

RESEARCH

Open Access



Trends of overweight and obesity among preschool children from 2013 to 2018: a cross-sectional study in Rhine-Neckar County and the City of Heidelberg, Germany

Weina Liu^{1,2}, Mike Z. He³, Peter Dambach¹, Rainer Schwertz⁴, Simiao Chen^{1,5*}, Fengyun Yu^{1,5} and Michael Marx¹

Abstract

Background: Early childhood overweight and obesity is a growing public health concern worldwide. Few recent studies have addressed how time trends varied by sociodemographic characteristics at the regional level using large and high-quality data. This study determines how time trends vary in the prevalence of early childhood overweight and obesity by age, gender, and migration background at the regional level.

Methods: We used a Kernel-density curve to describe the BMI distribution, and evaluated the trends of overweight and obesity by age, gender, and migration background using logistic regression.

Results: Mean BMI and the overall prevalence of overweight and obesity increased among preschool children aged 4–6 years in the Rhine-Neckar County and the City of Heidelberg. After adjusting for age, sex, and migration background, trends of overweight significantly increased only among male children in the age 5 year group with migration background ($P < 0.05$), and an upward trend of obesity was observed only among male children in the age 5 year group and female children in the age 6 year group with migration background ($P < 0.05$).

Conclusions: BMI distribution as well as general prevalence of overweight and obesity are still increasing among preschool children. Children with migration backgrounds, particularly male children in the age 5 year groups and female children in the age 6 year group should be prioritized. Health promotion strategies for children with migration backgrounds will help address this challenge.

Keywords: Trends of overweight and obesity, Preschool children, Cross-sectional study, Migration background

Introduction

Early childhood is a critical stage of life, marked by significant physical and neural development. Particularly, early childhood overweight and obesity is a growing public health concern worldwide. Early childhood overweight

and obesity not only lead to adverse consequences including physical and mental health disorders [1, 2], but also results in impacts on the later adulthood life, such as an increased risk of diabetes, osteoarticular diseases, cardiovascular diseases, and cancer [2]. The pooled prevalence estimates of obesity and overweight in European children (aged 2–7 years) was 22.2% from 2006 to 2016 [3], which was higher than those in Africa (10.4%), North America (12.1%), Asia (5.7%) and Latin America and the Caribbean (7.0%), and other developing countries (7.2%) during same period [4]. According to the results of the

*Correspondence: simiao.chen@uni-heidelberg.de

¹ Faculty of Medicine and University Hospital, Heidelberg Institute of Global Health (HIGH), Heidelberg University, Im Neuenheimer Feld 130, Heidelberg, Germany

Full list of author information is available at the end of the article



© The Author(s) 2022. **Open Access** This article is licensed under a Creative Commons Attribution 4.0 International License, which permits use, sharing, adaptation, distribution and reproduction in any medium or format, as long as you give appropriate credit to the original author(s) and the source, provide a link to the Creative Commons licence, and indicate if changes were made. The images or other third party material in this article are included in the article's Creative Commons licence, unless indicated otherwise in a credit line to the material. If material is not included in the article's Creative Commons licence and your intended use is not permitted by statutory regulation or exceeds the permitted use, you will need to obtain permission directly from the copyright holder. To view a copy of this licence, visit <http://creativecommons.org/licenses/by/4.0/>. The Creative Commons Public Domain Dedication waiver (<http://creativecommons.org/publicdomain/zero/1.0/>) applies to the data made available in this article, unless otherwise stated in a credit line to the data.

German Health Interview and Examination Survey for Children and Adolescents, the prevalence of overweight among preschool children in Germany was 10.8% for female children and 7.3% for male children, and the prevalence of obesity was 3.2% for female children and 1.0% for male children between 2014 and 2017 [5].

Existing studies show that the trend of overweight and obesity in preschool children are changing. A study performed in Bavaria showed an increasing trend from 1982 to 1997 [6]. Another investigation covering all of Germany conducted during 1991 to 2000 also indicated the same trend [7]. In comparison, the trend was decreasing in 16 German federal states from 2004 to 2008 [8]. A similar decreasing trend was also observed in the results of the German Health Interview and Examination Survey for Children and Adolescents between 2014 and 2017 [5]. Although Germany has achieved the WHO target for controlling obesity among children and adolescents, the prevalence of obesity remains at a high level. Overweight and obesity could already lead to lower life satisfaction [9] and more school bullying [10] than that of normal children in early childhood, and these consequences of obesity can carry on into adulthood [11]. Therefore, it is important from a public health perspective to rigorously evaluate the development of overweight and obesity with large and high-quality samples at a regional level, as well as contextualize them internationally. This study is the first to describe the trend of overweight and obesity stratified by socioeconomic characteristics using a dataset involving 37,858 preschool children in Heidelberg. In addition, the up-to-date estimates are essential to fill the gap of studies on the trend of overweight and obesity in Germany before 2018. This study aims to explore how the prevalence of overweight and obesity during early childhood varies by age, sex, and migration background at the regional level over time by means of a large dataset from the School Entry Health Examination (SEHE), which includes all preschool children in the Rhine-Neckar County and the City of Heidelberg, Germany from 2013 to 2018 [12]. This study may provide evidence for local health policymakers at regional levels to implement programs for primary prevention of obesity.

