

# Early-life exposure to economic stress and metabolic risks in young adulthood: the children of the reunification in East Germany

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## ABSTRACT

**Background** Research on the long-term health consequences of early-life exposure to economic crises is scarce. We examine for the first time the long-term effects of early-life exposure to an economic crisis on metabolic health risks. We study objective health measures, and exploit the quasi-experimental situation of the postreunification economic crisis in East Germany.

**Methods** Data were drawn from two waves of the longitudinal German Health Interview and Examination Survey for Children and Adolescents (2003–2006, 2014–2017). We compared 392 East Germans who were exposed to the economic crisis in utero and at ages 0–5 with 1123 of their West German counterparts using propensity score matching on individual and family characteristics. We assessed blood pressure, cholesterol, blood fat and body mass index (BMI); both combined as above-average metabolic health risks and individually at ages 19–30.

**Results** Early-life exposure to the economic crisis significantly increased the number of above-average metabolic health risks in young adulthood by 0.1482 (95% CI 0.0169 to 0.2796), which was 5.8% higher compared with no exposure. Among individuals exposed in utero, only females showed significant effects. Early-life exposure to the economic crisis was associated with increased systolic (0.9969, 95% CI –0.2806 to 2.2743) and diastolic blood pressure (0.6786, 95% CI –0.0802 to 1.4373), and with increased BMI (0.0245, 95% CI –0.6516 to 0.7001).

**Conclusion** The increased metabolic health risks found for women exposed to the postreunification economic crisis in-utero are likely attributable to increased economic stress. While the observed differences are small, they may foreshadow the emergence of greater health disparities in older age.

## INTRODUCTION

Economic crises pose a serious threat to population health. Children are particularly sensitive to extreme economic stress, which can occur during an economic crisis.<sup>1</sup> Previous research has unambiguously shown that in utero and childhood exposure to chronic stress may trigger metabolic health responses,<sup>2</sup> and that economic stress in particular can have negative short-term health effects.<sup>3–6</sup> Moreover, there is evidence that early-life exposure to economic stress is associated with increased metabolic health risks in late adulthood<sup>7</sup> and cardiovascular mortality later in life.<sup>8</sup> This link can be explained using the critical period model within

## WHAT IS ALREADY KNOWN ON THIS TOPIC

⇒ Previous research has reported that exposure to economic stress has significant adverse effects on children and newborns. Moreover, while existing studies have found that economic crises can have short-term adverse effects on the metabolic health of children and adolescents, most of this research was focused solely on behavioural and subjective health measures. While early-life exposure to economic stress has been found to affect later-life cardiovascular mortality, adult metabolic health in the context of early-life exposure to an economic crisis remains understudied.

## WHAT THIS STUDY ADDS

⇒ Exploiting the quasi-experimental situation of the economic crisis in postreunification East Germany, our findings reveal significant increases in metabolic health risks for young adults who were exposed to the economic crisis early in life, especially for females. We found that the blood pressure and body mass index of young adults were particularly affected, which could be linked to the long-term metabolic health consequences of early-life exposure to economic stress. Furthermore, we observed that in utero exposure to the economic crisis led to increased metabolic health risks among young adult females in particular, which might be attributable to females having a higher sensitivity to economic stress than males. The impact of early-life exposure to the economic crisis on metabolic health risks was up to five times larger than that of other adverse childhood experiences, such as parental separation.

the life course approach, which hypothesises that development in the early and vulnerable life stages (eg, in utero or childhood) is sensitive to external stressors, and thus that exposure to such stressors can lead to long-term negative health outcomes.<sup>9</sup>

Research on the early adult health outcomes of individuals who experienced economic stress early in life is scarce. Metabolic health in particular is a health indicator that can be used to measure the long-term consequences of early-life exposure to economic stress. Negative metabolic health outcomes may result from increased exposure to financial and general distress<sup>10 11</sup> and from



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**HOW THIS STUDY MIGHT AFFECT RESEARCH, PRACTICE AND/OR POLICY**

⇒ Our findings suggest that individuals exposed to economic crisis early in their lives face a higher risk of physical dysregulation and cardiovascular health hazards later in life. This signals a possible delayed burden on the health system due to increased treatment requirements in the future. Subsequently, policy-makers should adopt measures to alleviate the economic stress of families during economic crises, and to promote compensating health behaviours among the affected individuals to help counteract the adverse long-term metabolic health consequences of early-life exposure to economic crises.

subsequent physiological dysregulation,<sup>12</sup> which has also been linked to long-term cardiovascular health.<sup>13</sup> Thus, studying these outcomes can enable us to capture the health effects of economic stress in a comprehensive way.

