European Journal of Pediatrics (2023) 182:1351–1359
https://doi.org/10.1007/s00431-023-04817-4

RESEARCH

Effects of short-term quarantine on growth and development of children aged 1–36 months during the Omicron outbreak

You Yang[1] · Lei Shi[2] · Xingming Jin[1] · Shilu Tong[3,4,5,6]

Received: 23 August 2022 / Revised: 31 December 2022 / Accepted: 10 January 2023 / Published online: 19 January 2023

Abstract

Consequences of epidemic quarantine on children's well-being are not clear and there are scarce data about the short-term impact of epidemic quarantine on children's growth and development. The study aimed to explore and analyze the potential impacts of the Omicron outbreak on children's growth and development during the lockdown in Shanghai, China. Totally, 4565 children aged 1–36 months who had a routine physical examination in the child health departments of hospitals before (June 1, 2021, to July 6, 2021) and after (June 1, 2022, to July 6, 2022) Shanghai's lockdown were included in this study. A population-based cross-sectional study was conducted by using the Infant Toddler Growth Development Screening Test (ITGDST). The children's growth and development in these two periods were compared with a propensity score matching (PSM) approach. After 1:1 matching, a total of 2462 children aged 1–36 months were analyzed. After PSM, there was no significant difference in terms of overall development, gross motor, fine motor, and language development for children before and after the Omicron lockdown. However, statistically significant decrease of wasting was observed for children after the lockdown ($p < 0.05$). Further interaction analysis indicated older age group (OR = 0.26, 95% CI 0.11–0.59) and the group of second parity (OR = 0.30, 95% CI 0.11–0.83) were favorable to language development during the lockdown.

Conclusion: Short-term quarantine had no significant adverse, but rather beneficial, effects on growth and development of children aged 1–36 months during the Omicron epidemic in Shanghai, China.

What is Known:

- *Consequences of epidemic quarantine on children's well-being are not clear. Long-term psychological effects of coronavirus disease 2019 pandemic on children have been reported. However, there are scarce data about the short-term impact of epidemic quarantine on children's growth and development.*

What is New:

- *Short-term quarantine had no significant adverse, but rather beneficial, effects on growth and development of children aged 1–36 months during the Omicron epidemic in Shanghai, China.*

Keywords Children · Quarantine · Omicron · Growth · Development

Communicated by Peter de Winter.

✉ Xingming Jin
xingming.jin@hotmail.com

✉ Shilu Tong
tongshilu@scmc.com.cn

[1] Department of Developmental and Behavioral Pediatrics, Shanghai Children's Medical Center, Shanghai Jiaotong University School of Medicine, 1678 Dongfang Road, Shanghai, People's Republic of China 200127

[2] Department of Pediatrics, Shanghai Fengxian District Hospital of Traditional Chinese Medicine, Shanghai, People's Republic of China

[3] Department of Clinical Epidemiology and Biostatistics, Shanghai Children's Medical Center, Shanghai Jiaotong University School of Medicine, 1678 Dongfang Road, Shanghai, People's Republic of China 200127

[4] School of Public Health, Institute of Environment and Population Health, Anhui Medical University, Hefei, People's Republic of China

[5] Center for Global Health, School of Public Health, Nanjing Medical University, Nanjing, People's Republic of China

[6] School of Public Health and Social Work, Queensland University of Technology, Brisbane, Australia

Abbreviations

CI	Confidence intervals
COVID-19	Coronavirus disease 2019
ITGDST	Infant Toddler Growth Development Screening Test
OR	Odds ratios
PSM	Propensity score matching
SD	Standard deviations
WHO	World Health Organization

Introduction

Coronaviruses are a well-studied group of viruses in the Coronaviridae family that are known for their ability to infect a variety of hosts due to their capacity to evolve in epidemiologic situations, including crossing species barriers, mutagenesis, tissue tropism, and pathogenicity [1–3]. The coronavirus disease 2019 (COVID-19) pandemic has caused marked changes across all layers of children's social ecologies, including family routines, schooling, media habits, and the broader economy. Cross-national studies in the early months of the pandemic identified the patterns of self-reported lifestyle changes among adolescents and adults, including more time spent physically inactive and using screens [4–6]. Public health measures necessary to counteract the COVID-19 pandemic have resulted in dramatic changes in the physical and social environments within which children grow and develop [6].

