The Unintended Impact of Home Appliances to the Countryside policy on Childhood Myopia

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The Unintended Impact of Home Appliances to the Countryside policy on Childhood Myopia

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Abstract: This study examines the impact of the Home Appliances to the Countryside policy on childhood myopia in China. Using the 2007 policy rollout as an exogenous shock, we employ a difference-in-differences (DID) approach with data from the 2004 – 2011 China Rural Development Survey (CRDS) and the China Health and Nutrition Survey (CHNS). The results indicate that the policy significantly increased the likelihood of children wearing glasses for myopia. Robustness checks validate these findings, while heterogeneity analyses reveal stronger effects among girls, older children, wealthier regions, and areas where physical education is de-emphasized in exams. Mechanism analyses suggest that the policy led to increased screen-based and near-vision activities, reduced outdoor physical activities and sleep, and higher snack consumption. These findings highlight the potential visual health risks of excessive screen exposure and underscore the importance of interventions aimed at limiting screen time to promote visual health and enhance overall social welfare.

Key words: Home Appliances to the Countryside policy; Electronic Screen Devices; Childhood Myopia; Screen time

JEL Classification Codes: I12; I18; J13

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1. Introduction

Myopia is the predominant issue threatening children's visual health worldwide, with approximately 90% of childhood vision problems primarily attributed to refractive errors caused by excessive axial elongation of the eye, specifically myopia (Yi et al., 2015). Most children are born hyperopic, and as they age, the axial length of the eye increases, leading to emmetropization (Jones et al., 2005). During this process, excessive elongation of the axial length is the main cause of childhood myopia. Such elongation results in myopia, where parallel light rays from distant objects focus before reaching the photoreceptor cells, making it difficult for children to clearly see distant objects, such as a classroom blackboard. Myopia is most prevalent among Asian children (Pan et al., 2012) , and in China—one of the countries with the highest myopia rates—the prevalence among school-aged children has increased by more than 25 percentage points over the past two decades (Zhao & Zhou, 2018). Myopia not only directly raises out-of-pocket medical expenses for children (Ma et al., 2022) , such as vision tests and corrective glasses, but it also negatively impacts academic performance (Glewwe et al., 2016; Nie et al., 2018) and mental health (Pirindhavellie et al., 2023; Yi et al., 2015), potentially adversely affecting income in adulthood. Consequently, extensive literature explores the rapid development of childhood myopia, with educational pressure, increased near-vision activities, and reduced outdoor activities identified as critical factors (Bener et al., 2010; Kozeis, 2009; Morgan et al., 2012). In recent years, as electronic screen products like televisions, computers, and smartphones have proliferated in households, children's leisure activities have shifted from outdoor to indoor settings, significantly altering visual environments and increasing myopia rates. This shift has focused researchers' attention on the potential impacts of electronic screen devices on children's visual health. While existing research has examined correlations between electronic screen devices and children's visual health, studies investigating the causal impact of these devices on childhood myopia remain limited. Therefore, this paper leverages the Home Appliances (Going) to the Countryside (hereafter, HAGC) policy in China to examine the causal impact of introducing electronic screen devices, such as televisions and computers, on myopia among rural children.

Over the past two decades, various screen devices, including televisions, DVD players, computers, smartphones, iPads, and other handheld screen devices, have become widely integrated into household daily life. This phenomenon has raised concerns about the potential negative health impacts of screen devices, particularly among children. Some studies suggest a close association between screen device usage and myopia in children; however, this perspective has not reached scientific consensus (Lanca & Saw, 2020). A major challenge in researching the relationship between screen device usage and myopia in children is the issue of endogeneity. Many studies employ cross-sectional methods to describe the correlation between screen time and myopia in children, but these studies struggle to clearly define the causal relationship (Zong et al., 2024). Furthermore, existing research has yet to provide evidence that screen time is more harmful than other similar near-vision activities, such as reading or doing homework. Therefore, if increased screen activities merely substitute for other near-vision activities, it is unconvincing to explain the onset of myopia in children solely by the increase in screen activities (Wong et al., 2021). Thus, another key challenge in exploring the causal relationship between screen activities and myopia in children is the lack of comprehensive data on children's time allocation (Foreman et al., 2021). Such data should encompass various types of activities, including near-vision and outdoor activities, along with their specific durations, to provide more precise support for the research. In this paper, we utilize the Home Appliances to the Countryside (HAGC) policy as an exogenous shock to observe the causal effect of introducing electronic screen devices on myopia in rural children and employ the rich data on children's activities covered by the China Health and Nutrition Survey (CHNS) to explain the mechanisms behind the development of myopia in children.

The HAGC policy provided a variety of household appliances to rural families in China at discounted prices, significantly altering these households' lifestyles. The products included in the policy ranged from televisions, computers, and mobile phones[†] to washing machines, refrigerators, motorcycles, water heaters, and air conditioners. Among these, televisions and computers, as electronic screen products capable of displaying multimedia content, have profoundly changed the way rural children engage in leisure activities. Before the introduction of electronic screen devices, rural children's leisure activities primarily consisted of outdoor pursuits such as fishing, running, and swimming. With the entry of electronic screen devices into homes, children's leisure activities shifted towards indoor activities, such as watching television programs and playing computer games. This increase in screen activities during leisure time has led to more frequent near-vision

[†] In the Home Appliances to the Countryside policy, the primary mobile phones sold were traditional non-smart phones, which typically supported only call and text services, lacked touchscreens or high-resolution displays, and could not directly access the internet. In this paper, we do not classify these non-smart phones as electronic screen devices.

tasks, reducing viewing distance and increasing the risk of axial elongation and myopia. The reduction in outdoor activities decreased the time children's eyes are exposed to bright outdoor light, which reduces dopamine secretion in the retina and further increases the risk of axial elongation. Additionally, when using electronic screens for viewing or gaming, children often neglect to adjust ambient lighting and fail to take regular breaks for their eyes, exacerbating eye strain and reducing the eye's ability to accommodate, thereby increasing the risk of myopia. The use of electronic screen devices also poses potential risks to myopia by reducing children's sleep time and increasing snack consumption. However, while extensive literature establishes a correlation between electronic screen devices and childhood myopia, there is a lack of in-depth discussion on the causal impact of these devices on myopia and the mechanisms involved. This paper utilizes the 2007-2011 HAGC policy as an exogenous shock to identify the causal impact of introducing electronic screen devices on myopia among rural children in China.

