

# Identifying the Impact of U.S. State Work Relief Programs on Height using a Polygenic Score

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## Study Question

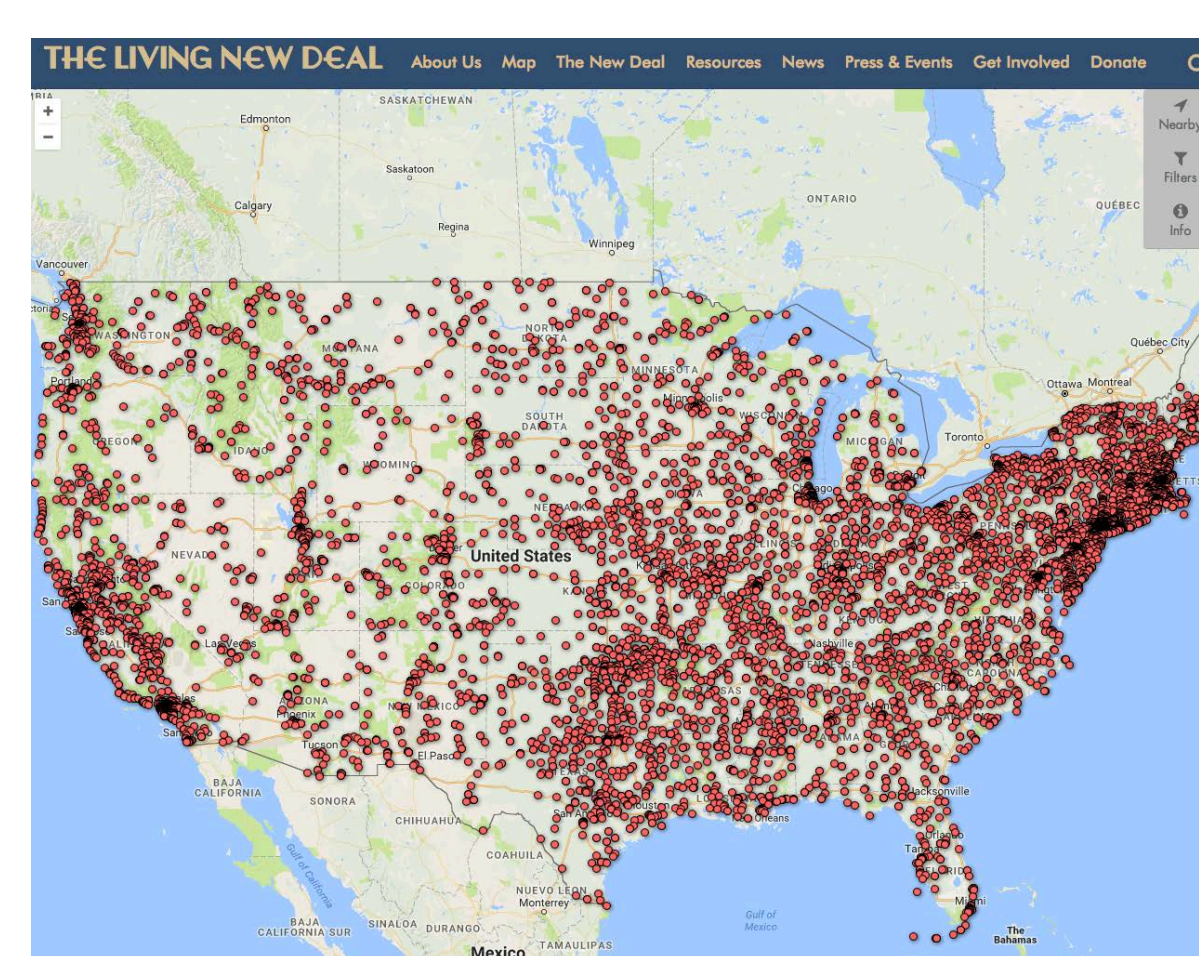
Does incorporating a polygenic score for height allow more sensitive detection of environmental impacts on height?