Millions of children have been affected worldwide by quarantine and social distancing measures which have been implemented by many countries to control the spread of COVID-19. However, consequences of such procedures on children's well-being are not clear. In late February, 2022, a wave of SARS-CoV-2 infection rapidly appeared in Shanghai, China [7]. The most striking change in children's daily lives and routines was the lockdown to reduce transmission of the highly contagious and more concealed Omicron variant in Shanghai, China. The lockdown started in Shanghai on March 28, 2022. The epidemic was effectively brought under control on May 16. On June 1, normal urban production and life were restored. However, there are scarce data about the short-term impact of epidemic quarantine on children's growth and development [8]. During the lockdown, people were confined at home, with changes in family routines during social distancing. Staying at home refers to not leaving the house, not going out of the house to the corridor, underground garage, open-air area, and other outdoor space activities in the community, such as walking, gathering and talking, and walking pets. Residents who want to pick up packages and throw away garbage can be assisted by maintenance or volunteers. Therefore, this study investigated the potential impacts of epidemic quarantine on growth and development of children aged 1–36 months within the context of previous epidemics and the Omicron pandemic in Shanghai, China.

Materials and methods

Study population

Children aged 1 to 36 months from the general population had a routine physical examination in the child health departments of hospitals before (June 1, 2021, to July 6, 2021) and after (June 1, 2022, to July 6, 2022) Shanghai's lockdown were selected in this study by using the Infant Toddler Growth Development Screening Test (ITGDST).

Data collection

The ITGDST can be used to screen for abnormal growth and development in children aged 1–36 months. In this study, ITGDST was used for collecting children's basic information and evaluating children's physical and neuropsychological development. Head circumference, body weight, and length/height were measured during physical examination. The physical development of infants and young children was evaluated by Z-score recommended by the World Health Organization (WHO). Normal head circumference ($-2 \le$ Z-score ≤ 2), macrocephaly (Z-score > 2), and microcephaly (Z-score < -2) were defined according to head circumference for age Z-score by the standard of WHO. Children with malnutrition (Z-score < -2) were determined according to weight-for-age, length/height-for-age, and weight-for-height Z-score by the standard of WHO.

Parents and caregivers were asked to complete the neuropsychological evaluation item by item with the animation demonstration and the doctors' instruction. The system also collected information about the perinatal period and children's families including age, gender, parity, birth order, advanced maternal age, multiple birth, assisted reproduction, cesarean section, gestational weeks, neonatal injury, family heredity history, body weight, and length at birth. Their record of ITGDST evaluation results was retrospectively collected.

The mean scores minus two standard deviations (SD) were used for the cut-off scores in terms of overall development, gross motor, fine motor, and language development for all subject. Children with a score less than the mean score minus 2 SD were regarded as a developmental delay, while other children (i.e., a score equal to or greater than the mean score minus 2 SD) were considered as normal.

All testers undertook unified on-site training and assessment. The test was conducted in a separate and quiet room with plenty of light. The room temperature was set at around

25 ℃. Children were awake and quiet. Children's growth (weight-for-age, length/height-for-age and weight-for-height) and development (overall neurodevelopment, gross motor, fine motor, and language development) during these two periods were compared.

Statistical analysis

We used complete data and there was no imputation of data to replace missing observations. Chi-squared tests were used to assess the differences between groups for categorical variables, respectively before and after propensity score matching (PSM). Qualitative data were expressed by frequency and rate. The interaction between age and lockdown and that between parity and lockdown was investigated by further stratified analysis based on PSM and odds ratios (OR) with their 95% confidence intervals (CI) were generated. All analyses were conducted using IBM SPSS version 22.0 (IBM Corp., Armonk, NY, USA).