The potential endogeneity of household electronic device usage presents a challenge in identifying the causal impact of electronic screen devices on childhood myopia. Higher-income families have more opportunities to adopt electronic screen devices earlier, and the presence of an income-health gradient may lead to biased estimation results. To address this challenge, this paper leverages the exogenous shock provided by the HAGC policy to overcome potential endogeneity issues. Between 2007 and 2011, the policy was implemented in phases across provinces over a four-year period. The main aspect of the policy involved selling household appliances, such as televisions and computers, to residents in rural areas at a discounted price of 13%, significantly incentivizing rural residents to purchase appliances, particularly entertainment products like televisions and computers. Statistics indicate that during the policy period, over 200 million household appliances were sold nationwide. The average number of televisions per 100 rural households increased by 27.47 units, and computers by 18.63 units. The introduction of electronic screen devices like televisions and computers into rural areas greatly stimulated interest and use among residents, especially children and adolescents. From 2004 to 2011, the average screen device usage time for children increased by 135.07 minutes per week, an increase of 23.08%. Accordingly, this paper employs a staggered Difference-in-Differences (DID) model using the temporal variations in the provincial implementation of the HAGC policy to examine changes in childhood myopia in areas affected by the policy compared to those not yet affected, before and after the policy's implementation.

Based on the results of the difference-in-differences analysis, we find that the HAGC policy significantly increased the probability of children wearing glasses for myopia. After the implementation of the policy, the probability of children wearing myopic glasses increased by 6.09%. We further discuss the causal mechanisms through which the policy affects childhood myopia from the perspectives of near-vision activities and physical activities. The results indicate that, on one hand, the policy increased children's screen activities without a significant substitution effect on other near-vision activities such as reading, doing homework, or sedentary games. This means that the total time children spend on near-vision activities increased, raising their risk of myopia. On the other hand, the policy reduced children's physical activities, particularly outdoor physical activities, decreasing the overall time children spend outdoors and increasing the risk of developing myopia. Additionally, the policy reduced children's sleep time and increased snack consumption, further elevating the risk of myopia. Our heterogeneity analysis indicates that the policy's impact on myopia is greater among girls, older children, children in regions with higher per capita GDP, and children in regions where sports scores account for a lower proportion of the high school entrance examination scores.

Our paper enriches the literature on the relationship between the HAGC policy and health, particularly by adding to the literature on the policy's impact on children's vision health. In the current body of literature, researchers primarily focus on the policy's effects on aspects such as weight, height, and nutritional intake (Chen et al., 2015; Du et al., 2024; Shi et al., 2022). They use similar identification strategies to study the policy's positive impacts on adult overweight issues and children's development. Unlike these studies, we focus on children's vision development outcomes and find that electronic screen devices provided by the policy increased the rate of myopia among children. This suggests that the modern appliances provided by the policy have unexpected adverse effects on children's health.

This paper also contributes to a body of literature focusing on the factors influencing childhood myopia. The existing literature primarily addresses the effects of genetics, education, and outdoor activities (Fan et al., 2014; Mountjoy et al., 2018; Rose et al., 2008). Recent studies have shifted attention to the increasing prevalence of electronic screen devices (Wong et al., 2021).

However, these studies primarily focus on the correlation between screen devices and childhood myopia, with limited exploration of their causal relationship (Lanca & Saw, 2020). Our study leverages the exogenous impact of the HAGC policy to observe the causal effects of electronic screen devices entering households on childhood myopia, providing more robust evidence for the factors contributing to childhood myopia. Additionally, our findings carry significant policy implications, suggesting that limiting children's exposure to electronic screens may help improve their vision health.

The remainder of this paper is organized as follows. Section 2 introduces the background of the Home Appliances to the Countryside Policy in China. Section 3 describes the empirical strategy and data used in this study. Section 4 reports the main results, robustness checks, and heterogeneity analysis. Section 5 discusses the potential mechanisms. Section 6 concludes.

2 Background: Home Appliances to the Countryside Policy in China

Following the outbreak of the 2007 global financial crisis, the Chinese government implemented a five-year Home Appliances to the Countryside (HAGC) policy aimed at stimulating domestic consumption to counter the decline in exports. In November 2007, the Ministry of Finance and the Ministry of Commerce jointly issued the Implementation Plan for the Pilot Program of the HAGC policy and the Notice on Launching the Pilot Program of the HAGC policy, marking the official rollout of the initiative. Under this policy, rural households with agricultural household registrations were eligible for a 13% rebate on the purchase of specific categories of home appliances. The rebate rate was set in line with the export tax rebate rate, and the subsidy costs were shared between central and local governments, with the central government covering 80% and provincial governments covering 20%. Each household was allowed to purchase up to two items per product category. To claim the rebate, households needed to submit receipts to their local finance bureaus.

The policy's timeline is as follows: In December 2007, the program was first piloted in rural areas of Shandong, Henan, and Sichuan provinces, covering four product categories—televisions, washing machines, refrigerators, and mobile phones. In December 2008, the program expanded to Inner Mongolia, Heilongjiang, Liaoning, Anhui, Hubei, Hunan, Guangxi, Chongqing, and Shaanxi. By February 2009, the policy was fully implemented in rural areas nationwide, and the product categories were extended to include computers, motorcycles, water heaters, and air conditioners. Each province could select two of the four new categories for promotion. Table 1 outlines the implementation schedule by province. The policy also set maximum price limits for subsidized products, such as 3,500 Chinese yuan for televisions and 1,000 Chinese yuan for mobile phones. Rural consumers purchasing products above these price ceilings were not eligible for the subsidy.

Table 1 The implementation years and provinces of the Home Appliances to the Countryside policy.

Province(s)	Period	Products
Shandong, Henan, Sichuan	2007-2011	Televisions, refrigerators, mobile phones, washing machines
Shandong, Henan, Sichuan, Inner Mongolia, Liaoning, Heilongjiang, Anhui, Hubei, Hunan, Guangxi, Chongqing, Shaanxi	2008-2012	Televisions, refrigerators, mobile phones, washing machines
All provinces nationwide	2009-2013	Televisions, refrigerators, mobile phones, washing machines, computers, air conditioners, water heaters, motorcycles

Note: Jiangsu and Guizhou provinces in the sample had not implemented the rebate at the beginning of 2009 but had introduced it by the end of the year.

3 Empirical strategy and data sources

3.1. Empirical strategy

The introduction of the HAGC policy provides a unique opportunity to examine the causal impact of household electronic screen devices on children's myopia outcomes. Additionally, it facilitates an investigation into potential mechanisms by analyzing changes in children's time-use patterns. Our empirical strategy leverages the staggered implementation of the policy across provinces, enabling the construction of a Staggered Difference-in-Differences (DID) model. The baseline specification is outlined as follows:

$$Y_{icpt} = \alpha_1 Treat_i \times Policy_{pt} + \mathbf{X}\gamma + \varphi_i + \lambda_t + \varepsilon_{icpt} \quad (1)$$

Here, i, c, p, and t represent individual, county, province, and survey wave, respectively.

Y_{icpt} indicates the outcome variable for child i in county c, province p, during wave t. $Treat_i$ indicates whether the individual is in the treatment group (rural registered resident = 1, otherwise = 0). $Policy_{pt}$ is a dummy variable representing the implementation of the policy, taking the value of 1 for province p during and after the policy implementation, and 0 otherwise. α_1 is the coefficient of interest, capturing the causal impact of the HAGC policy on the outcome variable. $\mathbf{X}$ is a vector of control variables at the individual, household, and county levels, including age, education level measured by years of formal education, household size, household income, county-level GDP per capita, county population density, the ratio of secondary to tertiary industry output at the county level, and county-level landline coverage rate. φ_i and λ_t represent individual fixed effects and wave fixed effects, respectively, accounting for non-time-varying individual characteristics and time-varying macroeconomic shocks. ε_{icpt} is the random error term clustered at the county level.

