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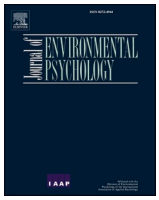

Green anxiety or green well-being? The effect of waste sorting policy on mental health in China

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ABSTRACT

Environmental conditions are increasingly recognized as key determinants of mental health. Waste and garbage, as ubiquitous elements of our environment, significantly influence our daily life and emotional well-being. However, research exploring the impact of waste-management policies, which are defined as institutional rules guiding the sorting, collection, and disposal of household waste, on mental health remains limited. Using data from the China Health and Retirement Longitudinal Study (CHARLS) and a difference-in-differences (DID) approach, we treat the mandatory, state-led waste sorting policy implemented in China since 2017 as a policy shock to investigate its effects on mental health. Our analyses indicate that mandatory waste sorting is associated with better mental health through two dimensions encompassing four specific mechanisms. First, through direct environmental improvements, including higher harmless waste treatment rates that correspond to reduced visible pollution, as well as lower PM2.5 concentrations. Second, through indirect social and behavioral changes, reflected in increased outdoor social interactions and greater participation in physical exercise. However, these benefits are not evenly distributed. Elderly individuals, those with lower education levels, and people with physical impairments do not experience significant mental health improvements following the policy implementation, suggesting potential adaptation challenges. These findings emphasize the need for more inclusive and user-friendly waste management systems to ensure mental health across all social groups.

1. Introduction

In 2013, the World Health Organization emphasized that environmental determinants, including social, cultural, economic, political, and physical factors, play a crucial role in shaping mental health (World Health Organization, 2013). As many environmental policies directly shape the physical conditions in which people live, they can also have meaningful implications for residents' mental health.

Environmental policies may influence mental health through two broad pathways. The first involves improvements in natural and built environmental conditions. Exposure to air pollutants, particularly fine particulate matter and traffic-related emissions, is strongly linked to higher risks of depression, anxiety, and even suicidal behavior, supported by biological evidence of neuroinflammation and altered emotion-related brain function (Buoli et al., 2018; Chen et al., 2024; Gładka et al., 2018; Klompmaker et al., 2019; Radua et al., 2024; Zundel et al., 2022). Non-occupational exposure to hazardous substances such as heavy metals, pesticides, and solvents similarly elevates psychological risks (Dickerson et al., 2020; Ventriglio et al., 2021; Vinti et al., 2021). Residents living near landfills or waste facilities also report poorer mental health, reflecting both potential toxic exposure and heightened perceptions of environmental risk (Lima, 2004). Conversely, environmental policies that reduce air pollution and improve the cleanliness and greenness of urban environments can help to enhance residents' mental health (Alcock et al., 2014; Triguero-Mas et al., 2015). The second pathway operates through behavioral and social mechanisms. Poor environmental conditions, particularly high pollution levels, discourage outdoor leisure and reduce visits to parks and recreational facilities, reflecting avoidance behaviors (Jiang et al., 2019; Sun, 2023; Zheng, 2020). In contrast, favorable outdoor environments can promote physical activity and social interaction - behaviors consistently linked to improved mental health (Hanson & Jones, 2015; Jackson et al., 2021; Lee et al., 2025; Litwiller et al., 2017; Liu et al., 2022; Lourenço et al., 2024). Structured outdoor exercise programs, community walking

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groups, and neighborhood recreation initiatives show reductions in depressive symptoms and increases in well-being, especially among older adults and clinical populations (Hanson & Jones, 2015; Litwiller et al., 2017). Survey evidence further indicates that adolescents and older adults who engage more frequently in outdoor social or nature-based activities report better mental health, even during stressful periods such as the COVID-19 pandemic (Jackson et al., 2021; Liu et al., 2022). Integrative reviews synthesize this evidence and suggest that participation in community-based physical, social, and creative activities can support recovery, promote social inclusion, and enhance mental health among individuals facing psychological challenges (Litwiller et al., 2017).

Despite increasing policy attention to environmental protection, waste management remains a pressing challenge, especially in rapidly urbanizing contexts (Li et al., 2016). Improper disposal of household waste contributes to air pollution, foul odors, visual disorder, and reduced usability of shared outdoor spaces - conditions that may constitute daily, highly visible stressors for urban residents. Yet, compared with research on air quality or green spaces, the mental health implications of waste management policies remain strikingly understudied.

In response to escalating waste generation, many governments have adopted waste-sorting or recycling policies aimed at improving environmental quality (Villafán et al., 2023; Wang et al., 2021; Xiao et al., 2020; Zhang et al., 2021). In China, although some localities began exploring waste sorting at an earlier stage, these initiatives were primarily advocacy-oriented and were not supported by unified directives from the top leadership. A substantial policy shift occurred in 2017, when the central government designated a group of pilot citie to implement mandatory household waste sorting. This policy sought to enhance waste management through systematic categorization and improved treatment processes. Because the policy is embedded in everyday routines, it may generate more immediate psychological responses than many other environmental interventions. While such policies may yield environmental benefits, mandatory participation also requires time, effort, and understanding of sorting rules. Emerging evidence suggests that these demands may create psychological burden or anxiety, particularly for vulnerable groups such as the elderly or individuals with limited education (Cudjoe et al., 2020; Wu & Zhang, 2023). Thus, the psychological consequences of waste-sorting policies are theoretically ambiguous and empirically unclear.

To address this gap, we link nationally representative microdata from CHARLS survey with city-level information on the rollout of mandatory waste-sorting policies. We employ a multi-period DID framework to estimate the policy's impact on mental health and to examine potential mediating pathways through direct environmental improvements and indirect social and behavioral changes. Our analysis also investigates how the effects vary across demographic and socioeconomic groups.

This study makes three key contributions. First, while existing research has primarily examined the physical health and environmental benefits of waste sorting, little attention has been devoted to its psychological implications. By explicitly focusing on mental health outcomes, our study broadens the scope of inquiry and complements prior research on environmental determinants of well-being. Second, whereas earlier analyses have largely relied on single-city evidence, such as studies restricted to Shanghai (Wang et al., 2021; Wang & Shi, 2022), we leverage nationally representative microdata combined with city-level policy implementation records to construct a multi-period DID framework. This approach allows for more credible causal inference and enhances the generalizability of the findings across diverse urban contexts in China. Third, our results reveal significant heterogeneity in policy effectiveness. Specifically, while waste sorting policies are associated with lower depressive symptoms, they provide no measurable benefits for vulnerable groups such as the elderly, individuals with limited education, and those with mobility constraints. These findings underscore the importance of designing inclusive environmental interventions that address the unique challenges faced by marginalized populations.

2. Policy background and theoretical analysis

2.1. Policy background

Rapid urbanization in China has led to a substantial increase in municipal solid waste, resulting in visible environmental disorder and declining neighborhood cleanliness (Adhikari, 2022; Srivastava et al., 2015). Unsorted waste, commonly landfilled or incinerated without pretreatment, has generated unpleasant odors, smoke, and other forms of environmental degradation that residents experience directly in daily life (Abdalrahman Abdalsalam Salem & Fattah, 2021; Tang et al., 2022). These conditions have become salient environmental stressors, heightening psychological discomfort and reducing perceived environmental quality.

In response, local governments in China began experimenting with waste sorting initiatives as early as the 2000s. However, these attempts were fragmented and short-lived. Without unified national coordination and policy support, local authorities struggled to set common standards or mobilize public participation. As a result, enforcement was weak and the programs failed to achieve lasting success. A key turning point occurred in 2017, when the Ministry of Housing and Urban-Rural Development issued *the Implementation Plan for the Domestic Waste Classification System* (https://www.gov.cn/zhengce/content/2017-03/30/content_5182124.htm), which mandated pilot cities to enforce compulsory waste classification. The policy specified requirements across categories, types, disposal, collection, transportation, and treatment of waste. Following this directive, local governments successively introduced corresponding regulations to implement mandatory sorting. As shown in Fig. 1, most regions issued relevant regulations or measures to implement mandatory waste sorting policies in 2018 and 2019.

Under unified national leadership, the mandatory waste sorting policy yielded significant outcomes. According to statistics, within two years of implementation, the coverage rate of waste sorting reached nearly 70% in residential communities across 46 key cities, including municipalities, provincial capitals, and cities with independent planning status. Shanghai exemplified this success. After implementing its mandatory waste sorting regulations in 2019, the compliance rate in residential areas rose sharply from 15% at the end of 2018 to 90% by the end of 2019, with an overall compliance rate of 87% in workplaces. Apart from these measurable outcomes, media reports[1] described visible improvements in neighborhood cleanliness following the policy implementation, including cleaner streets, fewer unpleasant odors, and more standardized waste collection practices. Although these reports are not part of the empirical analysis, they draw on on-site coverage and interviews with residents, reflecting perceived changes in the living environment under the waste-sorting policy.

It is worth noting that pilot cities for mandatory waste sorting were designated by the central government rather than selected voluntarily by local authorities, and the timing of implementation was mainly administrative. Although the selection was not purely random, it can be regarded as relatively exogenous to residents' mental health. This institutional setting enables a comparison between pilot and non-pilot

[1] CCTV News (2019), "上海垃圾分类'满月'考:垃圾分类,从时尚到日常" ["One Month After Shanghai's Waste Sorting Reform: From Trend to Routine Practice"], August 5, 2019, available at: https://news.cctv.cn/2019/08/05/ARTI8JhQmE0ePWZlosLC5xyz190805.shtml (in Chinese);

CCTV News (2025), "看见美丽中国 垃圾分类新时尚" ["Seeing a Beautiful China: Waste Sorting as a New Social Trend"], August 18, 2025, available at: https://news.cctv.com/2025/08/18/ARTIBvg2FYLE4fMfeZyKGc0J250817.shtml (in Chinese).

