a base increases the likelihood of receiving more gallons than the 50th percentile level **by about 43%**

Dependent Variables	Treated (≥ 50 ^{tl}	^h percentile)	Treated (≥ 70 th	percentile)	Treated (≥ 90 th	percentile)
	(1)	(2)	(3)	(4)	(5)	(6)
Distance to VC & NVA base	-0.084***	-0.078***	-0.049 ^{***}	-0.043***	-0.013 ^{***}	-0.010***
(km)	(0.010)	(0.010)	(0.007)	(0.007)	(0.003)	(0.003)
Mean in the control group	0.191	0.191	0.115	0.115	0.028	0.028
F-statistics	70.37	60.21	43.10	34.16	14.81	11.73
Geographical characteristics	Yes	Yes	Yes	Yes	Yes	Yes
Bombing Intensity	No	Yes	No	Yes	No	Yes

Main Results: Education

- An individual in a treated district at the 50th percentile level sees a:
- . 8.9% decrease in years of schooling, and
- . 100% decrease in the likelihood of attaining vocational training.

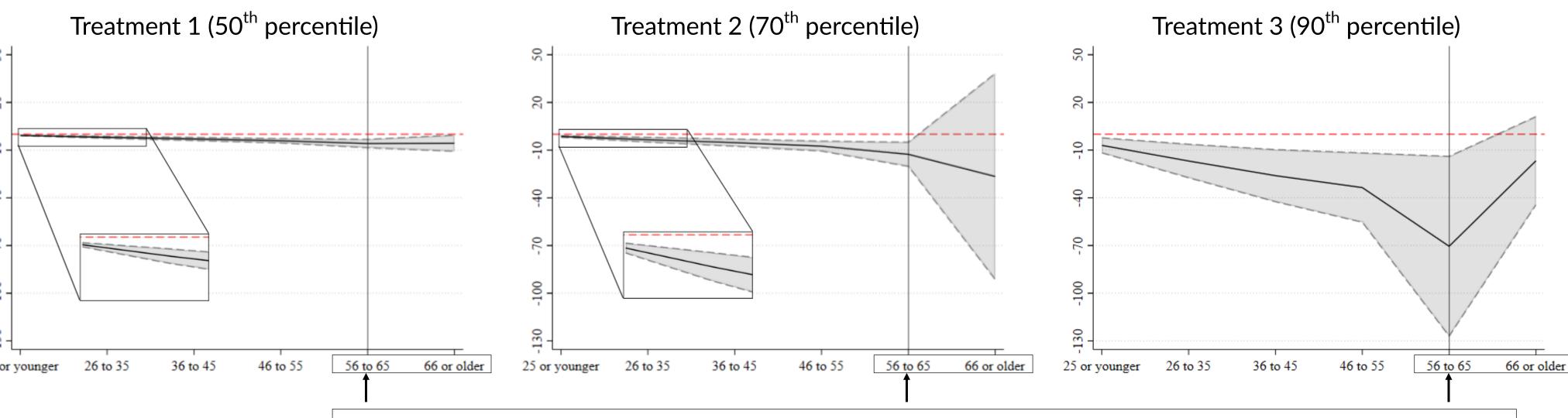
The **negative effects** on educational outcomes **increase** as treated districts are defined to be more heavily sprayed (i.e., going from treatment 1 to 3).

Dependent Variables	Years of Schooling			Vocational Training			
	OLS	2SLS		OLS	2SLS		
	(1)	(2)	(3)	(4)	(5)	(6)	
Treated (≥ 50 th percentile)	-0.037	-0.468***	-0.563***	-0.003**	-0.035***	-0.041***	
	(0.030)	(0.086)	(0.102)	(0.001)	(0.006)	(0.007)	
Mean in the control group	6.340	6.340	6.340	0.041	0.041	0.041	
Treated (≥ 70 th percentile)	-0.024	-0.816***	-1.035***	-0.002	-0.061***	-0.075***	
	(0.036)	(0.174)	(0.231)	(0.002)	(0.011)	(0.015)	
Mean in the control group	6.262	6.262	6.262	0.039	0.039	0.039	
Treated (≥ 90 th percentile)	-0.095**	-3.063***	-5.042***	-0.002	-0.228***	-0.363***	
	(0.047)	(0.953)	(1.797)	(0.002)	(0.067)	(0.123)	
Mean in the control group	6.222	6.222	6.222	0.038	0.038	0.038	
Geographical characteristics	Yes	Yes	Yes	Yes	Yes	Yes	
Bombing Intensity	Yes	No	Yes	Yes	No	Yes	

Main Results: Years of Schooling by Age Group

In treated districts, post-war cohorts (i.e., 55 or younger) have fewer years of schooling.

The negative effects on schooling are larger for districts with higher levels of herbicide exposure.



Cohorts that completed 12 years of high school education + 4 years of college before or during the war

Contributions

- . Provide evidence of the **environmental effects**
- . Literature focused on Agent Orange & direct-exposure health outcomes.
- 2. Consider all herbicides with dioxin and arsenic components
- Literature focused on Agent Orange, which is incomplete.