PSM is a balancing approach whereby a numerical value is assigned for the probability of an intervention. To minimize selection bias inherent in treatment group allocation, PSM was used to match the two groups using a logistic regression approach [9]. An absolute standard bias measure < 0.20 is considered small, and sufficient overlap is required for the propensity scores. In our investigation, we standardized the groups based on propensity and 14 covariates were selected about the perinatal period and children's families (age, gender, parity, birth order, advanced maternal age, multiple birth, assisted reproduction, cesarean section, gestational weeks, neonatal injury, family heredity history, head circumference at physical examination, birth weight, and birth length).

Ethical issue

There was no particular concern on the ethical issue in the study.

Results

Totally, 4565 (of 4612) children participated in this study. Participants with incomplete data were excluded. Among the 4565 children aged 1–36 months who were included in our analysis, 2067 (45.3%) were girls and 2498 (54.7%) were boys. Before matching, children after lockdown had a median age of 10.6 months, while controls had a median age of 11.2 months. Sample characteristics are reported in Table 1.

Distribution of covariates was adequately balanced in the matched data set. After 1:1 matching, a total of 2462 children were included in further analysis, before lockdown ($n = 1231$) and after lockdown ($n = 1231$). After PSM, median age was 10.2 months before lockdown and 11.0 months after lockdown.

We compared the growth of children at physical examination before and after lockdown. A statistically significant difference of weight-for-height between the two periods was observed ($p < 0.05$) after PSM. No statistical difference was obtained in children aged 1–36 months for the difference of overall development, gross motor, fine motor, and language development after PSM between these two periods. Comparisons according to lockdown grouping are detailed in Table 2. However, there was a statistically significant interaction between age and lockdown for overall development delay (OR = 0.15, 95% CI 0.04–0.52) and language development delay (OR = 0.26, 95% CI 0.11–0.59) in the group of 24–36 months by using stratified analysis after PSM (Table 3). Also, there was a statistically significant interaction between parity and lockdown for wasting (OR = 0.33, 95% CI 0.12–0.90) in the group of first parity and that for language development delay (OR = 0.30, 95% CI 0.11–0.83) in the group of second parity by using stratified analysis after PSM (Table 4). No other statistical interaction between age and lockdown and that between parity and lockdown was observed for growth and the neural development.

Discussion

Science has shown that genetic predispositions are modified by environmental influences, such as those experienced during a pandemic, and affect learning capacities, adaptive behaviors, lifelong physical and mental health, and adult productivity [8, 10]. There are several factors that influence the physical and mental health of children experiencing the stress inherent in a pandemic, such as isolation itself, reduced social life and physical activities, changes to routine, sleep difficulties, exposure to disharmony at home, excessive screen use, unhealthy diet, and others [11]. Pandemics, such as Omicron, produce potential risks to child development due to protective confinement, social isolation, and the increased stress level of parents and caregivers. Studies to improve the understanding of the impact of pandemic quarantine such as Omicron on children's mental health and development can help to guide strategies to prevent damage to children's growth and promote positive development [8].

Some of the teams looking into these issues around the world are starting to publish their findings. Firm answers are hard to come by [12]. Depending on levels and kinds of support, high and continuous stress may either be tolerable or become toxic to children [8]. Some babies born during the past two years might be experiencing developmental delays, whereas others might have thrived, if carers were at home for extended periods and there were more opportunities for siblings to interact [12]. Another study reported that there

Table 1 Comparison before and after lockdown with respect to perinatal and gestation variables before and after PSM