Methods

Data sources and study design

According to the laws and regulations in Baden-Württemberg [13–15], all children who reached the calendar age for obligatory school attendance were requested to attend school entry health examination prior to their sixth birthday. Each child in the sample was only measured once between 2013 and 2018. From 2013 to 2018, 37,858 children from 454 kindergartens of 54 district towns and municipalities participated in the SEHE. We

conduct a cross-sectional study with data from SEHE during this period, in order to describe how the prevalence of overweight and obesity changed by age, sex and migration background. All children's data were anonymized before analyses.

Measurements and covariates

The generated data includes measurements of height and weight and general sociodemographic information (age, sex, and migration background). Children were required to wear light clothes and take off shoes. Body height was accurate to the nearest 1 cm, and body weight was accurate to the nearest 100 g. BMI was classified as underweight, normal weight, overweight, and obese according to BMI-for-age Z-scores from the World Health Organization child growth standards [16]. Immigrant background was defined as children with at least one of their parents being born abroad or the language spoken at home is not German or it is German together with another language, as described by Schenk et al. [17]. If any children whose information such as age, sex, migration background, weight, or height were missing, they were excluded from the study.

Statistical analysis

We described the distribution change in BMI between 2013 and 2018 using a Kernel-density curve [18, 19], which is a nonparametric smoothed graph. The trend of overweight and obesity was evaluated with the adjustment of age, sex, and migration background using a logistic regression model with the survey year as independent variable (continuous variable) and the statuses of overweight/obesity as dependent variables (binary variables). Model I was adjusted by age and sex. Model II was adjusted by age, sex, immigrant background, and survey year. Statistical significance was set at $P < 0.05$. We used the statistical software R (version 3.6.3) to analyze the data.

Results

Characteristics of the study participants

In this survey, 37,858 children aged 4 to 6 years old were enrolled from 2013 to 2018. 33,407 children had valid information, including 17,304 male children and 16,103 female children. The response rate was 88.2%. The percentage of children that had a migration background was 50.8%. The overall prevalence of overweight and obesity was 7.6% and 2.8%, respectively. The children ages 4, 5, and 6 accounted for 12.2%, 75.0% and 12.8% of the

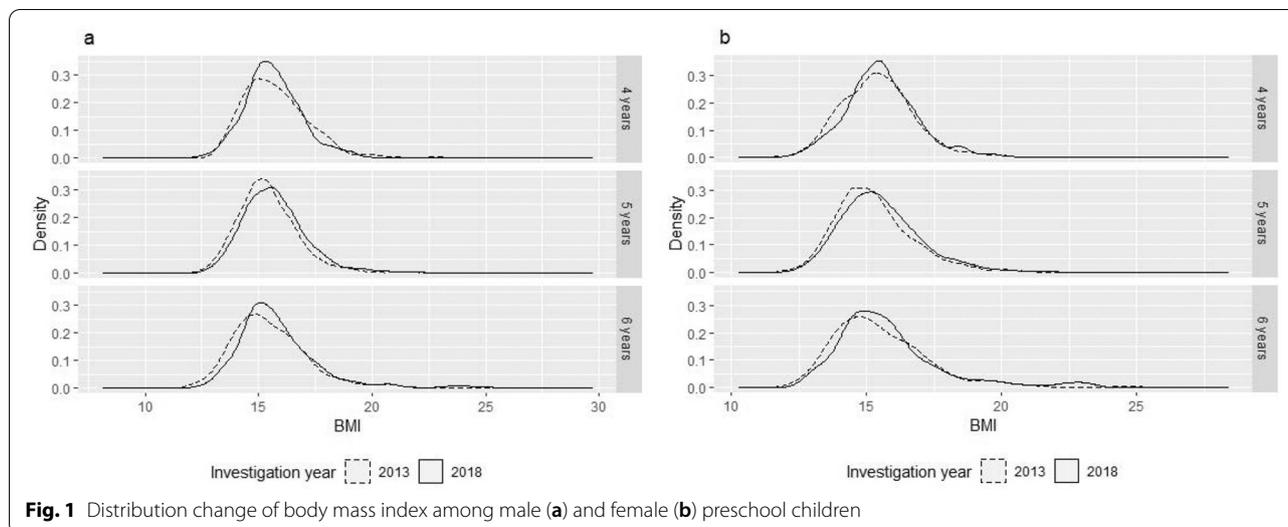


Fig. 1 Distribution change of body mass index among male (a) and female (b) preschool children