To validate the identification strategy, we have implemented a series of robustness checks. These include assessing treatment effect heterogeneity, conducting placebo tests, controlling for concurrent policies, incorporating county-level time trends, accounting for county characteristics, and employing wild cluster bootstrap methods. Detailed results of these analyses are presented in Section 4.

3.2. Data and variables

This study utilizes three primary data sources: the China Rural Development Survey (CRDS), the China County Statistical Yearbook, and the China Health and Nutrition Survey (CHNS).

Data on children's myopia are drawn from the CRDS, a survey conducted by the Center for Chinese Agricultural Policy at the Chinese Academy of Sciences over five waves (2004, 2008, 2011, 2016, and 2019). The CRDS employs stratified multistage random sampling to capture diverse economic, social, and health conditions across five provinces. China was initially divided into five regions based on agricultural production conditions and economic development levels: the Northeast (Liaoning, Jilin, Heilongjiang), the eastern coastal region (Jiangsu, Zhejiang, Shandong, Fujian, Guangdong), the northern and central regions (Hebei, Henan, Anhui, Hubei, Hunan, Jiangxi), the northwest Loess Plateau region (Shanxi, Mongolia, Ningxia, Gansu, Qinghai, Xinjiang), and the southwest region (Sichuan, Guizhou, Yunnan, Guangxi). From these, five provinces were randomly selected: Jilin, Jiangsu, Hebei, Shaanxi, and Sichuan. In each province, counties were ranked by per capita industrial output value, and five were randomly selected at equal intervals, resulting in 25 sample counties. Within each county, towns were similarly ranked and divided into two groups, with one town randomly selected from each group, producing 50 sample towns. Subsequently, two villages were randomly selected from each town, totaling 100 villages. In each village, 20 households were chosen using household lists and random numbers, resulting in a sample of 2,000 households (approximately 8,000 individuals). For this study, the final sample includes all rural children aged 18 and below.

The primary outcome of interest in this study is the myopia rate among children. Myopia is commonly defined by a negative diopter value; however, detailed diopter measurements for children in rural China are scarce. As a result, this study uses the wearing of glasses for myopia as a proxy to assess children's myopia status. In addition to vision-related data, the household questionnaire collected comprehensive socioeconomic information at both the individual and household levels, including children's age and education, household size, and income. These variables serve as key controls and provide robust support for the baseline specification.

To account for county-level factors that may influence the policy's implementation, four variables are controlled for in the baseline specification using data from the China County Statistical Yearbook: per capita GDP, industrial structure (measured as the ratio of secondary to tertiary industry output), population density, and landline telephone penetration (landline telephones per 100 people). All socioeconomic data at the county level are sourced from the China County Statistical Yearbook.

Data on children's time use, food consumption, and personal health behaviors are sourced from the China Health and Nutrition Survey (CHNS), a collaborative project by the University of North Carolina at Chapel Hill and the Chinese Center for Disease Control and Prevention's Institute of Nutrition and Health. Conducted over ten waves (1989–2015), the CHNS sample expanded from nine provinces in 1989 to 15 provinces in 2015, covering diverse economic, social, and health conditions. Using multistage, random cluster sampling based on income levels (high, medium, low), the survey randomly selected four counties and two cities per province, followed by random selection of villages and urban communities. Within each village or community, 20 households were chosen. By 2015, the CHNS included over 30,000 respondents from 7,200 households. This study focuses on rural children aged 18 and below within the CHNS sample.

To explore the mechanisms through which the HAGC policy impacts children's myopia, we examine three outcome groups: near-vision activities, physical activities, and other myopia risk factors. First, the policy likely increases children's likelihood and duration of electronic screen use, potentially substituting other activities. However, it remains unclear whether screen use displaces other near-vision activities (e.g., homework) or physical activities. If screen use replaces only other near-vision activities, the overall increase in near-vision activities might be negligible, limiting its impact on myopia. To address this, we empirically analyze children's near-vision and physical activities post-policy implementation. For near-vision activities, three groups of variables are considered: (1) screen activities behavior and time, including television and computer use; (2) reading and homework behavior and time; and (3) sedentary game behavior and time. We hypothesize that the policy significantly increases children's screen time, evidenced by post-policy changes in these activities. For physical activities, we examine indoor and outdoor activities. Due to the lack of indoor sports facilities in rural China, the policy is expected to reduce outdoor physical activities significantly. Regarding other myopia risk factors, we focus on children's sleep and snack consumption. The policy is anticipated to reduce sleep duration and increase snack intake.

As televisions and computers entering rural households may provide families with health information, we also investigate changes in parental health behaviors, complementing the three mechanisms above. Drawing from Chen and Liu (2022), we hypothesize that increased health knowledge among parents could influence children's myopia outcomes. Specifically, we examine fathers' and mothers' smoking, drinking, health insurance participation, and regular medical check-up behaviors.

Descriptive statistics for the primary variables used in the analysis are presented in Table 2.

Table 2. Summary Statistics.

Variable	N	Mean	SD	Min	Max
Individual Variables					
Wearing myopia glasses	4290	0.06	0.24	0	1
Gender	4290	0.56	0.50	0	1
Hukou	4290	0.94	0.23	0	1
Age	4290	9.74	5.67	0	18
Education	4290	4.27	4	0	14
Near-vision activities	4556	0.94	0.23	0	1
The time of near-vision activities	4556	972.5	768.5	0	7440
Screen activities	4556	0.90	0.30	0	1
The time of screen activities	4556	671.5	584.9	0	5040
Reading and homework activities	4556	0.67	0.47	0	1
The time of reading and homework activities	4556	176.1	320.5	0	4740
Sedentary game activities	4556	0.26	0.44	0	1

The time of sedentary game activities	4556	125.0	307.9	0	4080
Watching TV	4556	0.89	0.31	0	1
The time of watching TV	4556	610.9	526.0	0	4680
Watching the computer	4556	0.14	0.34	0	1
The time of watching the computer	4556	60.61	243.7	0	3990
Physical activities	3539	0.78	0.41	0	1
The time of Physical activities	3539	226.9	391.0	0	4871
Physical outdoors activities	3539	0.71	0.45	0	1
The time of physical outdoors activities	3539	184.0	360.1	0	4871
Physical indoors activities	3539	0.40	0.49	0	1
The time of physical indoors activities	3539	93.50	218.7	0	4871
Sleep for 8 hours	4309	0.95	0.21	0	1
Sleep duration	4309	9.38	1.48	5	16
Snack	4122	71.93	149.3	0	1840
Drink	4122	34.68	146.9	0	2250
Household Variables					
Household size	4290	5.38	1.71	1	15
Annual Household income	4290	2.28	3.34	-4	56.12
County Variables					
Log of County-level GDP per capita	4290	9.89	0.69	8.28	11.40