## Project Overview

The impact of major macroeconomic policy on human health and development is still unclear, and the role that policies play in impacting key health indicators such as height are not well understood. An approach for considering this potential is by examining how the generosity of large public policies varied, policies that have an impact on other more proximal determinants of height that include multiple pathways of impact. One such exposure is unemployment, an attribute that on the aggregate is under substantial influence by various macroeconomic policy levers. The largest temporary policy for increasing employment in the last 100 years was the New Deal associated work relief programs that were implemented beginning in 1932 with the election of Franklin Roosevelt. The total spending of the Works Progress Administration between 1935 and 1943 was \$13.4 Billion, which provided employment for eight and a half million individuals, at the time the population of the U.S. was 132 million.

The material impact of this program was stunning, with the work resulting in 650,000 miles of new or improved roads, 124,000 new or improved bridges, 39,000 schools built, improved or repaired, 24,000 miles of sewer lines installed and 4,000 new or improved utility plants.

The map to the right shows the location of New Deal Programs. Further details are available at [livingnewdeal.org](http://livingnewdeal.org)

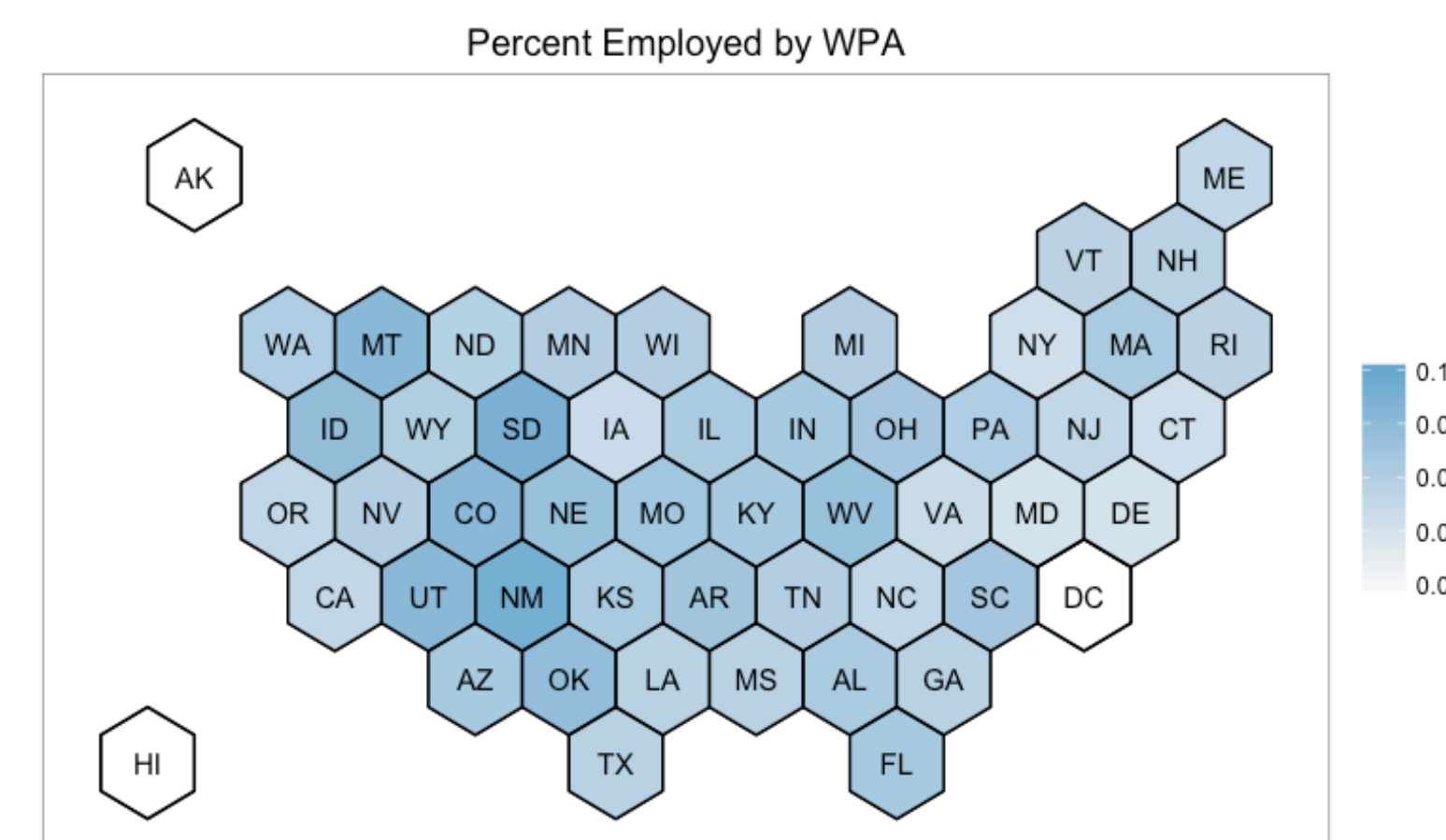


## Data and Exposures

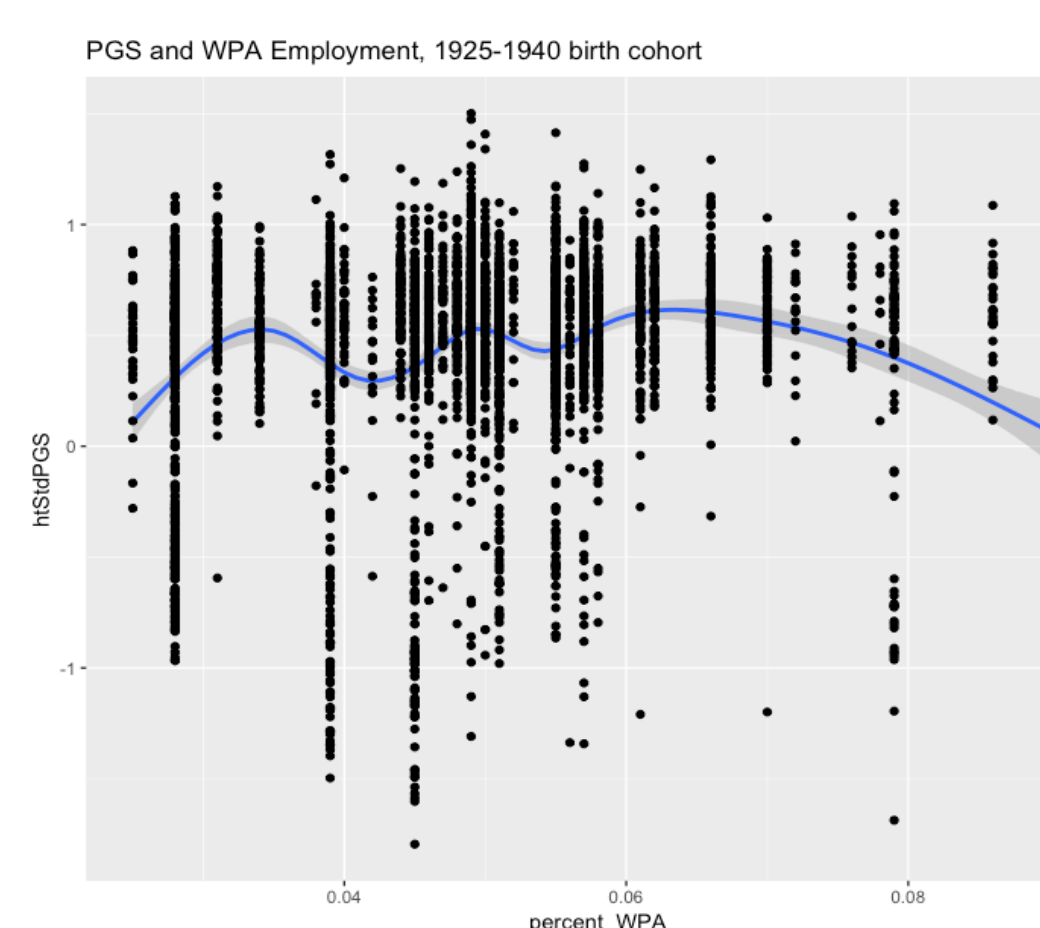
We used data from the Health and Retirement Study from 1992 to 2012. The baseline survey in 1992 was of U.S. residents born 1931 to 1941 and their spouses, with new samples added in 1998, 2004 and 2010. Height was measured among participants. We used a genome wide polygenic score for height as constructed by the Health and Retirement Study. Respondents answered a question on what state they were born in. For exposure we consider three categories of state employment generated by the Work Progress Administration (WPA), 2-4%, 4-6% and greater than 6%. We perform a falsification test with individuals born in the birth cohort 1925 to 1940 as the “treated group”, and those born before and after as “untreated”.