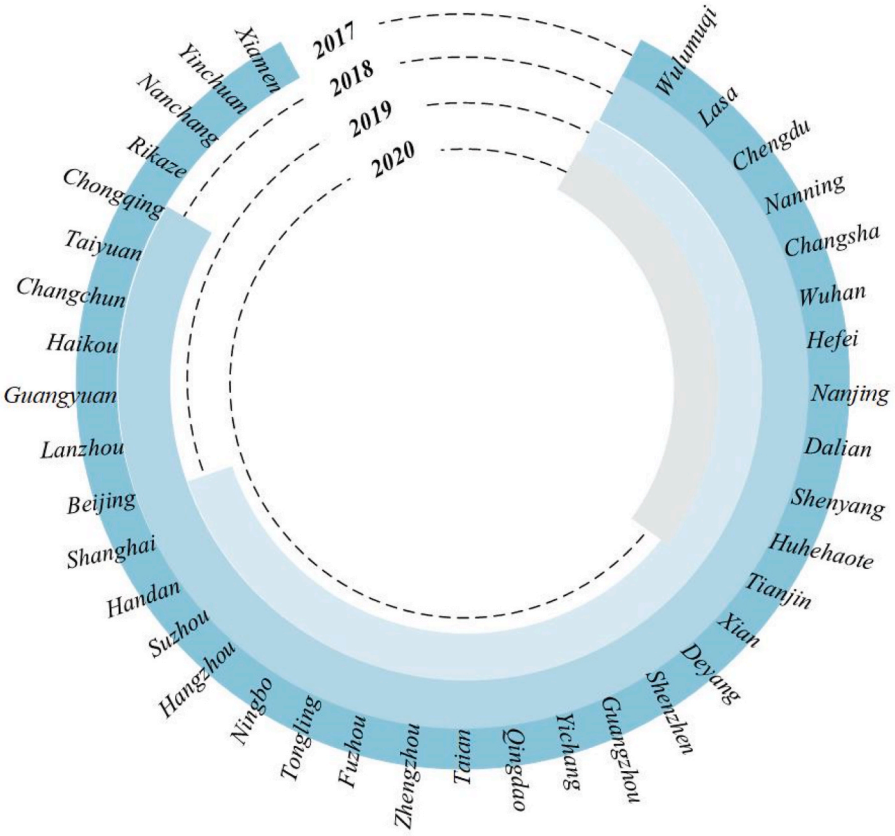

Fig. 1. Timeline of mandatory waste-sorting policy implementation across pilot cities in China (2017–2020).
Note: This circular timeline shows when the 46 pilot cities issued local regulations for mandatory household waste sorting under China's national policy framework. The timeline moves from the outer to the inner ring (2017–2020). City names are placed in the ring corresponding to the year their local regulation was released. A few early adopters appear in 2017, most cities clustered in 2018–2019, and several later entrants in 2020. The figure organizes cities by the year their regulations were enacted.

cities before and after the policy, providing a quasi-experimental basis for DID analysis.

2.2. Theoretical analysis and hypotheses

Waste management is an everyday feature of the urban environment and thus a salient determinant of residents' well-being (Evans, 2003; Wei et al., 2024). Accumulated or poorly handled waste can generate visible disorder, unpleasant odors, and potential health risks, all of which increase environmental stress and contribute to feelings of discomfort, anxiety, and loss of control over one's surroundings (Canter & Craik, 1981; Chen et al., 2021; Cohen-Cline et al., 2015; Sugiyama et al., 2008). In response, China's mandatory waste-sorting policy, introduced in 2017 in selected pilot cities, represents a major institutional effort to improve urban environmental order. By establishing standardized sorting categories, enforcing designated collection schedules, and upgrading waste stations, the policy has visibly enhanced neighborhood cleanliness and reduced environmental disturbances (Guo et al., 2021). We argue that the environmental improvements brought about by this policy are closely linked to residents' mental health. A cleaner and more organized community environment can strengthen residents' sense of control and safety, reduce perceived environmental stress, and foster stronger neighborhood attachment (Guite et al., 2006), all of which are closely associated with mental health In this sense, waste sorting functions not merely as an environmental management tool but also as a policy intervention that reshapes residents' everyday environmental experiences and emotional states, thereby contributing to improved mental health. Therefore, we propose a tentative hypothesis:

H1. *The mandatory waste-sorting policy is associated with improvements in residents' mental health. In other words, compared with non-pilot cities, pilot cities experienced a noticeable improvement in residents' mental health following the policy's implementation.*

Specifically, we examine why residents' mental health changed after the policy implementation from two perspectives - environmental and behavioral - as illustrated in Fig. 2.

At the environmental level, mandatory waste sorting reshapes the waste-treatment process and improves overall environmental quality. By separating household waste into recyclables, kitchen waste, hazardous waste, and residual waste, the policy enables safer and more efficient downstream treatment, such as recycling, biological processing, or controlled disposal of hazardous materials. These improvements increase the harmless-treatment rate and reduce secondary pollution from improper dumping or open burning (Li et al., 2023).

Improved classification also contribute to cleaner air. Prior to the reform, mixed waste often accumulated in open spaces or landfills, where combustion and decay generated particulates and harmful gases. Centralized sorting and scheduled transport reduce the volume of exposed mixed waste, lowering emissions that contribute to PM2.5 formation. Evidence shows that decreases in waste-related emissions can improve local air quality, especially in densely populated cities (Holnicki et al., 2021). Because PM2.5 exposure is a well-established environmental stressor linked to neuroinflammation and elevated risks of depression and anxiety (Braithwaite et al., Zhang et al., 2017; Abed Al Ahad et al., 2022), we propose the following hypothesis:

H2a. *The mental health benefits associated with the mandatory waste-sorting policy operate through enhanced harmless treatment of domestic*

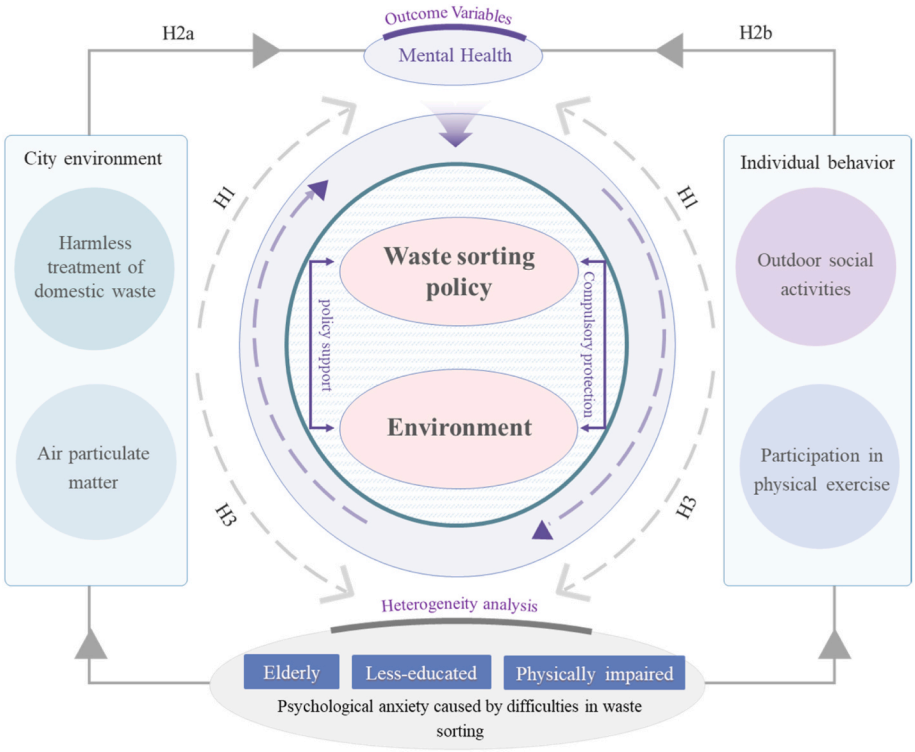

Fig. 2. Mechanism diagram.

waste and reduced PM2.5 concentrations.

At the behavioral level, waste-sorting policies improve the cleanliness and aesthetics of residential and public spaces, which encourages healthier and more active lifestyles. Prior to the reform, overflowing bins, odors, and scattered refuse often discouraged outdoor leisure and neighborhood interaction. After implementation, standardized sorting and timely waste collection reduce visible disorder and odor pollution, making community spaces more pleasant and comfortable. Cleaner surroundings enhance residents' sensory experiences, lower perceived environmental risks, and foster a sense of safety and ease. As a result, residents become more willing to engage in outdoor social activities, such as chatting with neighbors, walking in courtyards, or participating in community events - activities that expand social networks and strengthen belonging, both of which support mental health (Jackson et al., 2021; Liao et al., 2022; Nezlek et al., 2002; Southwick et al., 2016).