The few previous studies that have examined the short-term adverse metabolic health consequences of economic crises for children and adolescents<sup>14–16</sup> identified significant adverse effects, but focused solely on subjective health measures. These authors looked at the short-term health responses of individuals aged 0–17, 3–10 years after the onset of the global financial crisis of 2008. The studies found, for example, a 39% increase in the number of families experiencing food insecurity in the USA<sup>14</sup>; higher levels of fast food consumption and of average weight gain in Portugal<sup>15</sup>; and an 8.5% increase in obesity prevalence, a 2.1% increase in junk food consumption, and a 3.61% decrease in physical activity in Catalonia, Spain.<sup>16</sup> These adverse health effects may be attributable to family economic stress arising from actual or perceived threats of job loss, reduced income or material hardship that occurred during the economic crisis.<sup>17–20</sup>

Thus, it is clear that the long-term metabolic health consequences of early-life exposure to economic stress are not yet well understood. In addition to being academically relevant, investigating the relationship between exposure to economic stress in utero or in childhood and adult metabolic health responses can help policy-makers develop health interventions that protect people who have been exposed to economic crises as minors from experiencing long-term negative health consequences.<sup>2</sup>

Our objective is to study the metabolic health effects of early-life exposure to an economic crisis in young adulthood.

We examine for the first time the long-term effects of early-life exposure to an economic crisis on metabolic health risks in early adulthood. For our analysis, we use the unique context and quasi-experimental setting of the postreunification economic crisis in East Germany. Starting in 1990, the East German economy underwent a severe economic crisis as the region transitioned from having full employment before German reunification to suffering from extremely high unemployment and economic decline after reunification. By contrast, economic conditions remained relatively stable in West Germany over this period<sup>21 22</sup> (see online supplemental chapter S1.1). We study objective measures of metabolic health while exploiting the longitudinal design of the German Health Interview and Examination Survey for Children and Adolescents (KiGGS).

**METHODS**

We exploited the quasi-experimental setting of the severe economic crisis in postreunification East Germany<sup>21 22</sup> using retrospective observational data from the German Health

Interview and Examination Survey for Children and Adolescents (KiGGS).<sup>23</sup> We obtained baseline information and information on the demographic characteristics of these children and their parents from the first KiGGS wave (collected 2003–2006), and information on their health outcomes in young adulthood from the third KiGGS wave (collected 2014–2017). We obtained a total sample of 1515 individuals (see online supplemental figure S1 for sample selection), including 392 East Germans (26%) and 1123 West Germans (74%) who were born between 1985 and 1994, and were thus exposed to the economic crisis early in life (in utero or at ages 0–5).

Our outcome measure was metabolic health measured at ages 19–30. We used four cardiometabolic risk factors: (1) blood pressure (systole-diastole ratio, mm Hg), (2) body mass index (BMI) in kg/m<sup>2</sup>, (3) cholesterol levels (high-density lipoprotein (HDL) in blood, mg/dL) and (4) body fat levels (triglyceride in blood, mg/dL).<sup>24</sup> We analysed the measures individually and combined as a composite measure indicating the number of above-average metabolic health risks for each metabolic health measure, that is, a count variable ranging from zero (no above-average metabolic risks) to four (four above-average metabolic risks).