population respectively. The baseline characteristics of the study population are shown in Table 1.

Secular trend in BMI

From 2013 to 2018, mean BMI increased from 15.5 to 15.7 kg/m² for male children, and increased from 15.4 to 15.6 kg/m² for female children. Similar upward trends were observed among almost all preschool children except for male children aged 4 years (Table S1). The BMI distribution curves for male children and female children all shifted to the right from 2013 to 2018, except for male children of aged 4 years (Fig. 1).

Trends of overweight

From 2013 to 2018, the prevalence of overweight (6.7% vs 7.2%) in preschool children increased significantly in Rhine-Neckar County and the City of Heidelberg (Fig. 2(a)), especially for the 5-year old age group ($P < 0.05$; Table S2). As shown in Table S3 and Table S4, the prevalence of overweight increased from 7.1% to 8.2% for male children, while showing no upward trend for female children ($P > 0.05$). After adjusting by age and sex (Fig. 2(b)), the prevalence of overweight for male children increased from 6.5% to 8.0% among 5-year olds ($P < 0.05$; Table S3; Fig. 2(d)), while for female children it did not significantly increase across all age groups during this period ($P > 0.05$; Table S4; Fig. 2(d)). After adjusting by age, sex, and migration background, for male children, the prevalence of overweight increased from 5.4% to 6.7% among 5-year olds with migration background ($P < 0.05$; Table S3; Fig. 2(f)), while no significant changes were observed for female children ($P > 0.05$; Table S4; Fig. 2(f) and (h)) across all age groups, irrespective of migration background.

Trends of obesity

When comparing with the trend of overweight, the prevalence of obesity (3.0%, 2018 vs 2.2%, 2013) also increased significantly across all age groups over the 6-year period ($P < 0.05$; Table S5, Fig. 2(a)). After adjusting by sex and age, the prevalence of obesity among male children and female children barely changed from 2013 to 2018 ($P > 0.05$; Table S6 and S7, Fig. 2(c)); however, it increased among 6-year olds in both sex ($P < 0.05$; Table S6 and Table S7, Fig. 2(e)). After adjusting by sex, age, and migration background, male children aged 5 years with migration background and female children aged 6 years experienced an increase in the prevalence of obesity ($P < 0.05$; Table S6 and S7, Fig. 2(g) and (i)).

Discussion

This cross-sectional study showed that the BMI distribution and the prevalence of overweight and obesity among preschool children aged 4–6 years in the Rhine-Neckar County and the City of Heidelberg increased between 2013 and 2018. After adjusting for age, sex, and migration background, the significant increasing trend of overweight was only detected among 5-year old male children with migration backgrounds. The upward trend of obesity was observed only for male children aged 5 years and for female children aged 6 years with migration backgrounds. This is the first population-level study that uses a dataset with such a large sample of School Entry Health Examination data to illustrate the time trends of overweight and obesity among preschool children in Rhine-Neckar County and the City of Heidelberg.

Our study demonstrated that the BMI distribution was increasing, which was consistent with studies by Jena et al. [20] and Aachen et al. [21]. In recent decades,