	Before PSM			After PSM		
	Before lockdown n (%)	After lockdown n (%)	*p*-value	Before lockdown n (%)	After lockdown n (%)	*p*-value
Number of participants	1488	3077		1231	1231	
Gender						
Girls	670 (45.0)	1397 (45.4)		562 (45.7)	592 (48.1)	
Boys	818 (55.0)	1680 (54.6)	0.873	669 (54.3)	639 (51.9)	0.407
Ages (1–36 months)						
1–11 months	769 (51.7)	1664 (54.1)	0.298	662 (53.8)	651 (52.9)	
12–23 months	506 (34.0)	901 (29.3)	0.007	403 (32.7)	388 (31.5)	0.594
24–36 months	213 (14.3)	512 (16.6)	0.065	166 (13.5)	192 (15.6)	0.169
Weight at birth						
≥ 2500 g	1376 (92.5)	2842 (92.4)		1159 (94.2)	1161 (94.3)	
< 2500 g	112 (7.5)	235 (7.6)	0.899	72 (5.8)	70 (5.7)	0.867
Length/height at birth						
Z-score ≥ -2	1436 (96.5)	2975 (96.7)		1198 (97.3)	1206 (98.0)	
Z-score < -2	52 (3.5)	102 (3.3)	0.757	33 (2.7)	25 (2.0)	0.293
Gestational weeks						
Full term	1332 (89.5)	2806 (91.2)		1141 (92.7)	1156 (93.9)	
Preterm	156 (10.5)	271 (8.8)	0.083	90 (7.3)	75 (6.1)	0.243
Advanced maternal age						
No	1270 (85.3)	2605 (84.7)		1082 (87.9)	1087 (88.3)	
Yes	218 (14.7)	472 (15.3)	0.575	149 (12.1)	144 (11.7)	0.770
Type of delivery						
Vaginal	744 (50.0)	1563 (50.8)		647 (52.6)	647 (52.6)	
Caesarian	744 (50.0)	1514 (49.2)	0.720	584 (47.4)	684 (47.4)	1.000
Assisted reproduction						
No	1390 (93.4)	2874 (93.4)		1171 (95.1)	1165 (94.6)	
Yes	98 (6.6)	203 (6.6)	0.989	60 (4.9)	66 (5.4)	0.593
Parity						
First	1021 (68.6)	2374 (77.2)		928 (75.4)	937 (76.1)	
Second	325 (21.8)	522 (17.0)	< 0.001*	256 (20.8)	239 (19.4)	0.445
Third or above	142 (9.6)	181 (5.9)	< 0.001*	47 (3.8)	55 (4.5)	0.428
Birth order						
First	1160 (78.0)	2561 (83.2)		1025 (83.3)	1017 (82.6)	
Second	295 (19.8)	478 (15.5)	0.001*	195 (15.8)	201 (16.3)	0.763
Third or above	33 (2.2)	38 (1.3)	0.013*	11 (0.9)	13 (1.1)	0.683
Multiple birth						
No	1430 (96.1)	2946 (95.7)		1197 (97.2)	1200 (97.5)	
Yes	58 (3.9)	131 (4.3)	0.576	34 (2.8)	31 (2.5)	0.710
Neonatal injury						
No	1478 (99.4)	3053 (99.2)		1224 (99.4)	1226 (99.6)	
Yes	10 (0.6)	24 (0.8)	0.692	7 (0.6)	5 (0.4)	0.564
Family heredity history						
No	1467 (98.6)	3027 (98.4)		1222 (99.3)	1224 (99.4)	
Yes	21 (1.4)	50 (1.6)	0.587	9 (0.7)	7 (0.6)	0.617
Head circumference at physical examination						
Normal	1402 (93.3)	2790 (90.7)		1176 (95.5)	1176 (95.5)	
Macrocephaly	64 (4.2)	258 (8.4)	< 0.001*	46 (3.7)	52 (4.2)	0.545
Microcephaly	22 (1.5)	29 (0.9)	0.108	9 (0.7)	3 (0.2)	0.083

*Significant at 0.05

Table 2 Comparison of growth and development with respect to lockdown before and after PSM