The exposure measure was early-life exposure to the postreunification economic crisis in East Germany, which was based on whether each respondent's place of residence in the first KiGGS wave (2003–2006) was in East Germany instead of in West Germany. Because East and West Berlin were not differentiated in the data, we excluded Berlin. We obtained the average treatment effect (ATE) of exposure to the postreunification economic crisis in East Germany by applying propensity score matching, which reduced bias from confounding by ensuring that the exposed sample and the unexposed sample were balanced in terms of their characteristics<sup>25</sup> (online supplemental table S4). We matched the East German (treatment group) with the West German sample (control group) using the following uncorrelated variables as confounders (online supplemental table S5): age at health examination (continuous), gender, birth year (continuous), birth weight (continuous), preterm birth (dummy), mother's age at childbirth (continuous) and parental education (continuous). See online supplemental tables S1–S3 for the variable descriptions and the descriptive statistics for outcome, treatment and control measures.

For a more detailed description, see online supplemental chapter S1.

**RESULTS**

The overall number of above-average metabolic risks was higher for the exposed group (=East Germans), with an average of 2.70, than for the unexposed group (=West Germans), with an average of 2.57. This difference was statistically significant ( $p < 0.05$ ) (table 1). There was no statistically significant difference in the individual metabolic health measures of the exposed group and the unexposed group. However, the systolic and diastolic blood pressure was higher for the exposed group than for the unexposed group (123.65/73.45 mm Hg vs 122.66/72.85 mm Hg). The metabolic health outcomes for males were also not significantly different. For females, however, we found significantly higher average metabolic health risks in the composite measure (2.49 vs 2.24,  $p < 0.05$ ) and the systolic and diastolic blood pressure (119.77/72.96 mm Hg vs 117.74/71.70 mm Hg,  $p < 0.05$ ).

The effect on the composite metabolic health measure for the exposed group was, at 0.1482 ( $p < 0.05$ ) (table 2), 5.8% higher than the number of above-average metabolic health risks for the

**Table 1** Comparison of the young adult (ages 19–30) mean metabolic health outcomes between the exposed (East German) and the unexposed (West German) matched samples, 2014–2017 (N=1515)

Metabolic health outcome	Total		Males (n=791)		Females (n=724)	
	Exposed† (n=389)	Unexposed‡ (n=1121)	Exposed† (n=212)	Unexposed‡ (n=564)	Exposed† (n=171)	Unexposed‡ (n=543)
Composite measure (0–4)	<b>2.70*</b>	<b>2.57*</b>	2.88	2.89	<b>2.49*</b>	<b>2.24*</b>
Systolic blood pressure§	123.65	122.67	126.69	127.36	<b>119.77*</b>	<b>117.74*</b>
Diastolic blood pressure§	73.47	72.85	73.97	74.03	<b>72.96*</b>	<b>71.70*</b>
Body mass index¶	24.25	24.39	24.32	24.91	24.07	23.88
High-density lipoprotein***††	26.51	26.40	23.73	23.33	30.01	29.57
Triglyceride**	24.09	24.20	25.18	26.54	22.73	21.87

Bold values indicate significant coefficients.  
Significance levels (T-test results): \*\*\*p<0.001, \*\*p<0.01, \*p<0.05.  
Interpretation of measures: †matched East German sample, ‡matched West Germany sample, §mmHg; ¶kg/square metre; \*\*mg/dL in blood; ††lower high-density lipoprotein means higher cholesterol levels

unexposed group. While the effect on the composite measure was not statistically significant in males, it was in females, at 0.236 ( $p<0.05$ ). For the individual metabolic health measures, the estimates of systolic and diastolic blood pressure and BMI were increased in the total exposed sample, although only the effect for diastolic blood pressure was statistically significant. Conversely, the positive HDL and negative triglyceride estimates indicate that the control group were in worse health, although these values were not statistically significant. The single estimates show no significant effect in males. However, systolic blood pressure was, at 2.136 mmHg ( $p<0.05$ ), significantly higher in the exposed females than in the unexposed females. While the outcomes for the remaining metabolic health measures seem to be worse in the exposed females than in the unexposed females, the differences were not significant.