Environmental and Health (Dioxin) Environmental and Health (Arsen | Environmental only **Agent Orange** Agent Blue **Agent White** Agent Pink **Agent Purple** Agent Green

- 3. Further evidence on the long-term effects of war
- . Miguel & Roland (2011) no long-term impacts of bombing on local poverty rate, consumption levels, infrastructure, and literacy rate.

Environmental or Health?

There is no conclusive evidence for the health effects. Danas dant Vasiables - Unable to work disability C health - Datie Children Comb

Dependent Variables	Unable to work, disability & health		Ratio Children Survived-Born			
	OLS 2SLS		OLS	2SLS		
	(1)	(2)	(3)	(4)	(5)	(6)
Treated (≥ 50 th percentile)	-0.004***	-0.001	-0.002	-0.001	0.003	0.004
	(0.001)	(0.004)	(0.004)	(0.001)	(0.002)	(0.002)
Mean in the control group	0.015	0.015	0.015	0.984	0.984	0.984
Treated (≥ 70 th percentile)	-0.001	-0.001	-0.004	-0.001	0.006	0.007
	(0.001)	(0.006)	(0.007)	(0.001)	(0.004)	(0.004)
Mean in the control group	0.015	0.015	0.015	0.984	0.984	0.984
Treated (≥ 90 th percentile)	-0.005***	-0.005	-0.016	-0.004 [*]	0.023	0.035
	(0.002)	(0.022)	(0.030)	(0.002)	(0.016)	(0.024)
Mean in the control group	0.015	0.015	0.015	0.984	0.984	0.984
Geographical characteristics	Yes	Yes	Yes	Yes	Yes	Yes
Bombing Intensity	Yes	No	Yes	Yes	No	Yes
Observations	6,920,278	6,920,278	6,920,278	930,356	930,356	930,356
Note: *** p<0.01, ** p<0.05, * p<0.1. Standar All columns include demographic characteris			•	here are 447 cluste	ers.	

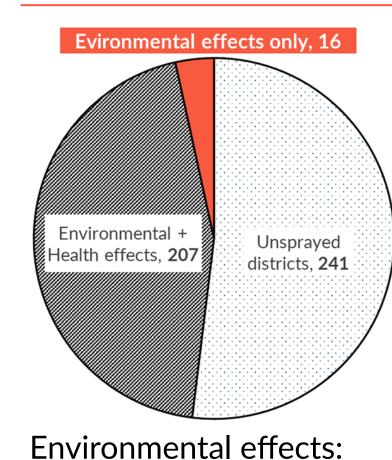
The likelihood of an individual to work in agriculture sees a 84% decrease.

The proportion of land used for agricultural purpose sees a 64% reduction.

Dependent Variables	Dependent Variables Working in Agriculture			Proportional Land Use - Agricultural			
	OLS	2SLS		OLS	2S	2SLS	
	(1)	(2)	(3)	(4)	(5)	(6)	
Treated (≥ 50 th percentile)	-0.042**	-0.372***	-0.390***	-0.158***	-0.286***	-0.336***	
	(0.017)	(0.073)	(0.082)	(0.025)	(0.050)	(0.061)	
Mean in the control group	0.465	0.465	0.465	0.528	0.528	0.528	
Treated (≥ 70 th percentile)	-0.070*** (0.020)	-0.643*** (0.136)	-0.700*** (0.163)	-0.157*** (0.030)	-0.469*** (0.094)	-0.595*** (0.129)	
Mean in the control group	0.468	0.468	0.468	0.503	0.503	0.503	
Treated (≥ 90 th percentile)	-0.015 (0.027)	-2.328 ^{***} (0.690)	-3.070 ^{***} (1.022)	-0.141*** (0.047)	-1.248 ^{***} (0.363)	-1.882*** (0.639)	
Mean in the control group	0.462	0.462	0.462	0.481	0.481	0.481	
Geographical characteristics Bombing Intensity	Yes Yes	Yes No	Yes Yes	Yes Yes	Yes No	Yes Yes	

Note: *** p<0.01, ** p<0.05, * p<0.1. Standard errors clustered at the district level are in parantheses. There are 6,920,278 observations and 447 cluster Columns (1)-(3) include demograpic characteristics, disability status, and education control.

Suggestive Evidence¹: Environmental



. more likely to be

Panel A: Dependent variable: Years of Schooling Treated ($\geq 50^{th}$ percentile) 5.363 5.363 Mean in the control group Panel B1: Dependent variable: Unemployed Mean in the control group Panel B2: Dependent variable: Working in Agriculture Treated (≥ 50th percentile) (0.219)(0.207)0.419 0.419 Mean in the control group Geographical characteristics • fewer years of schooling Bombing Intensity

¹Weak IV

2SLS

unemployed lower agriculture participation

Conclusion

- 1. 38 years after the last spraying mission, people in treated districts have fewer years of education & are more likely to be unemployed.
- 2.a. Fail to confirm health effects strong survivor bias
- 2.b. Evidence for the environmental effects: lower agriculture participation and less agricultural land use
- → Slow catch-up growth, limit career options, and pose nutrient challenges

Why do environmental effects persist?

- . Arsenic inhibits rice growth and is extremely difficult to remove
- . Mass spraying killed the area's biodiversity and created space for invasive species of grasses.
- · Vietnam is a **sub-tropical** country: Without the canopy coverage, soil and new growths are not protected from harsh sun.