Log of Population Density	4290	5.72	1.02	3.97	7.76
Output share of manufacturing/services industry	4290	2.16	2.05	0.61	14.96
County-level landline telephone coverage	4290	19.22	10.60	3.36	50.67

Notes: Individual variables include characteristics of the child, such as whether the child wears myopia glasses, gender, household Registration (Hukou): 1 = Rural, 0 = Non-Rural, age, years of education, whether they participate in near-vision activities weekly, time spent on near-vision activities weekly (minutes), whether they participate in screen activities weekly, time spent on screen activities weekly (minutes), whether they participate in reading and homework activities weekly, time spent on reading and homework activities weekly (minutes), whether they participate in sedentary game activities weekly, time spent on sedentary game activities weekly (minutes), whether they watch TV weekly, time spent watching TV weekly (minutes), whether they use a computer weekly, time spent on the computer weekly (minutes), whether they participate in physical activities weekly, time spent on physical activities weekly (minutes), whether they participate in outdoor physical activities weekly, time spent on outdoor physical activities weekly (minutes), whether they participate in indoor physical activities weekly, time spent on indoor physical activities weekly (minutes), whether they sleep more than 8 hours daily, sleep time daily (hours), snack intake daily (grams), and beverage intake daily (grams). Family-level characteristics include family size (number of people) and the family's annual income (10,000 China yuan). County-level characteristics include the logarithm of per capita GDP, the logarithm of population density, the ratio of secondary industry output to tertiary industry output, and the number of landline telephones per hundred people.

4 Main results

4.1. Baseline results

We begin by presenting the regression results from the baseline specification. Table 3 summarizes the impact of the HAGC policy on children's likelihood of wearing glasses for myopia. Column 1 reports the results without any control variables, indicating a positive association. Column 2 includes controls for individual characteristics such as age, years of education, family size, and household income. The result remains significantly positive, with minimal change in the coefficient size. Column 3 further incorporates county-level characteristics, leading to a larger coefficient that is statistically significant at the 1% level. Overall, the HAGC policy is shown to have significantly increased the likelihood of children wearing glasses for myopia, with an estimated 6.09% increase in the rate of glasses use among children.

Table 3. The effect of Home Appliances to the Countryside Policy on Children's wearing myopia glasses.

	(1)	(2)	(3)
	Wearing myopia glasses	Wearing myopia glasses	Wearing myopia glasses
Treat×Policy	0.052**	0.054**	0.061***
	(0.020)	(0.020)	(0.022)
Age		-0.015***	-0.016***
		(0.004)	(0.005)
Education		0.031***	0.032***
		(0.007)	(0.007)
Household size		-0.010	-0.010
		(0.009)	(0.009)
Annual Household income		0.003	0.004
		(0.005)	(0.005)
Log of County-level GDP per capita			-0.051
			(0.060)
Log of Population Density			0.280
			(0.289)
Output share of manufacturing/services industry			-0.002
			(0.007)
County-level landline telephone			-0.001

coverage			
			(0.002)
Wave FE	Yes	Yes	Yes
Individual FE	Yes	Yes	Yes
Observations	4290	4290	4290
R^2	0.892	0.898	0.898

Notes: * denotes significance at the 10% level, ** at the 5% level, and *** at the 1% level. The standard errors clustered at county level are presented in parentheses. The dependent variable is shown on the top of each column.

4.2. Dynamic Estimation of Treatment Effect Heterogeneity

The identification strategy underlying the difference-in-differences (DID) method requires that all groups exhibit a common trend prior to policy implementation. Specifically, the outcome variable should not display significant differences across provinces before the policy is enacted. To verify this assumption, a parallel trend test is conducted. However, consistent estimates of policy effects using a two-way fixed effects model rely on the assumption of strong treatment effect homogeneity. Recognizing the potential heterogeneity in the effects of the HAGC policy across different post-policy periods, this study employs several robust estimation methods that accounts for treatment effect heterogeneity to evaluate the dynamic impacts of the policy on children's myopia (Borusyak et al., 2024; Cengiz et al., 2019; Sun & Abraham, 2021).

Figure 1 illustrates the estimated coefficients of the outcome variable along with their 95% confidence intervals. The results indicate that, prior to the HAGC policy implementation, the estimated coefficients are not statistically significant. Following the policy's implementation, the trend in children’s myopia becomes distinctly positive, with coefficients showing significant positive values. These findings demonstrate that the HAGC policy has a sustained positive impact on children's myopia.

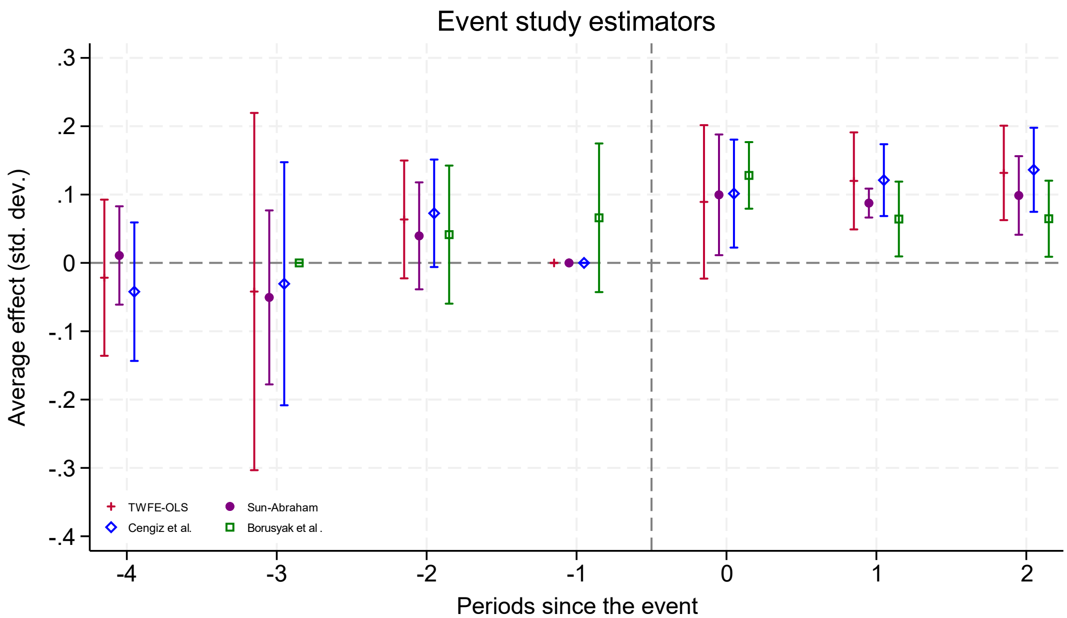

Figure 1. The dynamic effect of Home Appliances to the Countryside Policy on Children's wearing myopia glasses.