			Before lockdown	After lockdown	
			n (%)	n (%)	p-value
Before PSM	Weight-for-age	Z-score ≥ -2	1468 (98.7)	3059 (99.4)	
		Z-score < -2	20 (1.3)	18 (0.6)	0.008*
	Length/height-for-age	Z-score ≥ -2	1465 (98.5)	3052 (99.2)	
		Z-score < -2	23 (1.5)	25 (0.8)	0.024*
	Weight-for-height	Z-score ≥ -2	1461 (98.2)	3057 (99.4)	
		Z-score < -2	27 (1.8)	20 (0.6)	< 0.001*
	Overall development	Normal	1453 (97.6)	3033 (98.6)	
		Delay	35 (2.4)	44 (1.4)	0.026*
	Gross motor	Normal	1432 (96.2)	3002 (97.6)	
		Delay	56 (3.8)	75 (2.4)	0.013*
	Fine motor	Normal	1445 (97.1)	2981 (96.9)	
		Delay	43 (2.9)	96 (3.1)	0.676
	Language	Normal	1406 (94.5)	2948 (95.8)	
		Delay	82 (5.5)	129 (4.2)	0.052
After PSM	Weight-for-age	Z-score ≥ -2	1218 (98.9)	1226 (99.6)	
		Z-score < -2	13 (1.1)	5 (0.4)	0.059
	Length/height-for-age	Z-score ≥ -2	1212 (98.5)	1220 (99.1)	
		Z-score < -2	19 (1.5)	11 (0.9)	0.144
	Weight-for-height	Z-score ≥ -2	1210 (98.3)	1225 (99.5)	
		Z-score < -2	21 (1.7)	6 (0.5)	0.029*
	Overall development	Normal	1205 (97.9)	1212 (98.5)	
		Delay	26 (2.1)	19 (1.5)	0.297
	Gross motor	Normal	1191 (96.8)	1198 (97.3)	
		Delay	40 (3.2)	33 (2.7)	0.413
	Fine motor	Normal	1199 (97.4)	1185 (96.3)	
		Delay	32 (2.7)	46 (3.7)	0.113
	Language	Normal	1164 (94.6)	1182 (96.0)	
		Delay	67 (5.4)	49 (4.0)	0.095

*Significant at 0.05

were long-term psychological effects of COVID-19 pandemic on Children in Jordan [13]. In our study, there were no significant differences for children after Omicron lockdown in terms of overall development, gross motor, fine motor, and language development after PSM. However, statistically significant interactions were obtained between age and lockdown for overall development and language development in the older group (24–36 months) based on PSM. It indicated that older children benefited more in language development during lockdown. Since in the older age group, children's language development is mainly manifested in language expression rather than language comprehension. We also observed a protective effect of interaction between parity and lockdown for language development delay in the group of second parity. More family members may lead to more interaction that is beneficial to language development. Possibly due to the small sample size in the stratified analysis, this interaction was found to be insignificant in the group of third parity or above. Also, the mother's parity of more than three children may be linked with socioeconomic status, which may limit adequate child care and nurturing [14]. A statistically significant decrease of wasting was observed for children after two months' lockdown both before and after PSM. By stratified analysis, lockdown appears to be more favorable for physical development of the group of first parity (Table 4). From an economic perspective, the burden of raising an only child may be relatively low on the family compared to that of a non-only child.

It is critical to consider how changes in the social, cultural, economic, and physical environments resulting from the pandemic could affect the development of children [15]. During Omicron pandemic, effects on growth and development may be related to children's social confinement recommended in an attempt to slow the progress of Omicron, increased screen media usage [6] and changes in family routines during social distancing [16, 17]. This situation becomes an adverse childhood experience and may generate toxic stress, with consequent potential losses for