Figure 1 plots the ATE of early-life exposure to economic stress on metabolic health risks (composite measure) in young adulthood, assessed separately for the cohorts born between 1986 and 1994 and stratified by gender. We found no effect among males (left panel). Among females (right panel), we observed statistically significant effects of 0.821 for the 1992 birth cohort (increase of 39.2%,  $p<0.01$ ) and of 0.622 for the 1993 birth cohort (28.7%,  $p<0.05$ ) on the number of above-average metabolic health risks for the exposed group compared with the unexposed group. These birth cohorts were exposed to the economic crisis in utero. We found no effect for the exposed members of the earlier birth cohorts.

## CONCLUSION

### Summary of results

Early-life exposure to the economic crisis significantly increased the number of above-average metabolic health risks in young adulthood by 0.1482 (95% CI 0.0169 to 0.2796), which was 5.8% higher compared with no exposure. Significant effects were found only for females exposed in utero. Early-life exposure to the economic crisis was associated with increased systolic (0.9969, 95% CI  $-0.2806$  to 2.2743) and diastolic blood pressure (0.6786, 95% CI  $-0.0802$  to 1.4373) and with increased BMI (0.0245, 95% CI:  $-0.6516$  to 0.7001).

### Evaluation of data and methods

Our study has some data-related limitations.

First, because the KiGGS only provided information on the region of residence—that is, our exposure measure—for the first wave (2003–2006), we had to consider the possibility that our results were affected by unobserved migration between German reunification in 1990 and the first KiGGS wave. However, our sensitivity analysis, in which we considered the impact of East-West migration among a subsample for whom the pre-reunification residence was known, showed that migration did not affect our results (online supplemental table S7).

Second, because the KiGGS did not provide information on the respondents' exposure to economic stress, but only allowed for a linkage with contextual information on the postreunification economic crisis through geographical

**Table 2** Effect of early-life exposure to the postreunification economic crisis in East Germany (comparing East and West German samples) on combined and individual metabolic health outcomes at young adulthood (ages 19–30), 2014–2017 (N=1515)

Metabolic health outcome	Total (N=1515)		Males (N=791)		Females (N=724)	
	ATE	95% Conf. Int.	ATE	95% Conf. Int.	ATE	95% Conf. Int.
Composite measure (0–4)	<b>0.148*</b>	0.026 to 0.270	0.004	$-0.143$ to 0.151	<b>0.236*</b>	0.077 to 0.395
Systolic blood pressure†	0.997	$-0.229$ to 2.223	$-0.976$	$-2.702$ to 0.751	<b>2.136**</b>	0.397 to 3.875
Diastolic blood pressure†	<b>0.679*</b>	0.004 to 1.400	$-0.386$	$-1.196$ to 0.424	1.331	$-0.357$ to 3.019
Body mass index‡	0.024	$-0.637$ to 0.685	$-0.679$	$-1.423$ to 0.066	0.377	$-0.781$ to 1.535
High-density lipoprotein§¶	0.396	$-0.470$ to 1.263	0.538	$-0.255$ to 1.330	0.706	$-0.468$ to 1.879
Triglyceride§	$-0.306$	$-2.216$ to 1.605	$-1.155$	$-4.754$ to 2.445	0.820	$-1.141$ to 2.781

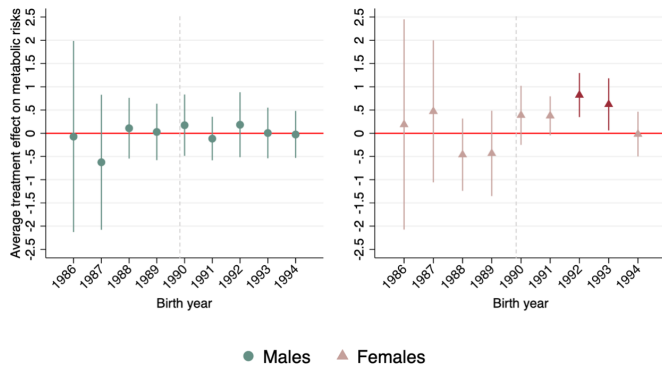
ATE which we obtained from propensity score matching; see online supplemental table S6 for calculations of the propensity score.

Bold values indicate significant coefficients.

Significance levels: \*\*\*p<0.001, \*\*p<0.01, \*p<0.05.