Environmental improvements may also increase participation in outdoor physical exercise. Cleaner, odor-free, and well-maintained public spaces reduce psychological and hygienic barriers to activity, making behaviors such as walking, jogging, dancing, and tai chi more appealing and routine. Access to safe exercise environments enhances motivation for regular physical activity, which is widely recognized as a key behavioral pathway for improving mental health by releasing endorphins, improving sleep, and regulating mood (Smith & Merwin, 2021; Sugiyama et al., 2008; Taylor et al., 1985). Therefore, we propose the following tentative hypotheses:

H2b. *The mental health benefits associated with the mandatory waste-sorting policy operate through increased outdoor social interactions and greater participation in physical exercise.*

Although mandatory waste sorting aims to enhance environmental quality, its implementation also introduces new social expectations and behavioral norms. Before the reform, many urban residents were accustomed to disposing of all waste in a single bin, while rural households often dumped garbage in nearby open areas. The policy therefore represents not only an environmental intervention but also a substantial shift in daily routines, which can generate "green anxiety" as residents adjust to new and unfamiliar requirements. In China's community-based management system, residents are frequently reminded or monitored by neighborhood committees and volunteers, and incorrect sorting may lead to warnings or public criticism. In a cultural context where *mianzi* (face) and social evaluation are highly salient, such public correction can trigger feelings of shame and psychological stress (Yang & Kleinman, 2008). In addition, many older adults struggle with distinguishing waste categories due to low literacy or cognitive limitations, and may experience frustration when dealing with complex sorting rules (Mitzner et al., 2010; Salthouse, 1996). Individuals with lower educational attainment may also face difficulties processing information or perceiving environmental risks (Cutler & Lleras-Muney, 2010). Furthermore, people with physical limitations may find repetitive sorting and waste carrying tasks burdensome (Hou et al., 2024). Accordingly, we propose the following tentative hypothesis:

H3. *The positive association between the mandatory waste-sorting policy and mental health is weaker among elderly individuals, those with lower education levels, and individuals with physical mobility constraints.*

3. Study design

3.1. Data sources

The individual-level data were obtained from the CHARLS, a nationally representative micro-level dataset covering households and individuals aged 45 and above in China (https://charls.pku.edu.cn/). Conducted by Peking University, CHARLS initiated its national survey in 2011, with subsequent waves completed in 2013, 2015, 2018, and 2020, yielding five rounds of data to date. The data on the implementation timeline of waste sorting policies are obtained from the regulations or ordinances published on the websites of prefecture-level city governments. Additional data for other prefecture-level cities are sourced from publicly available local statistical yearbooks. After excluding variables

with missing data, a total of 35,319 observations were retained.

3.2. Variable setting

3.2.1. Dependent variable

Mental health (*cesd10*). Although mental health is a multidimensional construct, depressive symptoms are widely recognized as one of its core and most representative indicator (Chen et al., 2023; Cohen--Cline et al., 2015). The CES-D Scale is a widely used instrument for assessing the mental health status of individuals (Radloff, 1977). In this study, we employ the abbreviated 10-item version of the CES-D scale, which retains the core conceptual framework of the original 20-item CES-D while enhancing survey efficiency (Andresen et al., 1994). Respondents are required to rate the frequency of depressive symptoms experienced in the past week using a 4-point Likert scale (Appendix A). Following the standard scoring procedure, we reverse-coded the items related to positive affect and summed the scores of all items to obtain a continuous total score for depressive symptoms, ranging from 0 to 30. Higher scores indicate more severe depressive symptoms.

The CESD-10 scale has demonstrated good reliability and validity among Chinese populations, including respondents in the CHARLS (Chen et al., 2023; Lei et al., 2014). Considering that mental health is multidimensional, we conduct robustness checks using several alternative indicators to verify the consistency of our findings. These variables capture related but distinct aspects of mental health, and including them all in the main regression could dilute the core interpretation; therefore, we analyze them separately as complementary robustness tests (Clark et al., 2008).

3.2.2. Independent variable

Waste sorting policy (*policy*). Mandatory waste sorting is typically manifested through local governments issuing regulations to standardize residents' behavior. We manually collected the dates when local governments implemented waste sorting policies across various regions. If a city promulgated relevant regulations or ordinances after China's introduction of the mandatory household waste sorting policy in 2017, the variable takes a value of 1 in the year of promulgation and in all subsequent years; otherwise, it is coded as 0.

3.2.3. Mediating variables

For the direct environmental dimension, we include harmless treatment of domestic waste (harmless) and air particulate matter (PM2.5), whereas for the indirect social and behavioral dimension, we include outdoor social activities (social) and participation in physical exercise (exercise). Specifically, harmless treatment of domestic waste (*harmless*) represents the extent to which municipal household waste is processed through environmentally safe methods, including sanitary landfilling, incineration with pollution control, and biological treatment. It reflects the effectiveness and safety of a city's solid waste management system. The indicator is measured by the harmless treatment rate at the prefecture-level city, calculated as: harmless treatment rate = (the amount of waste treated harmlessly/the total amount of waste treated) × 100%. A higher harmless treatment rate indicates more efficient and sanitary waste management, which helps reduce exposure to environmental pollutants such as odors, leachate, and visual waste accumulation. The air particulate matter (*pm2.5*) captures ambient air quality, measured by the average annual concentration of fine particulate matter ($PM_{2.5}$, μg/m^3) at the prefecture-level city. Lower $PM_{2.5}$ concentrations reflect cleaner air and fewer airborne pollutants.

Outdoor social activities (*social*) are constructed based on the CHARLS social activity module, retaining only those activities that plausibly involve time spent outdoors and face-to-face interaction. 1) In the Chinese community context, visiting neighbors and socializing with friends usually occur in courtyards, alleyways, or community squares, which require residents to spend a nontrivial amount of time outdoors. 2) Dancing, exercising, or practicing *qigong* in parks or other venues are explicitly outdoor behaviors. 3) Participating in club activities is also included, as most clubs for middle-aged and older adults, such as dancing groups or walking associations, typically gather in outdoor parks and involve necessary travel time outside the home. 4) Volunteer or charitable activities are another common form of outdoor participation, often conducted in public spaces such as community clean-ups, event assistance, or neighborhood patrols. For each respondent, this variable is coded as 1 if they engaged in any of the above activities, and 0 otherwise. We adopt a binary measure because CHARLS does not consistently report activity frequency or duration, and our interest lies in exposure to outdoor social participation rather than its intensity. Separately, the variable exercise is coded as 1 if the respondent reports participating in physical exercise and 0 otherwise.

3.2.4. Control variables

This study controls for individual-level characteristics including gender, marital status, residence, age, educational attainment, smoking and drinking behaviors, as well as health insurance and pension coverage; and household-level characteristics including total household income, household size, and total household consumption.

3.3. Model setting

To investigate the impact of waste sorting policies on mental health, we constructed a DID model for empirical analysis.[2] Cities were divided into a treatment group (those that had promulgated waste sorting regulations or ordinances) and a control group (those that had not). The treatment group consists of the 46 pilot cities designated by the central government, rather than cities that voluntarily adopted the policy. Although the selection was not fully random, it included a wide range of cities - large, medium, and small, and from eastern, central, and western regions. The purpose was to test the policy's performance across different urban contexts, not to select only economically advanced or administratively strong cities. This quasi-exogenous assignment provides a reasonable basis for using the DID model to examine the relationship between policy implementation and residents' mental health. The model specification is shown in Equation (1).

To examine the potential mechanisms underlying the observed effects, we adopt a three-step mediation analysis, following the classical framework (Baron & Kenny, 1986) and subsequent econometric applications (Liu et al., 2022; Ma et al., 2023). First, we estimate the baseline model to examine the effect of the waste-sorting policy on mental health. Second, we regress each mediator on the policy indicator to test whether the policy affects the mediating channels. Third, we include both the policy and the mediator in the model to examine whether the mediator explains part of the policy effect. A reduction or loss of significance in the policy coefficient indicates partial or full mediation. The model is outlined in Equations (2) and (3):

$$cesd10_{i,t} = \alpha_0 + \alpha_1 policy_{j,t} + \alpha_2 X_{i,t} + Individaul_i + Year_t + \varepsilon_{i,j,t} \quad (1)$$

$$mediator_{i,t} = \beta_0 + \beta_1 policy_{j,t} + \beta_2 X_{i,t} + Individaul_i + Year_t + \varepsilon_{i,j,t} \quad (2)$$

$$cesd10_{i,t} = \gamma_0 + \gamma_1 policy_{j,t} + \gamma_2 mediator_{i,t} + \gamma_3 X_{i,t} + Individaul_i + Year_t + \varepsilon_{i,j,t} \quad (3)$$

Here, i represents the individual and t represents the year. $cesd10_{i,t}$ denotes the mental health status of the individual, $policy_{j,t}$ indicates the

[2] The DID approach is a quasi-experimental method that compares outcome changes over time between treated and untreated units to difference out time-invariant confounders and common shocks(Card & Krueger, 1993; Angrist & Pischke, 2009); it has been widely applied in policy evaluation and public health (Zhang et al., 2017, Li et al., 2020; Rose et al., 2023).

domestic waste sorting policy, $mediator_{i,t}$ represents the mediating variable, and $X_{i,t}$ is a set of control variables at the individual and household levels. Meanwhile, $Individaul_i$ and $Year_t$ represent the fixed effects for individuals and years, respectively, and $\varepsilon_{i,j,t}$ is the error term.

4. Results

4.1. Descriptive statistics

Descriptive statistics are shown in Table 1. The mean score of mental health (*cesd10*) is 8.316 with a standard deviation of 6.275, indicating that the average Chinese resident experiences mild depressive symptoms, while substantial variations exist in mental health status across individuals. The average value of the waste sorting policy variable is merely 0.037, suggesting that only about 3.7% of cities nationwide had implemented mandatory waste sorting policies during the study period, reflecting relatively limited policy coverage. Other variables generally align with China's socioeconomic realities, demonstrating data reliability for subsequent regression analysis.