Table 3 Interaction between age and lockdown after PSM

		1–11 months			12–23 months			24–36 months		
		Before lockdown	After lockdown	OR (95%CI)	Before lockdown	After lockdown	OR (95%CI)	Before lockdown	After lockdown	OR (95%CI)
Weight-for-age	Z-score ≥ -2	653 (98.6)	649 (99.7)		402 (99.8)	386 (99.5)		163 (98.2)	191 (99.1)	
	Z-score < -2	9 (1.4)	2 (0.3)	0.22 (0.05–1.04)	1 (0.2)	2 (0.5)	2.08 (0.19–23.07)	3 (1.8)	1 (0.9)	0.28 (0.03–2.76)
Length/height-for-age	Z-score ≥ -2	652 (98.5)	646 (99.2)		395 (98.0)	385 (99.2)		165 (99.4)	189 (98.4)	
	Z-score < -2	10 (1.5)	5 (0.8)	0.50 (0.17–1.48)	8 (2.0)	3 (0.8)	0.38 (0.10–1.46)	1 (0.6)	3 (1.6)	2.62 (0.27–25.42)
Weight-for-height	Z-score ≥ -2	649 (98.0)	646 (99.2)		397 (98.5)	388 (100)		164 (98.8)	191 (99.5)	
	Z-score < -2	13 (2.0)	5 (0.8)	0.39 (0.14–1.09)	6 (1.5)	0 (0.0)	0.08 (0.004–1.40)	2 (1.2)	1 (0.5)	0.43 (0.04–4.78)
Overall development	Normal	661 (99.8)	645 (99.1)		394 (97.8)	378 (97.4)		150 (90.4)	189 (98.4)	
	Delay	1 (0.2)	6 (0.9)	6.15 (0.74–51.22)	9 (2.2)	10 (2.6)	1.16 (0.47–2.88)	16 (9.6)	3 (1.6)	0.15 (0.04–0.52)*
Gross motor	Normal	649 (98.0)	644 (98.9)		388 (96.3)	368 (94.8)		154 (92.8)	186 (96.9)	
	Delay	13 (2.0)	7 (1.1)	0.54 (0.22–1.37)	15 (3.7)	20 (5.2)	1.41 (0.71–2.79)	12 (7.2)	6 (3.1)	0.41 (0.15–1.131)
Fine motor	Normal	657 (99.2)	646 (99.2)		391 (97.0)	366 (91.8)		151 (91.0)	183 (95.3)	
	Delay	5 (0.8)	5 (0.8)	1.02 (0.29–3.53)	12 (3.0)	22 (8.2)	1.96 (0.96–4.01)	15(9.0)	9(4.7)	0.50 (0.21–1.16)
Language	Normal	631 (95.3)	624 (95.9)		391 (97.0)	374 (96.4)		142(85.5)	184(95.8)	
	Delay	31 (4.7)	27 (4.1)	0.88 (0.52–1.49)	12 (3.0)	14 (3.6)	1.22 (0.56–2.67)	24(14.5)	8(4.2)	0.26 (0.11–0.59)*

*Significant at 0.05

Table 4 Interaction between parity and lockdown after PSM

		First parity			Second parity			Third parity or above		
		Before lockdown	After lockdown	OR(95%CI)	Before lockdown	After lockdown	OR(95%CI)	Before lockdown	After lockdown	OR(95%CI)
Weight-for-age	Z-score ≥ -2	920(99.1)	934(99.7)		252(98.4)	237(99.2)		46(97.9)	55(100.0)	
	Z-score < -2	8(0.9)	3(0.3)	0.37(0.10–1.40)	4(1.6)	2(0.8)	0.53(0.10–2.93)	1(2.1)	0(0.0)	0.28(0.01–7.02)
Length/height-for-age	Z-score ≥ -2	915(98.6)	930(99.3)		250(97.7)	236(98.7)		47(100.0)	54(98.2)	
	Z-score < -2	13(1.4)	7(0.7)	0.53(0.21–1.33)	6(2.3)	3(1.3)	0.53(0.13–2.14)	0(0.0)	1(1.8)	2.61(0.10–65.72)
Weight-for-height	Z-score ≥ -2	913(98.4)	932(99.5)		252(98.4)	238(99.6)		45(95.7)	55(100.0)	
	Z-score < -2	15(1.6)	5(0.5)	0.33(0.12–0.90)*	4(1.6)	1(0.4)	0.26(0.03–2.39)	2(4.3)	0(0.0)	0.16(0.01–3.50)
Overall development	Normal	910(98.1)	923(98.5)		249(97.3)	235(98.3)		46(97.9)	54(98.2)	
	Delay	18(1.9)	14(1.5)	0.77(0.28–1.28)	7(2.7)	4(1.7)	0.61(0.18–2.10)	1(2.1)	1(1.8)	0.85(0.05–14.00)
Gross motor	Normal	900(97.0)	911(97.2)		244(95.3)	232(97.1)		47(100.0)	55(100.0)	
	Delay	28(3.0)	26(2.8)	0.92(0.53–1.58)	12(4.7)	7(2.9)	0.61(0.24–1.59)	0(0.0)	0(0.0)	0.87(0.02–44.78)
Fine motor	Normal	903(97.3)	903(96.4)		250(97.7)	227(95.0)		46(97.9)	55(100.0)	
	Delay	25(2.7)	34(3.6)	1.36(0.80–2.30)	6(2.3)	12(5.0)	2.20(0.81–5.97)	1(2.1)	0(0.0)	0.28(0.01–7.02)
Language	Normal	880(94.8)	898(95.8)		239(93.4)	234(97.9)		45(95.7)	50(90.9)	
	Delay	48(5.2)	37(4.2)	0.76(0.49–1.17)	17(6.6)	5(2.1)	0.30(0.11–0.83)*	2(4.3)	5(9.1)	2.25(0.42–2.18)