4.3. Robustness checks

In this section, we perform a series of robustness checks to validate the baseline results. These include accounting for county-level characteristics, isolating the effects of concurrent policies, modifying the clustering method, and implementing placebo tests.

4.3.1 Considering the County-Level Characteristics

The baseline specification already accounts for county-level characteristics, including per capita GDP, industrial structure (measured by the ratio of secondary to tertiary industry output), population density, and landline telephone penetration rate. However, additional county-level characteristics may still pose potential threats to the regression results. First, we incorporate the logarithms of the number of hospital beds and doctors at the county level as additional control variables. Column 1 of Table 4 shows that the results remain robust after these additions. Second, we address concerns about unobservable county-level factors that could affect children's myopia rates by introducing county-specific linear time trends. These trends capture the effects of all unobservable county-level variables with linear patterns, mitigating potential omitted variable bias. As shown in Column 2 of Table 4, even after including these trends, the HAGC policy significantly increases children's myopia rates, underscoring the robustness of our findings. Third, we consider the possibility that in impoverished counties, where glasses may be less affordable, the rate of glasses wearing among myopic children could be lower, potentially biasing our estimates. To address this, we exclude samples from impoverished counties and re-estimate the baseline regression. Column 3 of Table 4 indicates that the results remain consistent with the baseline findings.

4.3.2 Excluding the Concurrent Policies

We also account for the potential influence of concurrent policies. During the implementation of the HAGC policy, two significant initiatives were underway: the gradual introduction of smartphones with 3G connectivity and the rollout of the Connecting Every Village with Radio and TV Project, which extended cable TV to administrative villages. These developments could have affected children's myopia rates during this period. To address this concern, we control for the timing of the first 3G base station installations in each county and the timing of the Connecting Every Village with Radio and TV Project reaching the villages. This approach helps to isolate the effects of the HAGC policy by mitigating potential confounding influences. As reported in Column 4 of Table 4, the results remain robust.

4.3.3 Change the Clustering Method

Given the small number of clusters at the county level, cluster-robust standard errors may be biased. To address this issue, we employ a multiplicative wild bootstrap procedure with 1,000 repetitions to adjust for the limited number of clusters and re-estimate the baseline specification. As reported in Column 5 of Table 4, the baseline results remain robust.

Table 4. Robustness checks.

	County Characteristics			Concurrent policy	Wild cluster	Changing sample
	(1)	(2)	(3)	(4)	(5)	(6)
	Wearing myopia glasses	Wearing myopia glasses	Wearing myopia glasses	Wearing myopia glasses	Wearing myopia glasses	Wearing myopia glasses
Treat×Policy	0.064^{***}	0.065^{***}	0.054^{**}	0.063^{***}	0.061^{***}	-0.004
	(0.022)	(0.020)	(0.023)	(0.022)	(0.022)	(0.006)
Control Variables	Yes	Yes	Yes	Yes	Yes	Yes
Medical characters at the county level	Yes					
County linear trends		Yes				

All impoverished counties exclusion			Yes			
Concurrent policy controls				Yes		
Cluster level	County	County	County	County	Wildbootstrap	County
The sample aged 18-45						Yes
Wave FE	Yes	Yes	Yes	Yes	Yes	Yes
Individual FE	Yes	Yes	Yes	Yes	Yes	Yes
Observations	4290	4290	3594	4290	4290	9492
R^2	0.899	0.904	0.905	0.899	0.185	0.966

Notes: * denotes significance at the 10% level, ** at the 5% level, and *** at the 1% level. The standard errors clustered at county level are presented in parentheses. The dependent variable is shown on the top of each column. Control Variables contains child's age, years of education, household size, household income, the logarithm of per capita GDP, the logarithm of population density, the ratio of manufacturing industry output to services industry output and landline telephone coverage at county level.

4.3.4 Placebo Test

For adults aged 18 and above, eye development is largely complete, and significant changes in axial length are unlikely. Thus, we do not expect the HAGC policy to have a significant impact on myopia in this demographic. As a first placebo test, we investigate whether the policy affected myopia conditions among adults aged 18 – 45. Column 6 of Table 4 confirms that the policy has no significant impact on this older adult population.

To further assess the robustness of our findings, we conduct a second placebo test to evaluate whether the observed policy effects might result from random chance. Specifically, without altering the number of treated samples per year, we randomly assign a number of pseudo-treated samples equal to the actual treated samples. We then test the policy effects on these randomly generated pseudo-treated samples. Using 1,000 iterations of random sampling, we compare the estimated coefficients of the policy effect for the pseudo-treated group with the baseline results. The distribution of coefficients from the second placebo test is presented in Figure 2, which shows that the mean of the random sampling coefficients is close to zero and follows a normal distribution. The baseline specification's estimated coefficient lies well outside this range, indicating that the observed results are unlikely to be driven by random chance. These findings confirm the robustness of the regression results presented in this study.

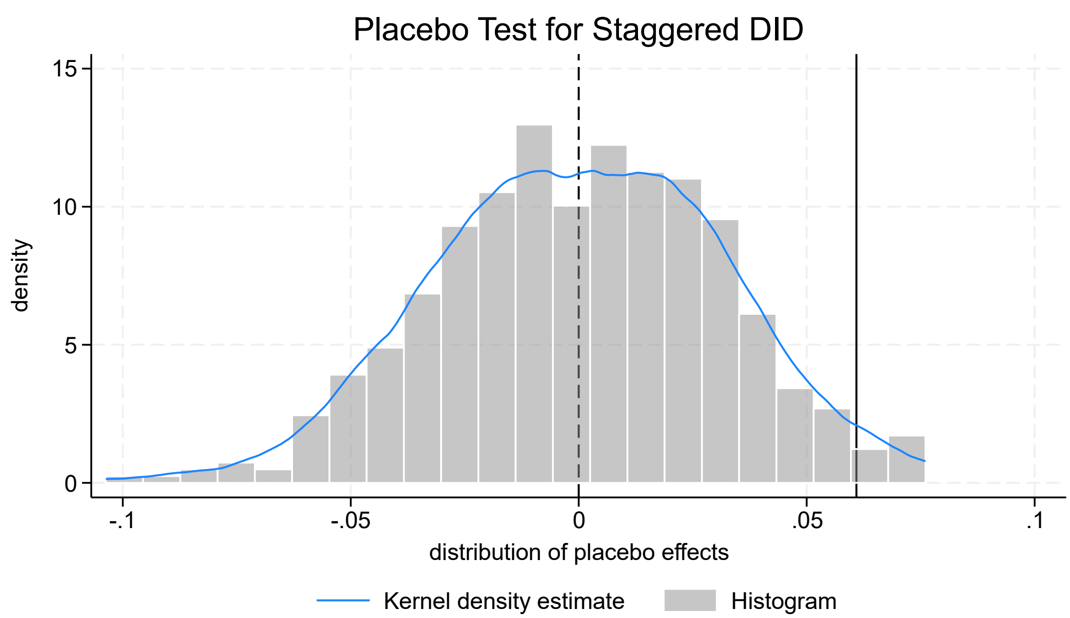

Figure 2. Distribution of Estimated Coefficients of Placebo Test.