4.2. Benchmark regression

Table 2 presents the baseline regression results of waste sorting policies on residents' mental health. Column (1) demonstrates that without incorporating any control variables, the treatment effect of waste sorting policies shows a statistically significant negative correlation at the 1% level ($\alpha = -1.052$, SD = 0.189), indicating that the policy helps reduce depression levels and improve mental health. After progressively adding individual- and household-level control variables in Columns (2) and (3), the results remain consistent with Column (1). Specifically, as shown in Column (3), the depression level of residents in the treatment group decreases by 0.884 units compared to the control group. In practical terms, after the implementation of the waste-sorting policy, the average depression level of residents in pilot cities decreased by 12.89%.[3]

Table 1
Descriptive statistics.

Variable	N	Mean	SD	Min	Max
cesd10	35319	8.316	6.275	0.000	30.000
Policy	35319	0.037	0.188	0.000	1.000
Harmless	30620	94.216	12.870	19.650	100.000
pm2.5	34374	44.191	18.574	13.438	108.393
Social	24568	0.405	0.491	0.000	1.000
Exercise	26906	0.916	0.277	0.000	1.000
Individual Characteristics					
Gender	35319	0.484	0.500	0.000	1.000
Marry	35319	0.872	0.334	0.000	1.000
Rural	35319	0.623	0.485	0.000	1.000
Age	35319	61.506	9.536	11.000	120.000
Edu	35319	2.037	1.052	1.000	4.000
drinkl	35319	0.358	0.479	0.000	1.000
smoken	35319	0.272	0.445	0.000	1.000
ins	35319	0.961	0.193	0.000	1.000
pension	35319	0.636	0.481	0.000	1.000
Household Characteristics					
income_total	35319	9.677	1.598	0.000	17.481
family_size	35319	2.999	1.567	1.000	16.000
hhcperc	35319	9.161	0.957	1.504	14.008

Table 2
Baseline regression.

Variables	(1)	(2)	(3)
	cesd10	cesd10	cesd10
policy	−1.052***	−0.893***	−0.884***
	(0.189)	(0.186)	(0.186)
gender		−1.568***	−1.585***
		(0.102)	(0.101)
marry		−1.493***	−1.283***
		(0.135)	(0.135)
rural		0.871***	0.583***
		(0.113)	(0.113)
age		0.036***	0.025***
		(0.005)	(0.005)
edu		−0.651***	−0.549***
		(0.043)	(0.043)
drinkl		−0.523***	−0.474***
		(0.082)	(0.081)
smoken		0.187*	0.152
		(0.098)	(0.097)
ins		−0.448**	−0.409**
		(0.186)	(0.185)
pension		−0.293***	−0.140*
		(0.084)	(0.084)
income_total			−0.450***
			(0.027)
family_size			0.036
			(0.025)
hhcperc			0.065
			(0.044)
Constant	8.354***	9.734***	13.741***
	(0.042)	(0.403)	(0.627)
Individual FE	✓	✓	✓
Year FE	✓	✓	✓
Observations	35,319	35,319	35,319
R^2	0.076	0.133	0.142

Note: Table 2 reports the OLS regression results of the waste sorting policy on depression levels. Column (1) does not include any control variables, while columns (2) and (3) gradually introduce individual and household control variables. Robust standard errors clustered at the individual level are reported in parentheses, with * p < 0.1, **p < 0.05, and ***p < 0.01.

4.3. Robustness tests

4.3.1. Pre-trend test

To rule out confounding time effects and confirm that the observed reduction in depression levels is positively associated with the waste sorting policy, we conduct a dynamic DID analysis (Chetty et al., 2009). As illustrated in Fig. 3, we aggregate samples from more than five years prior to the policy implementation into period −6 and designate period −1 as the baseline reference. Crucially, all pre-treatment coefficients are statistically insignificant, confirming that the mental health trends of the treatment and control groups were parallel prior to the policy intervention. Post-implementation, the treatment group exhibits a significant decline in depression levels, and this dynamic effect robustly supports the impact of the waste sorting policy on mental health.

In multi-period DID settings, traditional estimators may suffer from bias when treatment effects are heterogeneous across cohorts or over time. To verify the consistency of the outcome variable between the treatment and control groups in the absence of policy shocks, we follow the approach suggested in the existing literature and conduct a heterogeneity-robust DID test (Borusyak et al., 2024). The results, reported in Appendix B, indicate that the pre-treatment trends are consistent between the two groups.

4.3.2. Placebo test

To mitigate potential confounding from unobserved time-varying factors, a hybrid placebo test should be conducted. We randomly select from all 108 sample cities to form a "pseudo-treatment group", with the remaining cities serving as the "pseudo-control group".

[3] Using the "proportion of the mean explained by a one–standard-deviation change" approach, we compute the practical magnitude as follows: Impact (%) = [regression coefficient of Policy on cesd10 (−0.884) − standard deviation of Policy (0.188)]/mean of cesd10 (8.316) = 0.1289 = 12.89%.

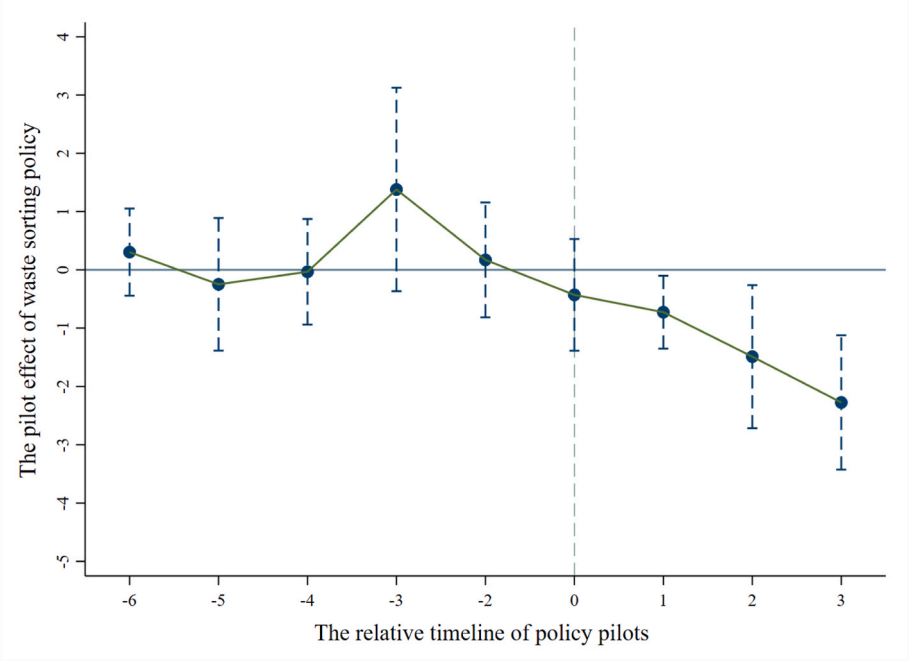

Fig. 3. Parallel trend test
Note: Fig. 3 shows the difference in mental health outcomes between the treatment group and the control group.

Simultaneously, we randomly assign a unified "pseudo-treatment timing" within the sample period to estimate changes in residents' mental health outcomes. This procedure is repeated 500 times to construct the empirical distribution of placebo effects (Fig. 4). It can be observed that the estimated treatment effect of depression is located in the left tail of the placebo effect distribution. Based on the characteristics of this distribution, we can reject the null hypothesis that the treatment effect is zero.

4.3.3. *Other robustness tests*

To further validate the robustness of our findings, we conduct several additional tests, with full results reported in Appendix C. First, we apply a PSM-DID approach to improve comparability between individuals in pilot and non-pilot cities by balancing observable characteristics prior to estimation. Second, we replace the CES-D depression scale with three alternative mental health indicators: 1) diagnosed psychiatric disorders (*psyche*), which provide a more objective measure of severe mental health problems (Matarazzo, 1983); 2) Life satisfaction (*satlife*), a key component of subjective well-being (Gigantesco et al., 2019; Headey

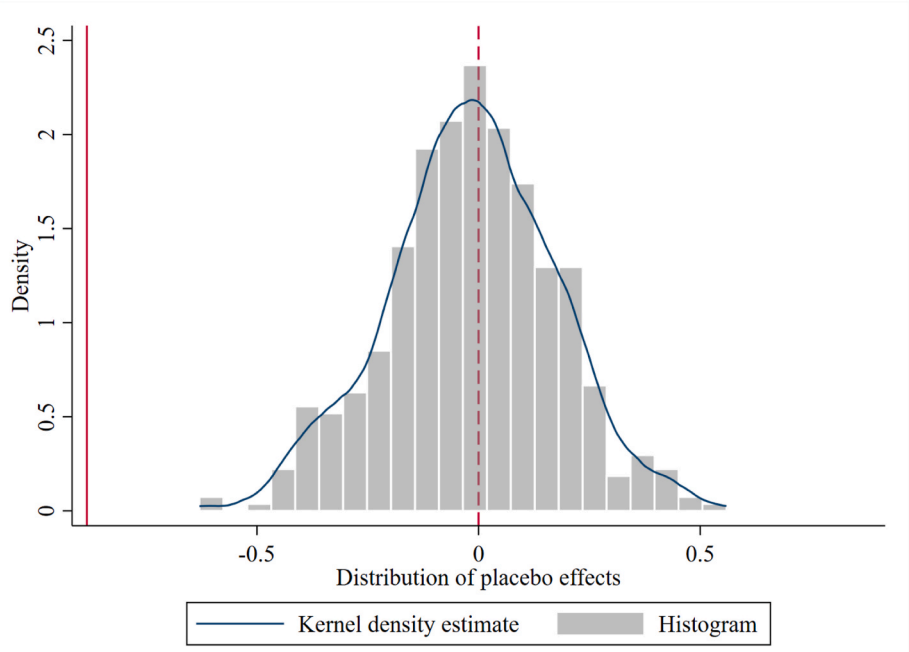

Fig. 4. Hybrid placebo test.
Note: Fig. 4 illustrates the distribution of placebo effects, obtained by resampling 500 times from the treatment group and year of policy implementation.

et al., 1993) measured on a five-point Likert scale; and (3) sleep duration (*sleep*), given that both insufficient and excessive sleep are closely linked to psychological distress (Castiglione-Fontanellaz et al., 2023; Fuligni et al., 2018). Third, recognizing the ordinal nature of the CES-D measure, we re-estimate the model using an ordered logit specification. Across all robustness checks, the estimated effects remain stable and consistent with the baseline results.