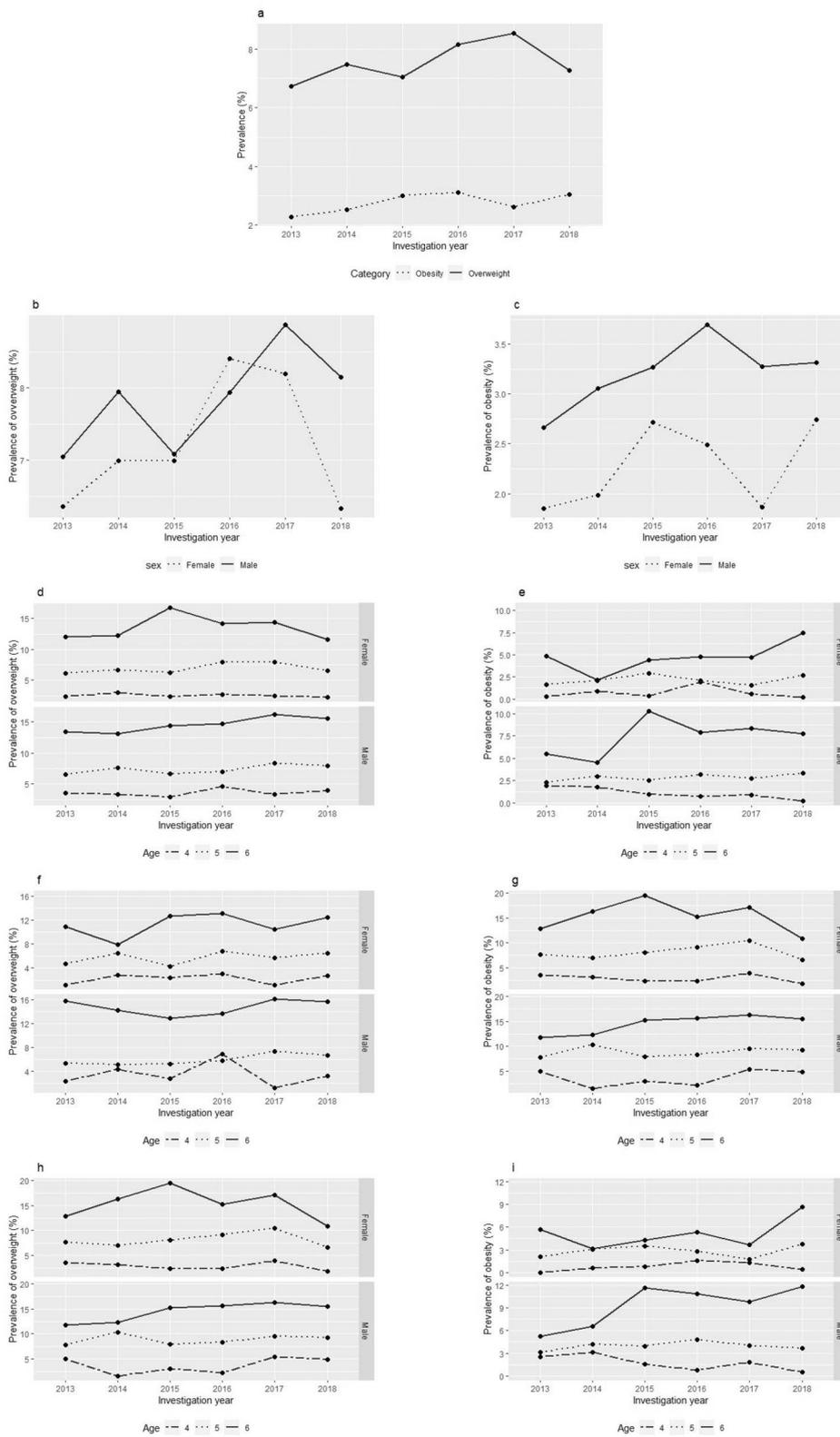


Fig. 2 The trend of overweight and obesity from 2013 to 2018. **a** The general trend. **b,c** The trend adjusted by sex. **d,e** The trend adjusted by sex,age. **f,g,h,i** The trend adjusted by sex,age and migration background

Table 1 Baseline characteristics of preschool children in Rhine-Neckar County and the City of Heidelberg

Characteristic	Number	Percentage (%)
Survey Year		
2013	5665	17.0
2014	5619	16.8
2015	4557	13.6
2016	5612	16.8
2017	5956	17.8
2018	5998	18.0
Total	33,407	100
Sex		
Male children	17,304	51.8
Female children	16,103	48.2
Age		
4	4062	12.2
5	25,078	75.0
6	4267	12.8
Migration background		
Non-migrant	16,436	49.2
Immigrant	16,971	50.8
Nutrition status		
Normal	29,605	88.5
Underweight	357	1.1
Overweight	2525	7.6
Obesity	920	2.8