4.4. Heterogeneity effects

We next analyze the heterogeneous effects of the HAGC policy on children's myopia from four perspectives: gender, age, GDP per capita, and the weight of physical education scores in high school entrance exams. To estimate these effects, we interact these variables with $Treat \times Policy$ in a triple-differences specification, with results presented in Table 5.

First, we examine the gender-related heterogeneous effects of the policy. Column 1 of Table 5 shows that, compared to boys, girls are significantly more likely to wear glasses due to the policy, with this difference significant at the 10% level. A potential explanation lies in the differing leisure activity preferences between genders. Previous studies suggest that boys are more likely to engage in outdoor activities, whereas girls tend to prefer sedentary activities (Bradley et al., 2000; Cherney & London, 2006). Consequently, after the policy's implementation, girls may have increased their screen time, contributing to a faster rise in myopia rates.

Second, we explore the age-related heterogeneous effects of the policy. Prior research highlights substantial differences in physical development and activity patterns between children under 10 and adolescents aged 10 and above (Alberga et al., 2012; Luo et al., 2023). Using age 10 as the threshold, we find that the policy's impact on children varies significantly by age. Column 2 of Table 5 indicates that children under 10 are much less likely to wear glasses due to the policy compared to adolescents aged 10 and above. This may be explained by the larger hyperopia reserve in younger children (Phelps et al., 2024). Increased screen time in this age group may reduce the hyperopia reserve but not sufficiently to necessitate wearing glasses.

Third, we investigate whether the policy's impact on children wearing glasses varies with the level of economic development in the county. Column 3 of Table 5 uses the median county-level GDP per capita as a threshold (above the threshold = 1, below the threshold = 0). The results indicate that children in higher-income areas are more likely to wear glasses due to the policy. One possible explanation is that the policy acts as a price subsidy for consumers purchasing home appliances, and such price reductions are more effective in stimulating purchases in areas with higher per capita income. Consequently, the policy has a greater impact on children in these regions.

Finally, we analyze the heterogeneous effects of the policy across cities with varying emphasis on physical education scores in high school entrance exams. Using the median ratio of physical education scores to total exam scores as a threshold (above the threshold = 1, below the threshold = 0), we interact this variable with $Treat \times Policy$. The results, presented in Column 4 of Table 5, show that in regions where the physical education score ratio is higher, children are less likely to wear glasses due to the policy. This suggests that physical activities, particularly outdoor sports, have a protective effect on children's vision health. These findings underscore the importance of promoting outdoor activities to safeguard children's visual health and emphasize the policy relevance of incorporating physical exercise into their routines.

Table 5. Heterogeneity analysis.

	Boys	Young age	High GDP	High Sports Scores
	(1)	(2)	(3)	(4)
	Wearing myopia glasses			
Treat×Policy×***X***	-0.066*	-0.102***	0.061**	-0.063**

	(0.034)	(0.027)	(0.028)	(0.029)
Control Variables	Yes	Yes	Yes	Yes
Wave FE	Yes	Yes	Yes	Yes
Individual FE	Yes	Yes	Yes	Yes
Observations	4290	4290	4290	4290
R^2	0.899	0.900	0.899	0.899

Notes: * denotes significance at the 10% level, ** at the 5% level, and *** at the 1% level. The standard errors clustered at county level are presented in parentheses. The dependent variable is shown on the top of each column. Control Variables contains child's age, years of education, household size, household income, the logarithm of per capita GDP, the logarithm of population density, the ratio of manufacturing industry output to services industry output and landline telephone coverage at county level.

5 Potential Mechanisms of the Impact of the Home Appliances to the Countryside policy on Children's vision health

5.1 The Channel of Near-Vision Activities

The HAGC policy directly increased children's electronic screen activities and usage time, potentially leading to a rise in overall near-vision activities and, consequently, an elevated risk of myopia among children. Unlike distant objects, light from nearby objects enters the eyes at sharper angles, forming an image behind the retina. To see these objects clearly, the eyeball elongates so the light focuses on the retina. While short-term elongation of the eyeball may revert to normal, prolonged near-vision activities reduce the eye's ability to recover, causing a permanent increase in axial length. This elongation shifts the focal point of light from distant objects in front of the retina, resulting in myopia (Morgan et al., 2012).

We first assess the effects of the policy on electronic screen and near-vision activities, as presented in Table 6. Columns 1 and 2 indicate that the policy significantly increased both the probability and duration of children's electronic screen usage. Specifically, the likelihood of engaging in electronic screen activities rose by 5.2%, while weekly screen time increased by 121.4 minutes. Columns 3 and 4 show that the policy also increased the probability and duration of children's near-vision activities, though the probability effect in Column 3 is not statistically significant.

These findings suggest that the policy led to an overall increase in near-vision activities, primarily driven by greater electronic screen usage. Increased near-vision activities elevate the risk of myopia in children. However, it remains unclear whether electronic device usage substitutes other near-vision activities. To address this, we further examine other near-vision activities, such as reading, writing homework, and sedentary games, as detailed in Table 7.

Table 6. The effect of Home Appliances to the Countryside Policy on Children's Screen activities and closeup activities.

	(1)	(2)	(3)	(4)
	Screen activities	The time of screen activities	Near-vision activities	The time of near-vision activities
Treat×Policy	0.052**	121.360***	0.020	130.614*
	(0.026)	(41.896)	(0.023)	(75.726)
Control Variables	Yes	Yes	Yes	Yes
Wave FE	Yes	Yes	Yes	Yes
Individual FE	Yes	Yes	Yes	Yes

Observations	4556	4556	4556	4556
R^2	0.736	0.729	0.718	0.697

Notes: * denotes significance at the 10% level, ** at the 5% level, and *** at the 1% level. The standard errors clustered at county level are presented in parentheses. The dependent variable is shown on the top of each column. Control Variables contains child's age, years of education, household size, household income, the logarithm of per capita GDP, the logarithm of population density, the ratio of manufacturing industry output to services industry output and landline telephone coverage at county level.

In Table 7, Columns 1 – 4 present the effects of the HAGC policy on children's reading and writing activities, the time spent on these activities, sedentary play activities, and the time allocated to them. The findings indicate that the policy does not significantly influence the participation or duration of reading, writing, or sedentary play activities.

Several factors may explain these results. First, reading and writing activities, which primarily involve completing homework, are essential components of children's leisure time. Due to the widespread pressure on Chinese children to complete mandatory homework (L. Zhao et al., 2024) and the strict academic expectations held by Chinese parents (Li et al., 2017), screen activities are unlikely to replace homework time. Second, in rural China, limited family wealth and lower availability of sedentary play equipment, such as toy cars and magnetic toys, constrain children's participation in sedentary play activities (Xu & Minca, 2008). This explains the absence of significant policy effects on sedentary play activities among rural children.