*Significant at 0.05

brain development, individual and collective health [8]. From our study, it indicated that short-term quarantine had limited impact on growth and development for younger children aged 1–36 months during Omicron pandemic in Shanghai, China. To some extent, short-term confinement was beneficial to the physical and neurological development of children. This may be related to the increase in parental care and companionship during this period, as everyone was not allowed to leave the house. Responsive interactions are linked to improved psychosocial, cognitive, and physical outcomes in children [18].

The results indicated the importance of persistent screening and developing preventative programs to minimize the impact of the Omicron pandemic on children's physical and psychological well-being. One of the pillars for overcoming adversity is interaction among people, which is compromised by isolation, leading to increased stress in both parents and children [8]. Children are a product of their environment and the measures what it's going to take is to stimulate them, play with them, and love them [12].

This study has three major strengths. First, detailed indicators of growth and development are compared before and after lockdown through a cross-sectional study of development screening in Shanghai China. Second, all physical and neuropsychological evaluation was conducted item by item with the animation demonstration and the doctors' instruction to ensure the screening accuracy. This study is, however, also limited in several ways. First, children who participated in this study were not randomly selected so the potential for selection bias cannot be ruled out. Second, there may be greater subjectivity of self-reported information that cannot be measured on site and we did not consider the parental characteristics, physical and economic factors. Also, a longitudinal study is required to better adjust for pre-tests to measure the impact of lockdown on children's growth and development. In the stratified analysis for the interaction, the smaller sample size may limit the interpretation of the interaction between lockdown and third parity or above.

Conclusions

This study reveals that short-term quarantine had no significant adverse, but rather beneficial, effects on growth and development of children aged 1–36 months during Omicron pandemic in Shanghai, China. Families need maintain adequate care to children and interaction among people to improve development and reduce wasting, even in the absence of the pandemic.

Acknowledgements The authors are grateful to all the parents for their assistance and cooperation in this study.

Authors' contributions Investigation and data curation: Lei Shi; Formal analysis: You Yang; Funding acquisition: You Yang; Methodology and validation: You Yang; Project administration: You Yang; Conceptualization and supervision: Xingming Jin; Writing – original draft: You Yang; Writing – review & editing: Shilu Tong. All authors reviewed the manuscript.

Funding The authors gratefully acknowledge the financial support of the Project of Shanghai Children's Health Service Capacity Construction (GDEK201708).

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

Declarations

Ethics approval The study was conducted in accordance with the Declaration of Helsinki and approved by the Ethics Committee of Shanghai Children's Medical Center.

Consent to participate The objectives and protocol of the study were explained to the students and their parents. A waiver of written informed consent was granted by the Ethics Committee of Shanghai Children's Medical Center for this study. No unique identifier for the children was collected. Confidentiality of data collected was maintained throughout the study period.

Consent for publication Not applicable.

Conflict of interest The authors declare no competing interests.