although the global trend of overweight and obesity among children has been increasing [22], previous studies reported that the prevalence of overweight and obesity among German preschool children showed a downward trend after 2004 [6, 7, 23]. From the second wave of the German Health Interview and Examination Survey for Children and Adolescents during 2014 to 2017, the national trend of overweight and obesity decreased from 13% in 2003 to 11% in 2017. In Europe, the trend also remained stable and even decreased from 30.3% to 25.6% during 1999 to 2016 [24]. Prevalence of other countries such as Australia (22.5% in 2006 to 21.6% in 2018) and Canada (30.7% in 2004 to 27.0% in 2013) also have the same trend as Europe. However, our study showed an opposite trend that the prevalence increased from 8.9% to 10.2% between 2013 and 2018, but remained a lower level than that of Germany and Europe. It has similar trends compared to China (8.8% in 2006 to 10.1% in 2014) [25] and the United States (7.2% in 2006 to 9.4% in 2018). The cause of this phenomenon may be that the trend of overweight and obesity varies widely in federal states [8], and different measurement or assessment methods of obesity [23] were conducted in different regions. Another reason could be that migration background is regarded

as a potential health determinant for the prevalence of overweight and obesity [26]; Rhine-Neckar County and the City of Heidelberg belongs to Baden-Württemberg, where the proportion of people with a migration background accounted for the top three states in Germany [27]. Besides, previous studies provided clear evidence of a significant association between migrant status and less use of preventive services [28]. All of the above factors may lead to an increasing trend in the prevalence of overweight and obesity. Although the German government has emphasized controlling obesity in the National Sustainable Developmental Strategy in 2016 [29], it remains difficult to apply health promotion and prevention measures to young children, especially for preschool children. Decreased energy expenditure or increased energy intake was regarded to be the cause of increasing obesity [30]. Many countries have established recommendations regarding the amount of time children and adolescents should take part in physical activities [31]. Due to the different type of kindergartens and their possible space limitations, it is difficult to quantify the intensity and time of physical exercise available for preschool children. Although one study showed that preschool children were more physically active on forest playgrounds than on traditional playgrounds [32], the forest kindergartens only accounted for a small proportion in Rhine-Neckar County and the City of Heidelberg. Besides, preschool children usually spend a lot of time with parents, and parenting style greatly affects children's behavior [33, 34], including different diet types and use of visual media, which may influence children's weight and/or height. Previous studies which indicated the same correlation between parenting style and obesity also showed similar trends of overweight and obesity among preschool children in Bavaria from 1982 to 1997 [6] and in the City of Aachen from 1968–1999 [21]. Taken together, our findings indicate that the government should develop and propagate appropriate policy, if possible, adapted to the type of kindergarten, and help parents establish healthy parenting styles.

Although the general prevalence of overweight and obesity in Rhine-Neckar County and the City of Heidelberg showed an upward trend, after adjusting by age, sex, and migration background, the increasing trend of overweight and obesity was only observed among male children aged 5 years with migration backgrounds and female children aged 6 years with migration backgrounds. Migration background has already been regarded as an independent potential risk factor for overweight and obesity in earlier studies [35–38]. Previous studies [39, 40] have indicated an increasing trend of overweight and obesity in children from lower socioeconomic status compared with children from

medium to higher socioeconomic status. Meanwhile, different culture and life style, dietary habits, physical activity, parents' overweight, breast feeding, or media consumption all played crucial roles for childhood obesity in children with migration backgrounds [33, 34]. We also found discrepancies in trends of overweight and obesity after adjusting for age, which were similar to previous findings [5, 41, 42] which found that the prevalence of overweight and obesity increased with age. This disparity may be related to the period of adiposity rebound occurring between 4 and 7 years old [43, 44]. Previous studies showed that the capacity of infants and young children to control their food intake is affected by feeding pattern and eating control of mothers [45]. When children become more autonomous and more in control of their food intake when growing older, their ability to regulate energy balance may be damaged, which could lead to obesity [44]. Targeted intervention projects are warranted for vulnerable groups, especially for children aged 5–6 years, to optimize the preventive measures.

Our study used a large cross-sectional dataset collected between 2013 and 2018 from the successive surveillance of SEHE, which involved all preschool children in Rhine-Neckar County and the City of Heidelberg. Our sample size was representative of the general preschool population of Rhine-Neckar County and the City of Heidelberg and was able to display the secular trend. Moreover, after adjusting by sociodemographic factors, it realistically reflects the trend of overweight and obesity in this area, which could offers formative evidence to regional policy-makers for preventing and controlling the prevalence of overweight and obesity among vulnerable groups.

Our study has several limitations. Firstly, since this study was based on a cross sectional study design, it could not assess temporality. Secondly, the trend we evaluated was adjusted only by age, sex, and migration background, and other sociodemographic factors should be investigated in further research. Thirdly, our results only represented preschool children from Rhine-Neckar County and the City of Heidelberg, and it may be difficult to generalize this to other populations.