Interpretation of measures: †mmHg; ‡kg/square metre; §mg/dL in blood; ¶lower high-density lipoprotein means higher cholesterol levels.

ATE, average treatment effect.



**Figure 1** Effect of early-life exposure to the postreunification economic crisis in East Germany (comparing East and West German samples) on above-average metabolic health risks in young adulthood (composite measure), individually estimated for the birth years 1986–1994 and stratified by gender, 2014–2017 (n (males) = 791, n (females) = 724). Note: Effect size of above zero indicates higher average metabolic risk factors for East Germans. The 1985 birth cohort was omitted due to the small sample size (n=7); ATE obtained from propensity score matching (see online supplemental table S4-S6 for propensity score matching procedure, balancing test statistics and calculations). The postreunification economic crisis began in East Germany after the fall of the Berlin Wall in November 1989. ATE, average treatment effect.

information based on the children's residential location, we must acknowledge the possible influence of unobservable confounders. Previous research has emphasised that during an economic crisis, child health is affected by parental unemployment and financial hardship, and by the family's socioeconomic gradient.<sup>15 16</sup> However, information regarding the parents' employment status, the household's financial situation or the family's socioeconomic status during the post-reunification economic crisis was not available in the data. We consider it likely that growing up in a socioeconomically disadvantaged family characterised by parental unemployment and financial hardship amplified the observed adverse metabolic health effects for those affected. We concede that having family-level information on exposure to the economic crisis would help to complete the overall picture,<sup>26</sup> and allow us to draw inferences regarding the socioeconomic stratification of the health consequences<sup>27</sup> of the macrolevel economic shock in postreunification East Germany. Thus, future research on the long-term metabolic health effects of exposure to an economic crisis should provide a closer examination of the role of family-level socioeconomic differences.

Third, although our outcome measures are objective measures and relevant predictors of metabolic health, two key indicators for the metabolic syndrome, namely abdominal obesity and hyperglycaemic,<sup>13</sup> are not available in the KiGGS. Additionally, clinical benchmarks for metabolic syndrome risk cut-off points for the available metabolic health measures that were exclusively adapted to the young age of our study population<sup>13 28</sup> are limited in the literature. For that reason, we did not use clinically relevant thresholds for the composite measure of the combined metabolic risk score. Instead, we relied on a sample-based operationalisation of the thresholds for increased metabolic risks, in line with previous studies on metabolic health in comparably young study populations.<sup>29</sup>

## Discussion of results

Our finding that individuals exposed to the postreunification economic crisis in East Germany had a higher number of above-average metabolic health risks in young adulthood can very likely be linked to their experiences of economic stress in early life, which may have negatively affected their long-term metabolic health.<sup>8 10</sup> Our observation that the blood pressure and the BMI of these young adults were particularly affected by exposure to the crisis can be explained by research showing that these health indicators are especially sensitive to stress.<sup>30 31</sup>

Moreover, our finding that these effects were only significant for females is in line with previous research that detected gender differences in physiological regulation in response to increased distress.<sup>32 33</sup> External stressors in particular often lead to hormonal and physical dysregulation in women,<sup>33</sup> and thus, can also have an impact on their metabolic health.<sup>32</sup> Our observation that the differences in the metabolic health of females were already evident in young adulthood reflects the severity of the economic crisis.

Particularly for those East German cohorts who were exposed to the economic crisis in utero—that is, the birth cohorts of 1992 and 1993—our results show significantly increased above-average metabolic health risks among females. These findings are in line with the critical period model,<sup>9</sup> as well as with previous research showing that experiences in the early years of life can have long-term effects on health, including on metabolism.<sup>34</sup> They also provide support for the fetal stress hypothesis, which argues that external stressors in the womb have long-term effects on development and health.<sup>35–37</sup> Thus, our findings indicate that the postreunification economic crisis in East Germany likely exposed unborn children to extreme in utero stress resulting from their mothers' economic distress. Why no significant effects were found for East Germans who were exposed to the crisis later in childhood is unclear. Although the negative impact of in utero exposure to economic stress is well known,<sup>8 35</sup> studies that compare the effects of economic stress on children who were exposed at different ages are rare. Future research should investigate possible differences by age in the effects of exposure to economic stress and seek to disentangle the corresponding mechanisms.