References

1. Decaro N, Mari V, Elia G, Addie DD, Camero M, Lucente MS, Martella V, Buonavoglia C (2010) Recombinant canine coronaviruses in dogs, Europe. Emerg Infect Dis 16:41–47
2. Wu F, Zhao S, Yu B, Chen YM, Wang W, Song ZG, Hu Y, Tao ZW, Tian JH, Pei YY, Yuan ML, Zhang YL, Dai FH, Liu Y, Wang QM, Zheng JJ, Xu L, Holmes EC, Zhang YZ (2020) A new coronavirus associated with human respiratory disease in China. Nature 579:265–269
3. Pollard CA, Morran MP, Nestor-Kalinoski AL (2020) The COVID-19 pandemic: a global health crisis. Physiol Genomics 52:549–557
4. Dutta K, Mukherjee R, Sen D, Sahu S (2022) Effect of COVID-19 lockdown on sleep behavior and screen exposure time: an observational study among Indian school children. Biol Rhythm Res 53:628–639
5. Pisot S, Milovanovic I, Simunic B, Gentile A, Bosnar K, Prot F, Bianco A, Lo Coco G, Bartoluci S, Katovic D, Bakalar P, Kovalik Slancova T, Tlucakova L, Casals C, Feka K, Christogianni A, Drid P (2020) Maintaining everyday life praxis in the time of COVID-19 pandemic measures (ELP-COVID-19 survey). Eur J Public Health 30:1181–1186
6. Eales L, Gillespie S, Alstat RA, Ferguson GM, Carlson SM (2021) Children's screen and problematic media use in the United States before and during the COVID-19 pandemic. Child Dev 92:e866–e882
7. Zhang X, Zhang W, Chen S (2022) Shanghai's life-saving efforts against the current omicron wave of the COVID-19 pandemic. Lancet 399:2011–2012

8. Araujo LA, Veloso CF, Souza MC, Azevedo JMC, Tarro G (2021) The potential impact of the COVID-19 pandemic on child growth and development: a systematic review. J Pediatr (Rio J) 97:369–377
9. Austin PC (2011) An introduction to propensity score methods for reducing the effects of confounding in observational studies. Multivariate Behav Res 46:399–424
10. Clark H, Coll-Seck AM, Banerjee A, Peterson S, Dalglish SL, Ameratunga S, Balabanova D et al (2020) A future for the world's children? A WHO-UNICEF-Lancet Commission. Lancet 395:605–658
11. Wang G, Zhang Y, Zhao J, Zhang J, Jiang F (2020) Mitigate the effects of home confinement on children during the COVID-19 outbreak. Lancet 395:945–947
12. Wenner Moyer M (2022) The COVID generation: how is the pandemic affecting kids' brains?. Nature 601:180–183
13. Al-Rahamneh H, Arafa L, Al Orani A, Baqleh R (2021) Long-term psychological effects of COVID-19 pandemic on children in Jordan. Int J Environ Res Public Health 18
14. Namazzi G, Hildenwall H, Mubiri P, Hanson C, Nalwadda C, Nampijja M, Kakooza-Mwesige A, Waiswa P, Tumwine JK (2019) Prevalence and associated factors of neurodevelopmental disability among infants in eastern Uganda: a population based study. BMC Pediatr 19:379
15. Suarez-Lopez JR, Cairns MR, Sripada K, Quiros-Alcala L, Mielke HW, Eskenazi B, Etzel RA, Kordas K (2021) COVID-19 and children's health in the United States: consideration of physical and social environments during the pandemic. Environ Res 197:111160
16. Baptista AS, Prado IM, Perazzo MF, Pinho T, Paiva SM, Pordeus IA, Serra-Negra JM (2021) Can children's oral hygiene and sleep routines be compromised during the COVID-19 pandemic?. Int J Paediatr Dent 31:12–19
17. Micheletti MB, Cafiero P, Nápoli S, Lejarraga C, Pedernera Bradichansky P, Vitale MP, Urinovsky MG, Escalante A, Rodríguez E (2021) Sleep problems in a sample of children with developmental disorders, before and during the COVID-19 pandemic. Arch Argent Pediatr 119:296–303
18. Scherer E, Hagaman A, Chung E, Rahman A, O'Donnell K, Maselko J (2019) The relationship between responsive caregiving and child outcomes: evidence from direct observations of mother-child dyads in Pakistan. BMC Public Health 19:252