## Descriptive Results

Using 1940 full count public census data we characterized the proportion of working age individuals who received employment through the WPA program by state. This varies between 2% and 9%.



Prior to analyses we analyzed the potential for rGE between state WPA employment and polygenic risk score and found no evidence for this.



## Analytic Results

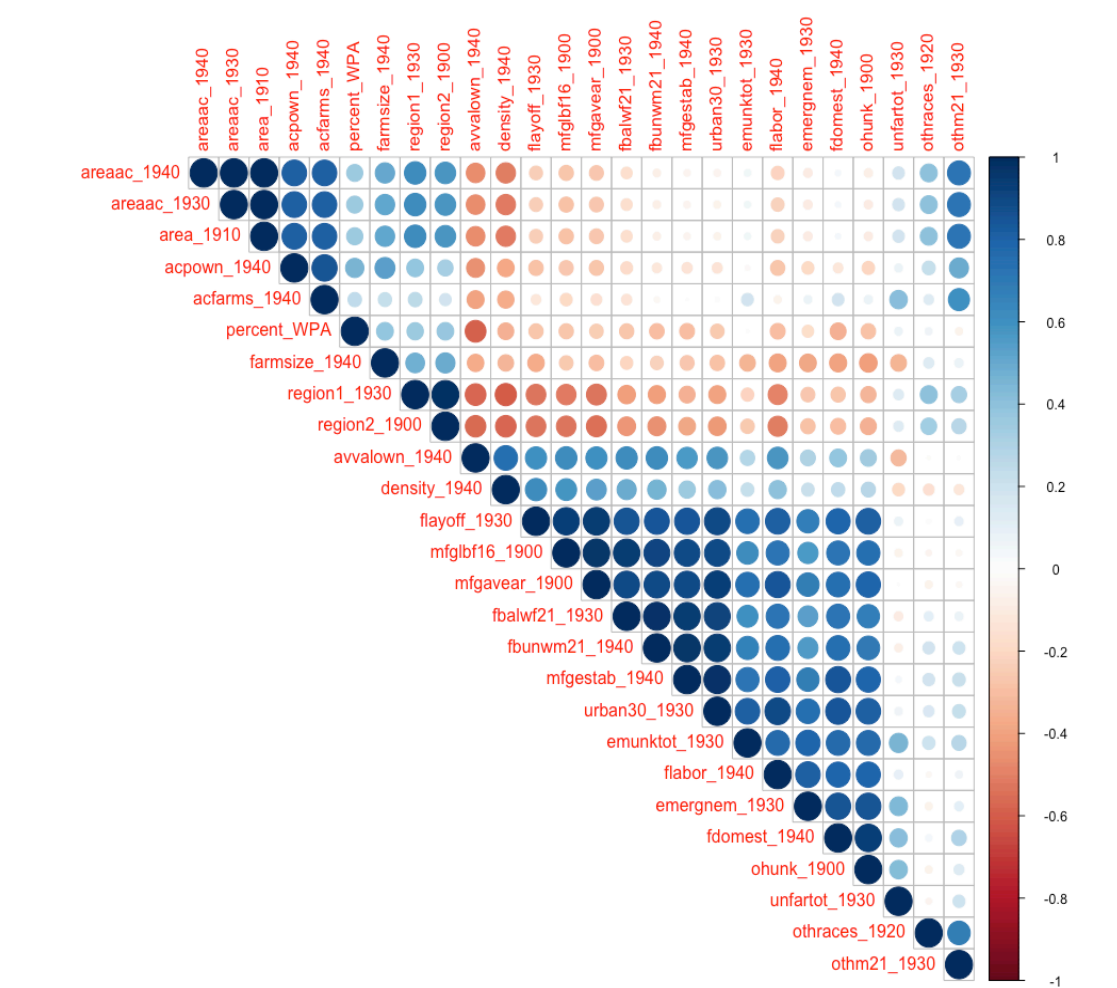
Model 1 shows PGS for height, model 2 WPA employment categories, and model 3 the G x E. The first row shows that in model 1 a one standard deviation difference in the PGS is associated with 2.1 centimeters in height. Model 2 shows that WPA employment category 2 (4-6%) and WPA employment category 3 (>6%) as compared to the omitted WPA employment category 1 (2-4%) are not associated with differences in height. In model 3, the interaction between the polygenic risk score and WPA employment category 3 is associated with 2.2 cm greater height (95% CI 0.611 to 3.955).