Combining the findings from Tables 6 and 7, the HAGC policy has led to an overall increase in children's near-vision activities, driven primarily by the rise in electronic screen use. However, Tables 6 and 7 do not allow us to discern whether the increase in total screen time is attributable to television or computer use. To address this, we further analyze the policy's specific effects on children's TV and computer activities, as shown in Table 8.

Table 7. The effect of Home Appliances to the Countryside Policy on Children's reading activities and sedentary game activities.

	(1)	(2)	(3)	(4)
	Reading and homework activities	The time of reading and homework activities	Sedentary game activities	The time of sedentary game activities
Treat×Policy	-0.035	-21.500	0.100	19.182
	(0.038)	(33.242)	(0.065)	(34.314)
Control Variables	Yes	Yes	Yes	Yes
Wave FE	Yes	Yes	Yes	Yes
Individual FE	Yes	Yes	Yes	Yes
Observations	4556	4556	4678	4678
R^2	0.743	0.701	0.720	0.695

Notes: * denotes significance at the 10% level, ** at the 5% level, and *** at the 1% level. The standard errors clustered at county level are presented in parentheses. The dependent variable is shown on the top of each column. Control Variables contains child's age, years of education, household size, household income, the logarithm of per capita GDP, the logarithm of population density, the ratio of manufacturing industry output to services industry output and landline telephone coverage at county level.

Table 8 presents the effects of the HAGC policy on children's television (TV) and computer activities, as well as the time spent on each. The results show that the policy significantly increased children's TV activities, but had no significant effect on computer use. One possible explanation is the differing durations of promotion for these two products: TVs were promoted for 4 years, while computers were promoted for only 2 years. Moreover, by the early 21st century, widespread TV signal coverage had already made TVs a common household item in rural China, with rural households placing them high on their shopping lists (Rong & Yao, 2003). During the policy period, the average number of TVs per 100 rural households increased by 27.47 units. In contrast, the relatively poor network infrastructure in rural areas, coupled with the higher cost of computers, diminished rural households' willingness and ability to purchase computers, which resulted in lower computer usage among children (Loo & Wang, 2017). Indeed, the average participation rate in computer activities among rural children was only 14%. Consequently, the policy primarily led to an increase in children's TV activities, which became the dominant factor contributing to increased screen time, near-vision activities, and the associated risk of myopia.

Table 8. The effect of Home Appliances to the Countryside Policy on Children's watching TV and watching the computer.

	(1) Watching TV	(2) The time of watching TV	(3) Watching the computer	(4) The time of watching the computer
Treat×Policy	0.050*	116.807**	0.003	4.494
	(0.026)	(46.293)	(0.034)	(15.473)
Control Variables	Yes	Yes	Yes	Yes
Wave FE	Yes	Yes	Yes	Yes
Individual FE	Yes	Yes	Yes	Yes
Observations	4556	4556	4556	4556

R^2	0.733	0.715	0.734	0.748

Notes: * denotes significance at the 10% level, ** at the 5% level, and *** at the 1% level. The standard errors clustered at county level are presented in parentheses. The dependent variable is shown on the top of each column. Control Variables contains child's age, years of education, household size, household income, the logarithm of per capita GDP, the logarithm of population density, the ratio of manufacturing industry output to services industry output and landline telephone coverage at county level.

5.2 The Channel of Physical Activities

Since no substitution effect was found between increased screen time and activities such as reading or sedentary play, we further investigate whether children's physical activities significantly decrease as screen time increases. Table 9 examines the impact of the HAGC policy on children's physical activities. Columns 1 and 2 present the effects on overall physical activities and the time spent, while columns 3 and 4 show the effects on outdoor physical activities and time, and columns 5 and 6 focus on indoor physical activities and time. The results indicate that the policy significantly reduced the time children spent on physical activities, particularly outdoor activities, but had no significant impact on indoor activities. In rural China, indoor sports facilities are scarce, accounting for only about 4.02% of the total number and 0.82% of the total area. Consequently, a large proportion of rural children's physical activities take place outdoors, making outdoor activities the primary component of their overall physical activity. As a result, the policy led to a reduction in outdoor physical activities, which in turn decreased the time children spent exposed to bright outdoor light. This reduction likely contributed to lower dopamine secretion in the retina, further increasing the risk of myopia in children (Feldkaemper & Schaeffel, 2013).

Table 9. The effect of Home Appliances to the Countryside Policy on Children's physical activities.

	(1)	(2)	(3)	(4)	(5)	(6)
	Physical activities	The time of Physical activities	Physical outdoors activities	The time of physical outdoors activities	Physical indoors activities	The time of physical indoors activities
Treat×Policy	-0.044	-76.186**	-0.016	-52.495**	-0.142	-16.516
	(0.038)	(31.544)	(0.057)	(25.370)	(0.085)	(18.006)
Control Variables	Yes	Yes	Yes	Yes	Yes	Yes
Wave FE	Yes	Yes	Yes	Yes	Yes	Yes
Individual FE	Yes	Yes	Yes	Yes	Yes	Yes
Observations	3539	3539	3539	3539	3539	3539
R^2	0.716	0.718	0.709	0.711	0.661	0.726

Notes: * denotes significance at the 10% level, ** at the 5% level, and *** at the 1% level. The standard errors clustered at county level are presented in parentheses. The dependent variable is shown on the top of each column. Control Variables contains child's age, years of education, household size, household income, the logarithm of per capita GDP, the logarithm of population density, the ratio of manufacturing industry output to services industry output and landline telephone coverage at county level.

5.3 Other Risk Factors for Myopia

The increase in children's electronic screen activities not only altered the leisure activities but also affected sleep patterns and dietary habits (Hale & Guan, 2015; Shqair et al., 2019). Both sleep and diet are considered risk factors for myopia (Jee et al., 2016; Lim et al., 2010). Therefore, we investigate the impact of the HAGC policy on children's sleep and food consumption, as shown in Table 10. Columns 1 and 2 display the policy's effects on the proportion of children obtaining at least 8 hours of sleep and their total sleep duration. The results show that the policy reduced both the proportion of children getting sufficient sleep and their overall sleep duration. Insufficient sleep is closely associated with an increase in axial length (X. Zhao et al., 2024), which in turn heightens the risk of myopia in children. Columns 3 and 4 present the effects of the policy on children's snack and beverage consumption. We find that the policy significantly increased children's snack intake but had no significant effect on beverage consumption. The high levels of saturated fat in snacks are believed to contribute to an increase in axial length in children (Lim et al., 2010), thereby further increasing the risk of myopia.

Table 10. The effect of Home Appliances to the Countryside Policy on Children's sleep, snacks and drinks.