4.4. Mechanism testing

We first examine the direct environmental pathways. As shown in Column (1) of Table 3, the waste sorting policy significantly increased the harmless treatment rate at the 1% significance level ($\beta = 5.817$, SD $= 0.376$), indicating that the policy was associated with improved waste treatment infrastructure and enhanced pollution control effectiveness. In practical terms, the harmless treatment rate in pilot cities increased by approximately 5.8% after policy implementation.[4] This aligns well with real-world observations, as waste classification has facilitated more convenient and efficient waste disposal, leading to notable improvements in treatment capacity and environmental safety. When the *harmless* is incorporated into the main regression model, as shown in Column (2), the absolute value and significance level of the *Policy* coefficient both decrease substantially ($\gamma = -0.323$, SD $= 0.179$), suggesting that harmless waste treatment serves as a mediating channel through which the policy affects residents' mental health. Furthermore, Column (3) demonstrates that $PM_{2.5}$ concentrations decreased significantly in prefecture-level cities following the implementation of the policy ($\beta = -2.271$, SD $= 0.163$). In practical terms, this represents a decline of about 5.5%,[5] corresponding to an average reduction of approximately 2.45 $\mu g/m^3$ in $PM_{2.5}$ levels. Although individuals may not directly perceive subtle changes in particulate concentration, they can clearly notice the reduction in smoggy days and overall improvements in air clarity. Similarly, according to Column (4), when $PM_{2.5}$ concentration is added to the regression model, the magnitude of the *Policy* coefficient declines compared with the baseline specification ($\gamma = -0.736$, SD $= 0.181$), indicating that improved air quality partially mediates the relationship between waste-sorting policy implementation and enhanced mental health.

Next, we examine the potential indirect social and behavioral pathways. Improved environmental conditions resulting from waste sorting encouraged residents to engage more frequently in outdoor social interactions and physical exercise. Column (5) tests the relationship between the waste-sorting policy and residents' outdoor social activities. The results show a statistically significant positive effect at the 1% level ($\beta = 0.206$, SD $= 0.040$), indicating that the likelihood of residents in pilot areas participating in outdoor social activities increased by approximately 4.44% after policy implementation.[6] When the social variable is added to the main regression model, as shown in Column (6), the coefficient of policy becomes statistically insignificant ($\gamma = -0.392$, SD $= 0.485$), suggesting that the increase in social activities serves as a complete mediating effect in the relationship between the policy and residents' mental health. Column (7) examines the association between the waste-sorting policy and residents' participation in physical exercise. The results indicate a statistically significant positive relationship at the 5% level ($\beta = 0.022$, SD $= 0.010$). The improved outdoor environment following the policy implementation provided residents with more suitable spaces for social and physical activities. When the *exercise* is incorporated into the regression model, as shown in Column (8), both the magnitude and significance of the *Policy* decrease ($\gamma = -0.414$, SD $= 0.206$), implying that increased participation in physical exercise partially mediates the relationship between the waste-sorting policy and improved mental health outcomes.

We further verified the validity of the mediation effects using the Sobel test. As shown in Table 3, the absolute values of Z are all greater than 1.65, and the corresponding p-values are below 0.05, indicating that the mediating effects are statistically significant. Additionally, a nonparametric bootstrap test with 1000 replications confirms the robustness of our mediation results. The detailed findings are reported in Appendix D.

4.5. Heterogeneity analysis

However, during the initial stage of policy implementation, waste sorting represented a new behavioral norm that required residents to adjust their long-standing habits. Proper compliance demands time, effort, and a certain level of knowledge and cognitive adaptability. While most individuals can eventually benefit from the cleaner and more orderly environment created by waste classification, those who initially lack the necessary knowledge or capacity to comply may experience adaptation challenges and heightened psychological stress - sometimes referred to as "green anxiety." To examine this heterogeneity, we conducted subgroup analyses based on age (defining those aged 70+ as elderly), education (considering primary school or below as uneducated), and physical mobility constraints (whether there are limitations in the six abilities).

The results presented in Fig. 5 show that the policy significantly reduces depression levels among individuals younger than 70, those with education, and physically active populations. However, the policy fails to improve mental health outcomes for elderly residents aged 70+, suggesting that mandatory waste classification may create psychological burdens for older adults. Furthermore, the policy shows no significant mental health benefits for either uneducated individuals or those with mobility constraints, with all coefficients being statistically insignificant. These findings highlight the necessity of incorporating special assistance measures for vulnerable groups when designing environmental policies to ensure equitable benefits across all population segments. The relevant table is shown in Appendix E.

5. Discussion

5.1. Linking environmental interventions to health: progress and research gaps

Over the past several decades, many countries have implemented various environmental policies aimed at improving the quality of residents' living environments (Hahn & Stavins, 1992; Kuklinska et al., 2015; Liu & Xu, 2022; Stavins, 2003; Zhang & Zheng, 2023). Although these policies cover a wide range of domains, existing empirical work on their mental health implications has focused primarily on interventions targeting air quality and urban green space. Some studies have demonstrated that these environmental interventions not only enhance physical health but also contribute to improved mental well-being (Correa et al., 2024; Robinson & Breed, 2019). For example, air quality management policies, such as the Clean Air Act in the United States, have led to significant improvements in air quality and are associated with improvements in mental health outcomes (Jin et al., 2016; Niedhammer et al., 2021; Popp, 2003; Yu et al., 2022). Similarly, urban greening initiatives, such as the development of public parks and green roofs, have been shown to enhance residents' well-being by providing natural spaces for relaxation and physical activity (Barton & Pretty, 2010; Beyer et al., 2014; Pretty et al., 2007). These studies collectively support the notion that environmental policies can significantly improve

[4] Since the harmless treatment rate itself is a proportional variable, the estimated coefficient can be directly interpreted as the change in percentage points. Therefore, the regression result indicates that the harmless treatment rate increased by about 5.8 % following the policy.

[5] Impact (%) = [regression coefficient of *Policy* on *pm2.5* (−2.271) − standard deviation of *pm2.5* (0.188)]/mean of *pm2.5* (44.191) = −0.056 = −5.6%.

[6] Impact (%) = [regression coefficient of *Policy* on *social* (0.206) − standard deviation of *social* (0.188)]/mean of *social* (0.405) = 0.044 = 4.4%.

Table 3
Mechanism testing.

Variables	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	harmless	cesd10	pm2.5	cesd10	social	cesd10	exercise	cesd10
Policy	5.817***	−0.323*	−2.271***	−0.736***	0.206***	−0.392	0.022**	−0.414**
	(0.376)	(0.179)	(0.163)	(0.181)	(0.040)	(0.485)	(0.010)	(0.206)
harmless		−0.008**						
		(0.003)						
pm2.5				−0.025***				
				(0.003)				
social						−0.523***		
						(0.081)		
exercise								−0.768***
								(0.150)
Constant	−95.113***	11.830***	45.233***	14.405***	0.130**	12.822***	0.904***	13.869***
	(0.852)	(0.665)	(0.418)	(0.671)	(0.055)	(0.698)	(0.032)	(0.698)
Control variables	✓	✓	✓	✓	✓	✓	✓	✓
Individual FE	✓	✓	✓	✓	✓	✓	✓	✓
Year FE	✓	✓	✓	✓	✓	✓	✓	✓
Observations	30,620	30,620	34,374	34,374	24,568	24,568	26,906	26,906
R^2	0.511	0.133	0.937	0.136	0.072	0.129	0.052	0.149
Sobel Test	−0.033***(z = −3.411)		−0.200***(z = −10.371)		−0.113***(z = −4.155)		−0.012**(z = −2.256)	

Note: Table 3 reports the results of the mechanism tests. Columns (1), (3), (5), and (7) present the effects of the policy variable on the mediating variables, whereas the remaining columns report the results after incorporating the mediating variables into the main regression model. The results of the Sobel test are also reported to verify the significance of the mediation effects. Robust standard errors clustered at the individual level are reported in parentheses. *p < 0.1, **p < 0.05, and ***p < 0.01.