	WPA and Height		
	PGS (1)	WPA (2)	G x E (3)
htStdPGS	2.151*** (1.729, 2.574)		2.120*** (1.479, 2.761)
wpacat2		0.330 (-0.203, 0.863)	0.467 (-0.196, 1.130)
wpacat3		0.296 (-0.515, 1.108)	-1.096** (-2.368, 0.175)
single	-6.008 (-15.910, 3.895)	-6.963 (-17.395, 3.469)	-6.786 (-17.121, 3.549)
stateWhite	0.541 (-2.716, 3.798)	0.711 (-2.683, 4.104)	1.048 (-2.305, 4.401)
medianIncome	0.0002 (-0.0001, 0.0004)	0.0002 (-0.0001, 0.0005)	0.0003* (-0.0002, 0.001)
unemployment	4.646 (-5.696, 14.987)	1.341 (-11.135, 13.817)	1.371 (-10.939, 13.682)
highschool	3.474 (-2.407, 9.355)	4.430 (-1.587, 10.447)	3.131 (-2.817, 9.080)
own	-4.319** (-7.626, -1.013)	-4.549** (-8.105, -0.994)	-4.740*** (-8.268, -1.213)
urban	-2.885* (-5.860, 0.090)	-3.170* (-6.359, 0.019)	-3.498** (-6.663, -0.332)
gini	-3.671 (-11.289, 3.947)	-3.813 (-11.733, 4.108)	-2.746 (-10.564, 5.073)
region1	0.098 (-0.873, 1.068)	-0.110 (-1.101, 0.881)	0.101 (-0.879, 1.081)
region2	0.104 (-1.009, 1.216)	0.069 (-1.062, 1.200)	0.020 (-1.097, 1.136)
region3	0.374 (-0.504, 1.251)	0.307 (-0.592, 1.206)	0.253 (-0.634, 1.141)
PC1w	-133.579* (-271.265, 4.106)	48.106 (-86.577, 182.789)	-126.155* (-263.953, 11.644)
PC2w	-2.259 (-1.027, 3.17, 1.022, 7.98)	172.100 (-865.748, 1,209.948)	23.930 (-1,001.052, 1,048.911)
PC3w	-74.135 (-968.698, 820.429)	95.521 (-810.056, 1,001.098)	-31.663 (-925.998, 862.672)
htStdPGS:wpacat2			-0.222 (-1.022, 0.578)
htStdPGS:wpacat3			2.283*** (0.611, 3.955)
Constant	67.554*** (62.497, 72.612)	69.184*** (64.049, 74.319)	67.401*** (62.317, 72.485)
N	3,865	3,865	3,865
Log Likelihood	-11,221.260	-11,269.940	-11,215.800
Akaike Inf. Crit.	22,474.520	22,573.880	22,471.600