Socioeconomic factors may play a crucial role in explaining the adverse effects on metabolic health of early-life exposure to economic crises, as being socioeconomically disadvantaged early in life has been found to negatively affect metabolic health outcomes in adulthood.<sup>27</sup> Experiencing elevated levels of economic stress during an economic crisis may exacerbate this effect and drive negative health selection. Research has clearly shown that children from socioeconomically disadvantaged backgrounds are particularly likely to suffer negative health consequences during economic crises.<sup>16</sup> While our study cannot provide insights into socioeconomic selection into experiencing negative metabolic health consequences due to early-life exposure to economic crises (see 4.2 Evaluation of data and methods), we acknowledge the relevance of these factors for individual metabolic health.

Alongside the explanatory mechanisms, it is important to discuss the magnitude of the observed effect sizes. In general, the differences we found in the metabolic health outcomes of the exposed and the unexposed groups were rather small. This is partially because we only observed effects for females and for individuals exposed to the economic crisis in utero. We, thus, acknowledge that gender differences likely drove the observed overall effect of early-life exposure to the economic crisis on

metabolic risks in young adulthood. In addition, socioeconomic gains over the early life course may have counteracted the adverse effects of the economic crisis on the exposed group. The rapid convergence of living standards, educational levels and health policies in reunified Germany might have offset some of the adversity experienced by children who were exposed to the economic crisis in East Germany.<sup>38 39</sup> Moreover, health behaviours at young adult ages, such as physical activity, smoking and alcohol consumption, might have influenced the effects on metabolic health of early-life exposure to the economic crisis by either reinforcing or counteracting the negative effects through unhealthy or healthy behaviours.<sup>40</sup> However, given that the scarce existing research on East-West German differences in health behaviour has found no significant differences between the cohorts exposed to the postreunification economic crisis,<sup>41 42</sup> we cannot determine whether health behaviour played a role.

To better understand and contextualise the effect sizes, we conducted an additional analysis using the experience of parental separation during childhood as a treatment. We chose this comparative treatment because previous studies identified parental separation as a significant stressor for children, and emphasised its association with long-term adverse metabolic health effects.<sup>43</sup> The additional analyses (online supplemental table S8) showed that the effect of early-life exposure to the postreunification economic crisis in East Germany on the metabolic health risks in young adulthood was three times larger than that of parental separation during childhood. For females, the effect was almost five times larger. These findings again illustrate the severity of the postreunification economic crisis in East Germany, and the subsequent consequences for the metabolic health of individuals who were exposed to the crisis early in life.

Additionally, as we observed the differences in metabolic health in young adulthood, it is possible that the exposed population will develop more serious health consequences over time, as previous research has shown that the prevalence of metabolic syndrome<sup>44</sup> and cardiovascular mortality<sup>8</sup> increases with age.

## Conclusion

Early-life exposure to economic stress during the postreunification economic crisis in East Germany led to increased metabolic health risks for young adults, although only for women. In particular, BMI and blood pressure were higher for the exposed females. As BMI and blood pressure are common stress markers, these findings can be attributed to stress responses to the economic crisis. Moreover, these results emphasise the importance of taking gender differences in responses fetal stress into account when considering the long-term health consequences of early-life exposure to economic crises.

Although the differences in the metabolic health outcomes we detected were small—possibly due to the compensating effects of later-life improvements in the socioeconomic status of the East Germans in our sample—the effects were certainly not negligible (compared with, eg, the effects of parental separation). Our findings could well signal that the exposed individuals face a higher risk of physical dysregulation and cardiovascular health hazards later in life. This could result in a very large but delayed burden on the health system due to increased treatment requirements.

We recommend that policy-makers in East Germany adopt measures to alleviate the economic stress of families during economic crises, and to promote compensating health behaviours among the birth cohorts affected by the postreunification economic crisis to help counteract the adverse long-term metabolic health consequences of exposure to this crisis.

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