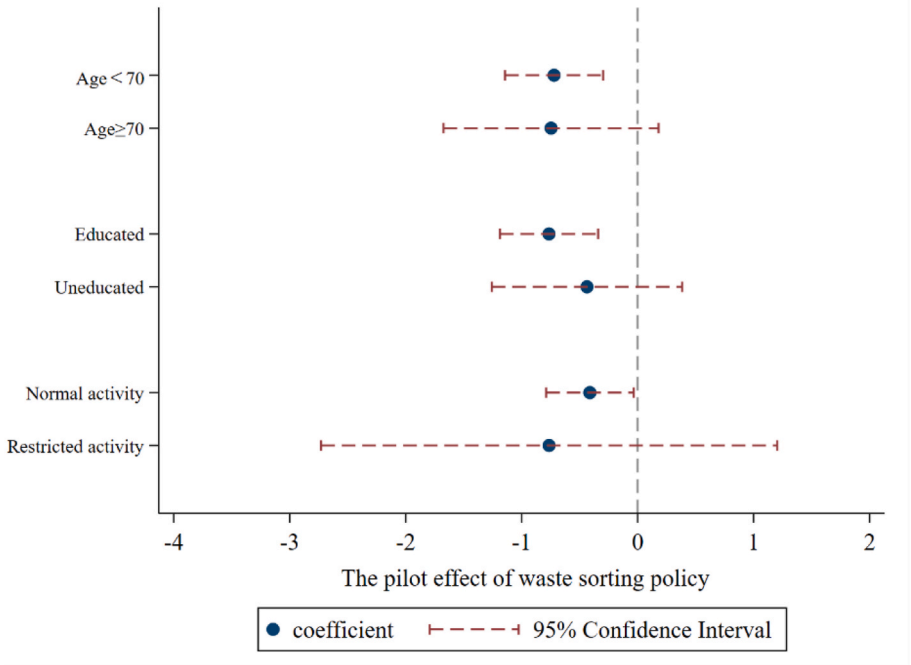

Fig. 5. Heterogeneity analysis
Note: Fig. 5 illustrates that the waste sorting policy significantly improves mental health for individuals under 70, educated individuals, and those with normal physical activity.

mental health outcomes, providing valuable insights for policymakers seeking to create healthier, more sustainable urban environments.

Unlike other environmental interventions that are mainly implemented through government-led projects, waste sorting policies are embedded in residents' daily routines and require sustained individual participation, suggesting that their psychological impacts may follow a distinct pattern. A few studies have touched upon this connection, with one focusing on the relationship between waste sorting behaviors and subjective well-being (Gong et al., 2023). Despite varying focuses, these studies underscore the significant yet underexplored relationship between waste sorting policies and mental health. This gap highlights the need for further research to examine the broader mental health effects of waste sorting policies.

5.2. Direct-level and indirect-level pathways of waste sorting policies

Our study finds that waste sorting policies are associated with mental health through two main channels: city-level environmental conditions and individual behaviors. These mechanisms align with findings from previous literature, which demonstrates that enhancing environmental quality and encouraging healthier behaviors can positively impact residents' mental health (Bhui et al., 2023; Lee & Song, 2021; Oftedal et al., 2019; Wickham et al., 2020).

For the direct environmental dimension, our findings suggest that

improvements in PM2.5 levels and harmless waste treatment significantly contribute to better mental health outcomes. While direct evidence linking waste sorting policies to a reduction in PM2.5 concentrations is scarce, several studies have highlighted that waste sorting initiatives can improve air quality by facilitating more efficient waste management and reducing the release of pollutants (Gao et al., 2023; Kanhai et al., 2021; Wang & Shi, 2022). Our results confirm that waste sorting policy is related to a decrease in $PM_{2.5}$ levels, supporting the broader findings on the environmental benefits of waste sorting. Exposure to $PM_{2.5}$ has long been associated with various physical and mental health issues, including increased symptoms of depression and anxiety (Feng et al., 2016; Hao et al., 2022; Krittanawong et al., 2023; Liu et al., 2023; Roberts et al., 2019; Sharma et al., 2020). Reductions in $PM_{2.5}$ concentrations have been shown to alleviate these psychological burdens by improving overall air quality, thus contributing to better mental health outcomes (Chu et al., 2019; Hao et al., 2022; Ji et al., 2024; Pun et al., 2017; Xue et al., 2021; Zhao et al., 2022). Our results are consistent with this body of research, indicating that the environmental improvements brought about by waste sorting policies, particularly the reduction in PM2.5, can have significant positive effects on residents' mental health Additionally, the enhancement of harmless waste treatment processes, often resulting from waste sorting policies, has been shown to reduce environmental pollutants that negatively impact both physical and mental health (Bharti, 2024, pp. 26–38; Hamer, 2003; Grant et al., 2013; Janik-Karpinska et al., 2023). This finding is in line with previous research, which suggests that waste sorting contributes to healthier and more sustainable urban environments.

For the indirect social and behavioral dimension, the mental health benefits of waste sorting policies also stem from increased outdoor social interactions and physical exercise. Research has shown that better environmental conditions, such as cleaner streets and public spaces, encourage individuals to engage more in outdoor activities, which in turn promote mental health (Allen et al., 2014; Dadvand et al., 2019; Kawachi & Berkman, 2001; Mikkelsen et al., 2017; Seeland et al., 2009; Taylor et al., 1985; Triguero-Mas et al., 2017). Outdoor social interactions are particularly beneficial, as they foster social support and alleviate stress (Allen et al., 2014; Kawachi & Berkman, 2001). Similarly, physical exercise, which is facilitated by improved environmental conditions, is a well-established factor in reducing symptoms of depression and anxiety (Mikkelsen et al., 2017; Taylor et al., 1985). Our study supports these findings, showing that the positive effects of waste sorting policies are mediated through increased social activities and physical exercise, which enhance overall mental health.

5.3. Heterogeneous effects of waste sorting policies on mental health

Although the overall results indicate that waste sorting policies are significantly associated with lower depressive symptoms, the benefits are not evenly distributed across population groups. Notably, our data capture the early stage of policy implementation. During this initial adjustment period, vulnerable groups face greater challenges in adapting to the new requirements, and the additional cognitive and physical demands of sorting may outweigh its potential psychological benefits.

Existing research shows that mandatory environmental policies, including waste sorting, can place psychological burdens on citizens when compliance requires time, knowledge, or physical effort (Christensen et al., 2020; Craig & Katikireddi, 2020; Halling & Baekgaard, 2023). Our results confirm that these burdens are more pronounced among vulnerable groups. For individuals aged 70 and above, the policy does not lead to mental health improvements, likely because cognitive and physical limitations hinder effective participation and increase stress. Similarly, people with low levels of formal education show no significant mental health benefits, as limited understanding of sorting rules may cause confusion or frustration. A similar pattern is observed among individuals with restricted physical mobility, who may perceive the policy as an additional burden rather than a pathway to improved well-being.

5.4. Limitations and future directions

First, mental health is primarily measured using the CES-D scale from the CHARLS survey, which offers a narrow assessment despite robustness checks with additional indicators like life satisfaction and psychiatric disorders. Future research should incorporate multidimensional mental health indicators or physiological data for a more comprehensive evaluation. Second, the study focuses on short-term effects, leaving the long-term consequences of waste sorting policies uncertain. Over time, these policies may shape pro-environmental norms and intergenerational well-being. Future research using extended panel data is needed to examine the persistence implications of these effects.

6. Conclusions and policy implications

Our key findings are as follows. First, the waste sorting policy is significantly associated with higher levels of residents' mental health. Second, the policy is linked to mental health outcomes through two dimensions encompassing four specific mechanisms: direct environmental improvements, reflected in higher harmless waste treatment rates and lower PM2.5 concentrations, and indirect social and behavioral changes, reflected in increased outdoor social interactions and greater participation in physical exercise. Third, no significant association is observed between the policy and mental health outcomes among elderly individuals, those without formal education, or people with physical mobility constraints.

Based on these findings, we argue that while waste sorting policies can yield mental health benefits for the general population, their effectiveness is limited among vulnerable groups. To enhance policy equity and inclusivity, we recommend the following measures: (1) Tailored guidance and assistance. Provide simplified classification guidelines and hands-on support, like community volunteers to assist the elderly and less-educated residents; (2) Accessible infrastructure. Ensure waste disposal facilities accommodate individuals with mobility limitations (e.g., install low-height bins and clear signage); and (3) Flexible enforcement. Adopt a phased implementation approach for disadvantaged groups, allowing them more time to adapt.

CRediT authorship contribution statement

Qianqian Zhang: Methodology, Formal analysis, Data curation.

Data availability statement

The data can be available from CHARLS (https://charls.pku.edu.cn/).

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Declaration of interest

The authors declare no competing interests.

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.jenvp.2026.102971.

References

Abdalrahman Abdalsalam Salem, D. Z. B. M., & Fattah, M. Y. (2021). Leachate properties of municipal solid waste in laboratory landfill. *Advances in Mechanics, 9*(3), 143–150.

Abed Al Ahad, M., et al. (2022). Air pollution and individuals' mental well-being in the adult population in United Kingdom: A spatial-temporal longitudinal study and the moderating effect of ethnicity. *PLoS One, 17*(3), Article e0264394.

Adhikari, R. C. (2022). Investigation on solid waste management in developing countries. *Journal of Research and Development, 5*(1), 42–52.

Alcock, I., et al. (2014). Longitudinal effects on mental health of moving to greener and less green urban areas. *Environmental Science and Technology, 48*(2), 1247–1255.