Notes: \*\*\*Significant at the 1 percent level. \*\*Significant at the 5 percent level. \*Significant at the 10 percent level.

## Robustness Checks

1. We examined placebo cohorts pre and post that would not be expected to benefit from the policy - **PASS**
2. We used random forest to pick the top 25 covariates that predict state level WPA spending as control variables from among over 400 census variables from 1900 to 1940 (see right). We then refit our models controlling for the top 8 that captured the most variance – **PASS**
3. We included interaction terms between control variables and WPA exposure as well as height PGS - **FAIL**



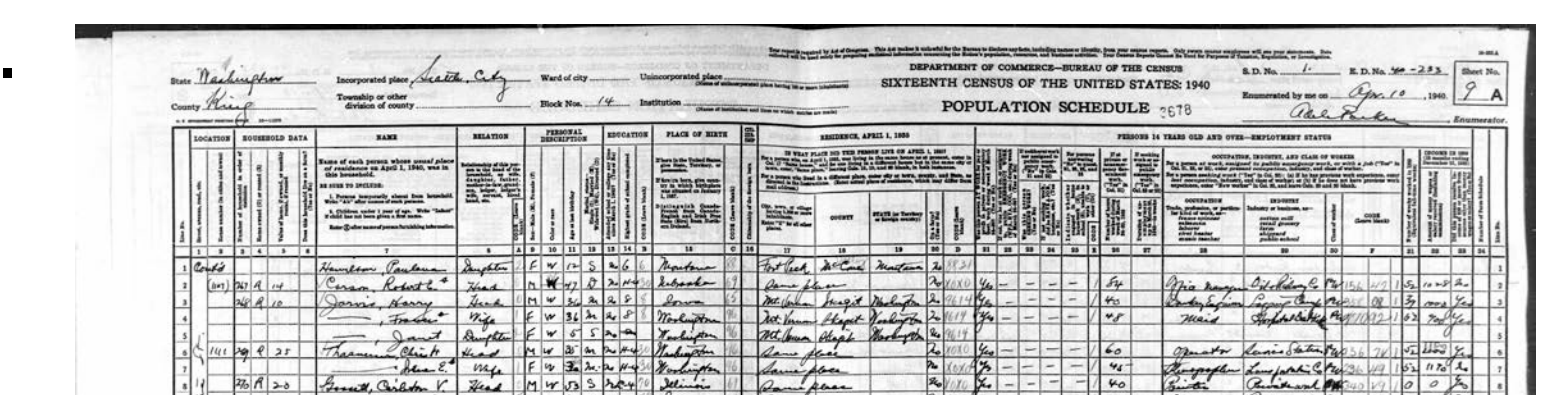
## Conclusion

While initial analyses showed that including a polygenic score for height allowed the identification of effects of the WPA program on attained height, this effect was eliminated after controlling for interactions between control variables and the environmental and genetic exposures.

New data and theory driven approaches to choosing comprehensive controls for confounding in gene x environment studies may have substantial benefits for power and validity of findings in future work.

## Next Steps

1. Examine other environmental exposures for interactions with height PGS for the outcome of attained height.
2. Apply data driven methods for covariate adjustment, including multiple interactions between variables, for statistical control in gene X environment studies.
3. Repeat analyses with individually linked census data. HRS and PSID linkages are being done by Robert Warren (U. Minnesota). We are linking 1940 Census data to the Women's Health Initiative data.



## References and Acknowledgments

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