	(1) Sleep for 8 hours	(2) Sleep duration	(3) Snack	(4) Drink
Treat×Policy	-0.048**	-0.218*	31.610**	4.589
	(0.023)	(0.113)	(14.574)	(40.380)
Control Variables	Yes	Yes	Yes	Yes
Wave FE	Yes	Yes	Yes	Yes
Individual FE	Yes	Yes	Yes	Yes
Observations	4309	4309	4122	4122
R^2	0.793	0.821	0.768	0.666

Notes: * denotes significance at the 10% level, ** at the 5% level, and *** at the 1% level. The standard errors clustered at county level are presented in parentheses. The dependent variable is shown on the top of each column. Control Variables contains child's age, years of education, household size, household income, the logarithm of per capita GDP, the logarithm of population density, the ratio of manufacturing industry output to services industry output and landline telephone coverage at county level.

5.4 The Channel of Parental Health Knowledge

As guardians of their children, parents play a crucial role in shaping children's activities, which are strongly influenced by both their actions and their health knowledge. We are concerned that the introduction of electronic screen devices into households may encourage parents to seek health information from sources such as TVs and computers, potentially mitigating the risk of myopia in their children. To explore this, we examine the impact of the HAGC policy on parents' health information. Following the approach of Chen and Liu (2022), we use parents' health behaviors as a proxy for health knowledge, as shown in Tables 11 and 12.

Our findings indicate that the policy had no significant effect on parents' health behaviors, suggesting that it did not substantially enhance their health knowledge. One possible explanation is that the health information available through TVs and computers is often limited and frequently disrupted by misinformation, particularly in the form of advertisements. As a result, parents may have received insufficient and ineffective health information from electronic screen devices.

Table 11. The effect of Home Appliances to the Countryside Policy on Mother's healthy behaviors.

	(1)	(2)	(3)	(4)	(5)	(6)
	Smoking of Mother	Cigarette numbers of Mother	Drinking of Mother	Drinking frequency of Mother	Health insurance of Mother	Checkup of Mother
Treat×Policy	0.000	-0.043	0.005	-0.013	0.078	0.020
	(0.005)	(0.079)	(0.029)	(0.050)	(0.068)	(0.024)
Control	Yes	Yes	Yes	Yes	Yes	Yes

Variables						
Wave FE	Yes	Yes	Yes	Yes	Yes	Yes
Individual FE	Yes	Yes	Yes	Yes	Yes	Yes
Observations	3968	3968	3971	3958	3966	3967
R^2	0.765	0.738	0.741	0.766	0.823	0.671

Notes: * denotes significance at the 10% level, ** at the 5% level, and *** at the 1% level. The standard errors clustered at county level are presented in parentheses. The dependent variable is shown on the top of each column. Control Variables contains child's age, years of education, household size, household income, the logarithm of per capita GDP, the logarithm of population density, the ratio of manufacturing industry output to services industry output and landline telephone coverage at county level.

Table 12. The effect of Home Appliances to the Countryside Policy on Father's healthy behaviors.

	(1) Smoking of Father	(2) Cigarette numbers of Father	(3) Drinking of Father	(4) Drinking frequency of Father	(5) Health insurance of Father	(6) Checkup of Father
Treat×Policy	-0.020	0.329	-0.067	-0.152	0.076	-0.025*
	(0.049)	(0.934)	(0.063)	(0.190)	(0.079)	(0.013)
Control Variables	Yes	Yes	Yes	Yes	Yes	Yes
Wave FE	Yes	Yes	Yes	Yes	Yes	Yes
Individual FE	Yes	Yes	Yes	Yes	Yes	Yes
Observations	3507	3485	3523	3484	3521	3516
R^2	0.842	0.857	0.740	0.795	0.833	0.733

Notes: * denotes significance at the 10% level, ** at the 5% level, and *** at the 1% level. The standard errors clustered at county level are presented in parentheses. The dependent variable is shown on the top of each column. Control Variables contains child's age, years of education, household size, household income, the logarithm of per capita GDP, the logarithm of population density, the ratio of manufacturing industry output to services industry output and landline telephone coverage at county level.

6 Conclusion

This paper leverages the exogenous changes introduced by the HAGC policy to examine the impact of electronic screen devices on children's myopia. Our findings indicate that the policy significantly increased the likelihood of children wearing glasses for myopia, with an overall increase of 6.09%. This provides causal evidence for the impact of electronic screen devices on children's myopia.

We conducted a series of robustness checks to verify the main results. These checks confirm that the results remain consistent when using robust methods for heterogeneous treatment effects, accounting for county characteristics, or excluding the effects of concurrent policies. Placebo tests suggest that the observed results are unlikely to be due to random chance.

In heterogeneity analyses, we find that the policy's effects are more pronounced among girls, older children, those from higher-income areas, and in areas where the proportion of physical education scores in high school entrance exams is lower. This suggests that promoting physical activities, especially outdoor activities, may help protect children's vision. Specifically, for adolescents, increasing the weight of physical education scores in exams to encourage greater physical activity could be an effective policy intervention.

Our mechanism tests reveal that the policy significantly increased the time children spent on screen activities and overall near-vision tasks, but did not have a significant substitutive effect on other near-vision activities such as reading or homework. Among the various screen activities, TV viewing saw the largest increase. We also observed a reduction in children's physical activities, particularly outdoor activities, following the policy. The increase in near-vision tasks and the decrease in outdoor physical activities contributed to more time spent on near-vision activities, which may lead to an elongation of the axial length of the eye. Additionally, the reduced exposure to bright outdoor light decreased dopamine secretion in the retina, both of which increase the risk of myopia. Furthermore, the reduction in sleep time and the increase in snack consumption further heightened the risk of myopia. However, we found no evidence that the policy increased parents' health knowledge.

Increasing children's outdoor activities may help mitigate the adverse effects of electronic screen devices on myopia. However, simply encouraging more participation in extracurricular activities may not yield significant results. Chinese children are subject to an education system that places a strong emphasis on academic performance and exams, leading to substantial academic pressure and long periods of sedentary study. Therefore, incorporating more physical education scores into overall exam results, alongside the construction of additional sports facilities and fields, may be more effective in encouraging physical activity.

Finally, we highlight the marginal contributions of this paper to the existing literature: (1) For the first time, we apply causal inference methods to assess the impact of electronic screen devices on children's myopia. By leveraging the exogenous shock of the HAGC policy, we provide reliable estimates of the effects of screen devices on children's visual health, offering the first causal evidence in this area. (2) The policy's effects are not solely positive; the introduction of electronic screen devices into households increases near-vision activities and reduces outdoor physical activities, thereby heightening the risk of myopia. (3) Outdoor physical activities may serve as a significant protective factor against myopia in children, and increasing the weight of physical education in entrance exams could be a feasible and effective policy measure to improve children's visual health.

This paper has some limitations: First, the myopia data is based on whether children wear glasses, meaning that a small portion of myopic children who do not wear glasses may lead to bias in our estimates. Second, the time use and dietary data are collected using a 24-hour recall method, which may result in incomplete recall or random errors. Future research should address these issues to further enhance the robustness of the findings.

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