Conclusions

In conclusion, the BMI and trend of overweight and obesity from 2013 to 2018 was increasing in Rhine-Neckar County and the City of Heidelberg, especially for male children aged 5 years and female children aged 6 years with migration background. Health promotion strategies including appropriate governmental policies, healthy parenting styles, public health service support, and health

education for children with migration backgrounds will help address this challenge.

Abbreviation

SEHE: School Entry Health Examination.

Supplementary Information

The online version contains supplementary material available at <https://doi.org/10.1186/s12889-022-13302-w>.

Additional file 1: Table S1. Mean BMI (kg/m²) in preschool children aged 4–6 years in Rhine-Neckar County and the City of Heidelberg, 2013–2018. **Table S2.** Trends in the prevalence of overweight in preschool children, 2013 to 2018. **Table S3.** Trends in the prevalence of overweight in male children, 2013 to 2018. **Table S4.** Trends in the prevalence of overweight in female children, 2013 to 2018. **Table S5.** Trends in the prevalence of obesity in preschool children, 2013 to 2018. **Table S6.** Trends in the prevalence of obesity in male children, 2013 to 2018. **Table S7.** Trends in the prevalence of obesity in female children, 2013 to 2018.

Acknowledgements

We are grateful to the Public Health Office of Rhein-Neckar-Kreis for using these data. They are not responsible for the analysis or interpretation of these data.

Authors' contributions

WL conceived the idea, RS collected data, WL analyzed and verified data, WL wrote the first draft, MH, PD, FY, SC and MM collaboratively reviewed the manuscript. The author(s) read and approved the final manuscript.

Funding

Open Access funding enabled and organized by Projekt DEAL. There was no funding supported.

Availability of data and materials

The datasets used and/or analysed during the current study are available from the corresponding author on reasonable request.

Declarations

Ethics approval and consent to participate

The data that we analysed was deidentified. All experimental protocols were approved by the Ethics Committee of Heidelberg University, and the ethics approval number is S-169/2021. The informed consent is waived for this study by the Ethics Committee of Heidelberg University. All methods were carried out in accordance with relevant guidelines and regulations.

Consent for publication

Our study was a retrospective study and only had access to deidentified data. Patients and/or the public were not involved in the design, or conduct, or reporting, or dissemination plans of this research, so the patient consent for publication was not required.

Competing interests

The authors declare that they have no competing interests.

Author details

¹Faculty of Medicine and University Hospital, Heidelberg Institute of Global Health (HIGH), Heidelberg University, Im Neuenheimer Feld 130, Heidelberg, Germany. ²Jiangsu Province Center for Disease Control and Prevention, Nanjing, China. ³Department of Environmental Medicine and Public Health, Icahn School of Medicine at Mount Sinai, New York, NY, USA. ⁴Public Health Authority of Rhein-Neckar-Kreis, Heidelberg, Germany. ⁵Chinese Academy of Medical Sciences and Peking Union Medical College, Beijing, China.