Allen, J., et al. (2014). Social determinants of mental health. *International Review of Psychiatry, 26*(4), 392–407.

Andresen, E. M., et al. (1994). Screening for depression in well older adults: Evaluation of. *Preventive Medicine, 10*, 77–84.

Baron, R. M., & Kenny, D. A. (1986). The moderator–mediator variable distinction in social psychological research: Conceptual, strategic, and statistical considerations. *Journal of Personality and Social Psychology, 51*(6), 1173.

Barton, J., & Pretty, J. (2010). What is the best dose of nature and green exercise for improving mental health? A multi-study analysis. *Environmental Science and Technology, 44*(10), 3947–3955.

Beyer, K. M., et al. (2014). Exposure to neighborhood green space and mental health: Evidence from the survey of the health of Wisconsin. *International Journal of Environmental Research and Public Health, 11*(3), 3453–3472.

Bharti, J. (2024). *Effect of improper waste disposal on environmental, physical, and emotional well-being of human beings. Waste management and treatment*. CRC Press.

Bhui, K., et al. (2023). Air quality and mental health: Evidence, challenges and future directions. *BJPsych Open, 9*(4), Article e120.

Borusyak, K., et al. (2024). Revisiting event-study designs: Robust and efficient estimation. *The Review of Economic Studies, 91*(6), 3253–3285.

Braithwaite, I., et al. "Air pollution (particulate matter) exposure and associations with depression, anxiety, bipolar, psychosis and suicide risk: A systematic review and meta-analysis." Environmental Health Perspectives 127(12): 126002.

Buoli, M., et al. (2018). Is there a link between air pollution and mental disorders? *Environment International, 118*, 154–168.

Canter, D. V., & Craik, K. H. (1981). Environmental psychology. *Journal of Environmental Psychology, 1*(1), 1–11.

Castiglione-Fontanellaz, C. E., et al. (2023). Sleep regularity in healthy adolescents: Associations with sleep duration, sleep quality, and mental health. *Journal of Sleep Research, 32*(4), Article e13865.

Chen, K., et al. (2021). How does urban green space impact residents' mental health: A literature review of mediators. *International Journal of Environmental Research and Public Health, 18*(22), Article 11746.

Chen, F., et al. (2023). Air pollution and mental health: Evidence from China Health and Nutrition Survey. *Journal of Asian Economics, 86*, Article 101611.

Chen, S., et al. (2024). Air pollution and mental health: Evidence from China. *AEA Papers and Proceedings, 114*, 423–428.

Chetty, R., et al. (2009). Salience and taxation: Theory and evidence. *The American Economic Review, 99*(4), 1145–1177.

Christensen, J., et al. (2020). Human capital and administrative burden: The role of cognitive resources in citizen-state interactions. *Public Administration Review, 80*(1), 127–136.

Chu, C., et al. (2019). Ambient PM2. 5 caused depressive-like responses through Nrf2/NLRP3 signaling pathway modulating inflammation. *Journal of Hazardous Materials, 369*, 180–190.

Clark, A. E., et al. (2008). Relative income, happiness, and utility: An explanation for the Easterlin paradox and other puzzles. *Journal of Economic Literature, 46*(1), 95–144.

Cohen-Cline, H., et al. (2015). Access to green space, physical activity and mental health: A twin study. *Journal of Epidemiology & Community Health, 69*(6), 523–529.

Correa, F. S., et al. (2024). The influence of environmental policies on public health outcomes. *Health Leadership and Quality of Life*, (3), 6.

Craig, P., & Katikireddi, S. V. (2020). Early impacts of universal credit: The tip of the iceberg? *The Lancet Public Health, 5*(3), e131–e132.

Cudjoe, D., et al. (2020). An assessment of the influence of awareness of benefits and perceived difficulties on waste sorting intention in Beijing. *Journal of Cleaner Production, 272*, Article 123084.

Cutler, D. M., & Lleras-Muney, A. (2010). Understanding differences in health behaviors by education. *Journal of Health Economics, 29*(1), 1–28.

Dadvand, P., et al. (2019). Use of green spaces, self-satisfaction and social contacts in adolescents: A population-based CASPIAN-V study. *Environmental Research, 168*, 171–177.

Dickerson, A. S., et al. (2020). A scoping review of non-occupational exposures to environmental pollutants and adult depression, anxiety, and suicide. *Current Environmental Health Reports, 7*(3), 256–271.

Evans, G. W. (2003). The built environment and mental health. *Journal of Urban Health, 80*(4), 536–555.

Feng, S., et al. (2016). The health effects of ambient PM2. 5 and potential mechanisms. *Ecotoxicology and Environmental Safety, 128*, 67–74.

Fuligni, A. J., et al. (2018). Adolescent sleep duration, variability, and peak levels of achievement and mental health. *Child Development, 89*(2), e18–e28.

Gao, S., et al. (2023). Role of garbage classification in air pollution improvement of a municipal solid waste disposal base. *Journal of Cleaner Production, 423*, Article 138737.

Gigantesco, A., et al. (2019). The relationship between satisfaction with life and depression symptoms by gender. *Frontiers in Psychiatry, 10*, 419.

Gładka, A., et al. (2018). Impact of air pollution on depression and suicide. *International Journal of Occupational Medicine & Environmental Health, 31*(6), 711–721.

Gong, Y., et al. (2023). Waste sorting behaviors promote subjective well-being: A perspective of the self-nature association. *Waste Management, 157*, 249–255.

Grant, K., et al. (2013). Health consequences of exposure to e-waste: A systematic review. *Lancet Global Health, 1*(6), e350–e361.

Guite, H. F., et al. (2006). The impact of the physical and urban environment on mental well-being. *Public Health, 120*(12), 1117–1126.

Guo, W., et al. (2021). Solid waste management in China: Policy and driving factors in 2004–2019. *Resources, Conservation and Recycling, 173*, Article 105727.

Hahn, R. W., & Stavins, R. (1992). Economic incentives for environmental protection: Integrating theory and practice. *The American Economic Review, 82*, 464–468.

Halling, A., & Baekgaard, M. (2023). Administrative burden in citizen–state interactions: A systematic literature review. *Journal of Public Administration Research and Theory, 34*(2), 180–195.

Hamer, G. (2003). Solid waste treatment and disposal: Effects on public health and environmental safety. *Biotechnology Advances, 22*(1-2), 71–79.

Hanson, S., & Jones, A. (2015). Is there evidence that walking groups have health benefits? A systematic review and meta-analysis. *British Journal of Sports Medicine, 49*(11), 710–715.

Hao, G., et al. (2022). Associations of PM2. 5 and road traffic noise with mental health: Evidence from UK Biobank. *Environmental Research, 207*, Article 112221.

Headey, B., et al. (1993). Dimensions of mental health: Life satisfaction, positive affect, anxiety and depression. *Social Indicators Research, 29*(1), 63–82.

Holnicki, P., et al. (2021). Analysis of emission abatement scenario to improve urban air quality. *Archives of Environmental Protection, 47*(2).

Hou, B., et al. (2024). Physical exercise and mental health among older adults: The mediating role of social competence. *Frontiers in Public Health, 12*, Article 1385166.

Jackson, S. B., et al. (2021). Outdoor activity participation improves adolescents' mental health and well-being during the COVID-19 pandemic. *International Journal of Environmental Research and Public Health, 18*(5), 2506.

Janik-Karpinska, E., et al. (2023). Healthcare waste—a serious problem for global health. *Healthcare*. MDPI.

Ji, S., et al. (2024). PM(2.5) exposure contributes to anxiety and depression-like behaviors via phenyl-containing compounds interfering with dopamine receptor. *Proceedings of the National Academy of Sciences of the United States of America, 121*(21), Article e2319595121.

Jiang, Y., et al. (2019). Air quality, human behavior and urban park visit: A case study in Beijing. *Journal of Cleaner Production, 240*, Article 118000.

Jin, Y., et al. (2016). Air pollution control policies in China: A retrospective and prospects. *International Journal of Environmental Research and Public Health, 13*(12), 1219.

Kanhai, G., et al. (2021). Urban municipal solid waste management: Modeling air pollution scenarios and health impacts in the case of Accra, Ghana. *Waste Management, 123*, 15–22.

Kawachi, I., & Berkman, L. F. (2001). Social ties and mental health. *Journal of Urban Health, 78*(3), 458–467.

Klompmaker, J. O., et al. (2019). Associations of combined exposures to surrounding green, air pollution and traffic noise on mental health. *Environment International, 129*, 525–537.

Krittanawong, C., et al. (2023). PM2. 5 and cardiovascular health risks. *Current Problems in Cardiology, 48*(6), Article 101670.

Kuklinska, K., et al. (2015). Air quality policy in the US and the EU–a review. *Atmospheric Pollution Research, 6*(1), 129–137.

Lee, J. L. C., et al. (2025). Outdoor exercise facility-based integrative Mobile health intervention to support physical activity, mental well-being, and exercise self-efficacy among older adults with prefrailty and frailty in Hong Kong: Pilot feasibility randomized controlled trial study. *JMIR mHealth and uHealth, 13*, Article e69259.

Lee, E., & Song, J. (2021). The effect of physical and mental health and health behavior on the self-rated health of pregnant women. *Healthcare*. MDPI.

Lei, X., et al. (2014). Depressive symptoms and SES among the mid-aged and elderly in China: Evidence from the China health and retirement longitudinal study national baseline. *Social Science & Medicine, 120*, 224–232.