Received: 11 November 2021 Accepted: 20 April 2022

Published online: 11 May 2022

References

- Moreno LA, Pigeot I, Ahrens W. Epidemiology of obesity in children and adolescents. New York: Springer; 2011.
- Orsi CM, Hale DE, Lynch JL. Pediatric obesity epidemiology. *Curr Opin Endocrinol Diabetes Obes*. 2011;18(1):14–22.
- Garrido-Miguel M, Oliveira A, Caverro-Redondo I, Álvarez-Bueno C, Pozuelo-Carrascosa DP, Soriano-Cano A, Martínez-Vizcaíno V. Prevalence of overweight and obesity among European preschool children: a systematic review and meta-regression by food group consumption. *Nutrients*. 2019;11(7):1698.
- de Onis M, Blossner M, Borghi E. Global prevalence and trends of overweight and obesity among preschool children. *Am J Clin Nutr*. 2010;92(5):1257–64.
- Schienkiewitz A, Brettschneider A-K, Damerow S, Schaffrath RA. Overweight and obesity among children and adolescents in Germany. Results of the cross-sectional KiGGS Wave 2 study and trends. *J Health Monit*. 2018;3(1):15.
- Kalies H, Lenz J, von Kries R. Prevalence of overweight and obesity and trends in body mass index in German pre-school children, 1982–1997. *Int J Obes*. 2002;26(9):1211–7.
- Apfelbacher CJ, Cairns J, Bruckner T, Möhrenschrager M, Behrendt H, Ring J, Krämer U. Prevalence of overweight and obesity in East and West German children in the decade after reunification: population-based series of cross-sectional studies. *J Epidemiol Community Health*. 2008;62(2):125–30.
- Moss A, Klenk J, Simon K, Thaiss H, Reinehr T, Wabitsch M. Declining prevalence rates for overweight and obesity in German children starting school. *Eur J Pediatr*. 2012;171(2):289–99.
- Tsiros MD, Olds T, Buckley JD, Grimshaw P, Brennan L, Walkley J, Hills AP, Howe P, Coates AM. Health-related quality of life in obese children and adolescents. *Int J Obes*. 2009;33(4):387–400.
- Puhl RM, King KM. Weight discrimination and bullying. *Best Pract Res Clin Endocrinol Metab*. 2013;27(2):117–27.
- Whitaker RC, Wright JA, Pepe MS, Seidel KD, Dietz WH. Predicting obesity in young adulthood from childhood and parental obesity. *N Engl J Med*. 1997;337(13):869–73.
- Liu W, Schwertz R, Welker A, Welker J, Chen S, Dambach P, Marx M. Associations between BMI and visual impairment of 33 407 preschool children in Germany: a pooled cross-sectional study. *Eur J Public Health*. 2021;31(1):105–11.
- Ministry of Social Affairs in Baden-Württemberg. Ordinance of the Ministry of Social Affairs for the implementation of school medical examinations as well as target group-specific examinations and measures in day care centers and schools (School Examination Ordinance) from December 8, 2011. Baden-Württemberg: Ministry of Social Affairs in Baden-Württemberg; 2011.
- Ministry of Social Affairs in Baden-Württemberg. Public Health Service Act (Health Services Act - ÖGDG) of December 17, 2015. Baden-Württemberg: Ministry of Social Affairs in Baden-Württemberg; 2015.
- Ministry of Education and cultural affairs in Baden-Württemberg. School Act for Baden-Württemberg (SchG) in the version of August 1, 1983. Baden-Württemberg: Ministry of Social Affairs of Baden-Württemberg; 2010.
- The WHO Child Growth Standards: BMI for age. https://www.who.int/childgrowth/standards/bmi_for_age/en/. Accessed 5 Apr 2020.
- Schenk L, Bau A, Borde T, Butler J, Lampert T, Neuhauser H, Razum O, Weilandt C. A basic set of indicators for mapping migrant status. Recommendations for epidemiological practice. *Bundesgesundheitsblatt-Gesund*. 2006;49(9):853–60.
- Terrell GR, Scott DW. Variable kernel density estimation. *Ann Stat*. 1992;20(3):1236–65.
- Chen Y-C. A tutorial on kernel density estimation and recent advances. *Biostat Epidemiol*. 2017;1(1):161–87.
- Kromeyer-Hauschild K, Zellner K. Trends in overweight and obesity and changes in the distribution of body mass index in schoolchildren of Jena, East Germany. *Eur J Clin Nutr*. 2007;61(3):404–11.
- Herpertz-Dahlmann B, Geller F, Böhle C, Khalil C, Trost-Brinkhues G, Ziegler A, Hebebrand J. Secular trends in body mass index measurements in preschool children from the City of Aachen, Germany. *Eur J Pediatr*. 2003;162(2):104–9.
- Ng M, Fleming T, Robinson M, Thomson B, Graetz N, Margono C, Mul-lany EC, Biryukov S, Abbafati C, Abera SF. Global, regional, and national prevalence of overweight and obesity in children and adults during 1980–2013: a systematic analysis for the global burden of disease study 2013. *Lancet*. 2014;384(9945):766–81.
- Blüher S, Meigen C, Gausche R, Keller b, Pfäffle R, Sabin M, Werther G, Odeh R, Kiess W. Age-specific stabilization in obesity prevalence in German children: a cross-sectional study from 1999 to 2008. *Pediatr Obes*. 2011;6(2):e199–206.
- Garrido-Miguel M, Caverro-Redondo I, Álvarez-Bueno C, Rodríguez-Artalejo F, Moreno LA, Ruiz JR, Ahrens W, Martínez-Vizcaíno V. Prevalence and trends of overweight and obesity among Chinese children from 1999 to 2016: a systematic review and meta-analysis. *JAMA Pediatr*. 2019;173(10):e192430–e192430.
- Xiao Y, Qiao Y, Pan L, Liu J, Zhang T, Li N, Liu E, Wang Y, Liu H, Liu G. Trends in the prevalence of overweight and obesity among Chinese preschool children from 2006 to 2014. *PLoS ONE*. 2015;10(8):e0134466.
- Zhou Y, Walter U, Dreier M. Migration background and overweight prevalence in preschool children. *Public Health Forum*. 2019;27(4):287–90.
- Number of foreigners in German federal states in 2020. <https://www.statista.com/statistics/891288/foreigner-numbers-by-state-germany/>. Accessed 1 Apr 2022.
- Kowalski C, Loss J, Kölsch F, Janssen C. Utilization of prevention services by gender, age, socioeconomic status, and migration status in Germany: an overview and a systematic review. In: Janssen C, Swart E, von Lengerke T, editors. *Health care utilization in Germany: theory, methodology, and results*. New York: Springer; 2014. p. 293–320.
- Germany's National Sustainable Development Strategy. <https://www.bundesregierung.de/breg-en/issues/sustainability/germany-s-national-sustainable-development-strategy-354566>. Accessed 1 Apr 2022.
- Anderson PM, Butcher KE. Childhood obesity: trends and potential causes. *Future Child*. 2006;16(1):19–45.
- Janssen I. Physical activity guidelines for children and youth. *Appl Physiol Nutr Metab*. 2007;32(S2E):S109–121.
- Torkar G, Rejc A. Children's play and physical activity in traditional and forest (natural) playgrounds. *Int J Educ Method*. 2017;3(1):25–30.
- Sarwar S. Influence of parenting style on children's behaviour. *J Educ Educ Dev*. 2016;3(2):222–49.
- Carter D, Welch D. Parenting styles and children's behavior. *Fam Relat*. 1981;30(2):191–5.
- Apfelbacher CJ, Loerbroks A, Cairns J, Behrendt H, Ring J, Krämer U. Predictors of overweight and obesity in five to seven-year-old children in Germany: results from cross-sectional studies. *BMC Public Health*. 2008;8(1):171.
- Besharat Pour M, Bergström A, Bottai M, Kull I, Wickman M, Håkansson N, Wolk A, Moradi T. Effect of parental migration background on childhood nutrition, physical activity, and body mass index. *J Obes*. 2014;2014:406529.
- Hilpert M, Brockmeier K, Dordel S, Koch B, Weiß V, Ferrari N, Tokarski W, Graf C. Sociocultural influence on obesity and lifestyle in children: a study of daily activities, leisure time behavior, motor skills, and weight status. *Obes Facts*. 2017;10(3):168–78.
- Vilar-Compte M, Bustamante AV, López-Olmedo N, Gaitán-Rossi P, Torres J, Peterson KE, Teruel G, Pérez-Escamilla R. Migration as a determinant of childhood obesity in the United States and Latin America. *Obes Rev*. 2021;22(S3):e13240.
- Yang Z, Phung H, Hughes AM, Sherwood S, Harper E, Kelly P. Trends in overweight and obesity by socioeconomic status in year 6 school children, Australian capital territory, 2006–2018. *BMC Public Health*. 2019;19(1):1512.
- Wariri O, Alhassan JAK, Mark G, Adesiyun O, Hanson L. Trends in obesity by socioeconomic status among non-pregnant women aged 15–49 y: a cross-sectional, multi-dimensional equity analysis of demographic and health surveys in 11 sub-Saharan Africa countries, 1994–2015. *Int Health*. 2020;13(5):436–45.
- Do LM, Tran TK, Eriksson B, Petzold M, Ascher H. Prevalence and incidence of overweight and obesity among Vietnamese preschool children: a longitudinal cohort study. *BMC Pediatr*. 2017;17(1):150.

42. van Jaarsveld CH, Gulliford MC. Childhood obesity trends from primary care electronic health records in England between 1994 and 2013: population-based cohort study. *Arch Dis Child*. 2015;100(3):214–9.
43. World Health Organization. Obesity: preventing and managing the global epidemic: report of a WHO consultation on obesity, Geneva, 3–5 June 1997. Geneva, Switzerland: World Health Organization; 1998.
44. Dietz WH. Periods of risk in childhood for the development of adult obesity — what do we need to learn? *J Nutr*. 1997;127(9):1884S-1886S.
45. Johnson SL, Birch LL. Parents' and children's adiposity and eating style. *Pediatrics*. 1994;94(5):653–61.

Publisher's Note

Springer Nature remains neutral with regard to jurisdictional claims in published maps and institutional affiliations.

Ready to submit your research? Choose BMC and benefit from:

- fast, convenient online submission
- thorough peer review by experienced researchers in your field
- rapid publication on acceptance
- support for research data, including large and complex data types
- gold Open Access which fosters wider collaboration and increased citations
- maximum visibility for your research: over 100M website views per year

At BMC, research is always in progress.

Learn more biomedcentral.com/submissions