Li, X., et al. (2016). Urbanization and health in China, thinking at the national, local and individual levels. *Environmental Health, 15*(Suppl 1), S32.

Li, Y., et al. (2023). Feasibility analysis of municipal solid waste incineration for harmless treatment of potentially virulent waste. *Sustainability, 15*(21), Article 15379.

Liao, Z., et al. (2022). The mediating role of psychological resilience between social participation and life satisfaction among older adults in China. *BMC Geriatrics, 22*(1), 948.

Lima, M. L. (2004). On the influence of risk perception on mental health: Living near an incinerator. *Journal of Environmental Psychology, 24*(1), 71–84.

Litwiller, F., et al. (2017). The benefits of recreation for the recovery and social inclusion of individuals with mental illness: An integrative review. *Leisure Sciences, 39*(1), 1–19.

Liu, G., et al. (2022). Environmental tax reform and environmental investment: A quasi-natural experiment based on China's environmental protection tax law. *Energy Economics, 109*, Article 106000.

Liu, S., et al. (2022). A study of the effect of participating in outdoor social activities on the degree of depression in the elderly. *2022 international conference on science and technology ethics and human future (STEHF 2022)*. Atlantis Press.

Liu, X.-q., et al. (2023). Neurodevelopmental toxicity induced by PM2. 5 exposure and its possible role in neurodegenerative and mental disorders. *Human & Experimental Toxicology, 42*, Article 09603271231191436.

Liu, X., & Xu, H. (2022). Does low-carbon pilot city policy induce low-carbon choices in residents' living: Holistic and single dual perspective. *Journal of Environmental Management, 324*, Article 116353.
Lourenço, P., et al. (2024). Feasibility and effectiveness of a 24-weeks outdoor exercise program on the physical and mental health of persons with schizophrenia. *Psychiatry Research, 339*, Article 116093.
Ma, W., et al. (2023). Enterprise sustainable development and green fund concern: The analysis and test of R&D from listed companies in China. *Energy Economics, 121*, Article 106654.
Matarazzo, J. D. (1983). The reliability of psychiatric and psychological diagnosis. *Clinical Psychology Review, 3*(1), 103–145.
Mikkelsen, K., et al. (2017). Exercise and mental health. *Maturitas, 106*, 48–56.
Mitzner, T. L., et al. (2010). Older adults talk technology: Technology usage and attitudes. *Computers in Human Behavior, 26*(6), 1710–1721.
Nezlek, J. B., et al. (2002). Psychological well-being and day-to-day social interaction among older adults. *Personal Relationships, 9*(1), 57–71.
Niedhammer, I., et al. (2021). Psychosocial work exposures and health outcomes: A meta-review of 72 literature reviews with meta-analysis. *Scandinavian Journal of Work, Environment & Health, 47*(7), 489.
Oftedal, S., et al. (2019). Associations of health-behavior patterns, mental health and self-rated health. *Preventive Medicine, 118*, 295–303.
Popp, D. (2003). Pollution control innovations and the clean air act of 1990. *Journal of Policy Analysis and Management, 22*(4), 641–660.
Pretty, J., et al. (2007). Green exercise in the UK countryside: Effects on health and psychological well-being, and implications for policy and planning. *Journal of Environmental Planning and Management, 50*(2), 211–231.
Pun, V. C., et al. (2017). Association of ambient air pollution with depressive and anxiety symptoms in older adults: Results from the NSHAP study. *Environmental Health Perspectives, 125*(3), 342–348.
Radloff, L. S. (1977). The CES-D scale: A self-report depression scale for research in the general population. *Applied Psychological Measurement, 1*(3), 385–401.
Radua, J., et al. (2024). Impact of air pollution and climate change on mental health outcomes: An umbrella review of global evidence. *World Psychiatry, 23*(2), 244–256.
Roberts, S., et al. (2019). Exploration of NO2 and PM2. 5 air pollution and mental health problems using high-resolution data in London-based children from a UK longitudinal cohort study. *Psychiatry Research, 272*, 8–17.
Robinson, J. M., & Breed, M. F. (2019). Green prescriptions and their co-benefits: Integrative strategies for public and environmental health. *Challenges, 10*(1), 9.
Salthouse, T. A. (1996). The processing-speed theory of adult age differences in cognition. *Psychological Review, 103*(3), 403.
Seeland, K., et al. (2009). Making friends in Zurich's urban forests and parks: The role of public green space for social inclusion of youths from different cultures. *Forest Policy and Economics, 11*(1), 10–17.
Sharma, S., et al. (2020). Health effects associated with PM2. 5: A systematic review. *Current Pollution Reports, 6*(4), 345–367.
Smith, P. J., & Merwin, R. M. (2021). The role of exercise in management of mental health disorders: An integrative review. *Annual Review of Medicine, 72*(1), 45–62.
Southwick, S. M., et al. (2016). Why are some individuals more resilient than others: The role of social support. *World Psychiatry, 15*(1), 77–79.
Srivastava, V., et al. (2015). Urban solid waste management in the developing world with emphasis on India: Challenges and opportunities. *Reviews in Environmental Science and Bio/Technology, 14*(2), 317–337.
Stavins, R. N. (2003). Experience with market-based environmental policy instruments. In *Handbook of environmental economics, 1* pp. 355–435). Elsevier.
Sugiyama, T., et al. (2008). Associations of neighbourhood greenness with physical and mental health: Do walking, social coherence and local social interaction explain the relationships? *Journal of Epidemiology & Community Health, 62*(5), e9. e9.
Sun, X. (2023). *Air pollution and avoidance behavior: Evidence from leisure activities in the US*. Available at SSRN 4570602.
Tang, L., et al. (2022). Contamination characteristics, coexistence relationships and health risk assessment of dioxins and metals in topsoil around municipal solid waste incinerator in Hainan, China. *Frontiers in Environmental Science, 10*, Article 898934.
Taylor, C. B., et al. (1985). The relation of physical activity and exercise to mental health. *Public Health Reports, 100*(2), 195.
Triguero-Mas, M., et al. (2015). Natural outdoor environments and mental and physical health: Relationships and mechanisms. *Environment International, 77*, 35–41.
Triguero-Mas, M., et al. (2017). Natural outdoor environments and mental health: Stress as a possible mechanism. *Environmental Research, 159*, 629–638.
Ventriglio, A., et al. (2021). Environmental pollution and mental health: A narrative review of literature. *CNS Spectrums, 26*(1), 51–61.
Villafán, S., et al. (2023). *Proposal to Improve the Reusable Urban Waste Management System in Santiago De Surco, Lima, Peru to Increase the Utilization of the District's Treatment Plant*.
Vinti, G., et al. (2021). Municipal solid waste management and adverse health outcomes: A systematic review. *International Journal of Environmental Research and Public Health, 18*(8).
Wang, Y., et al. (2021). Implementation effect of municipal solid waste mandatory sorting policy in Shanghai. *Journal of Environmental Management, 298*, Article 113512.
Wang, Y., & Shi, Q. (2022). The impact of municipal solid waste sorting policy on air pollution: Evidence from Shanghai, China. *PLoS One, 17*(11), Article e0277035.
Wei, Y. D., et al. (2024). Built environment, natural environment, and mental health. *GeoHealth, 8*(6). e2024GH001047.
Wickham, S.-R., et al. (2020). The big three health behaviors and mental health and well-being among young adults: A cross-sectional investigation of sleep, exercise, and diet. *Frontiers in Psychology, 11*, Article 579205.
World Health Organization. (2013). *Mental health action plan 2013–2020*. Geneva, Switzerland: World Health Organization.
Wu, W., & Zhang, M. (2023). Exploring the motivations and obstacles of the public's garbage classification participation: Evidence from Sina Weibo. *Journal of Material Cycles and Waste Management, 25*(4), 2049–2062.
Xiao, S., et al. (2020). Policy impacts on municipal solid waste management in Shanghai: A system dynamics model analysis. *Journal of Cleaner Production, 262*, Article 121366.
Xue, T., et al. (2021). Long-term PM2. 5 exposure and depressive symptoms in China: A quasi-experimental study. *Lancet Regional Health. Western Pacific, 6*.
Yang, L. H., & Kleinman, A. (2008). 'Face'and the embodiment of stigma in China: The cases of schizophrenia and AIDS. *Social Science & Medicine, 67*(3), 398–408.
Yu, Y., et al. (2022). Air pollution prevention and control action plan substantially reduced PM2.5 concentration in China. *Energy Economics, 113*, Article 106206.
Zhang, X., et al. (2017). Happiness in the air: How does a dirty sky affect mental health and subjective well-being? *Journal of Environmental Economics and Management, 85*, 81–94.
Zhang, J., et al. (2021). A quantitative study on the benefit of various waste classifications. *Advances in Civil Engineering, 2021*(1), Article 6660927.
Zhang, J., & Zheng, T. (2023). Can dual pilot policy of innovative city and low carbon city promote green lifestyle transformation of residents? *Journal of Cleaner Production, 405*, Article 136711.
Zhao, W., et al. (2022). PM2.5 exposure associated with prenatal anxiety and depression in pregnant women. *Ecotoxicology and Environmental Safety, 248*, Article 114284.
Zheng, S. (2020). *Air pollution, avoidance behaviors, and neglected social costs: Evidence from outdoor leisure and commuting behaviors*. Massachusetts Institute of Technology.
Zundel, C. G., et al. (2022). Air pollution, depressive and anxiety disorders, and brain effects: A systematic review. *NeuroToxicology, 93*, 272–300.