Increased risk for developmental delay among babies born during the pandemic

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Abbreviations: AOF - All Our Families study; ASQ-3 – Ages and Stages Questionnaire 3rd edition; CI – confidence interval; Impact of Maternal and Paternal Postpartum Depression: Assessing Concurrent Depression in the Family (IMPACT); OR – odds ratio; PdP - Pregnancy During the COVID-19 Pandemic; SD - standard deviation.

Contributors' Statement Page

Drs Giesbrecht conceptualized and designed the study, collected data, carried out the initial analyses, drafted the initial manuscript, and reviewed and revised the manuscript.

Drs Lebel and Tomfohr-Madsen conceptualized and designed the study, collected data, and reviewed and revised the manuscript.

Drs Tough and McDonald collected data for the All Our Families (AOF) study and reviewed and revised the manuscript.

Dr Dennis collected data for the Maternal and Paternal Postpartum Depression: Assessing Concurrent Depression in the Family (IMPACT) study and reviewed and revised the manuscript.

All authors approved the final manuscript as submitted and agree to be accountable for all aspects of the work.

Introduction

The COVID-19 pandemic has resulted in substantial and widespread changes to many prenatal (e.g., maternal stress) and postnatal (e.g., socialization) factors contributing to early child development. This has led to concerns about potential increases in developmental delays among infants born during the pandemic.[1] In particular, decreased opportunities for social interaction are of concern because they are associated with decreased language and socioemotional milestones.[2,3] We compared developmental screening of 1-year old infants born between April 17, 2020-November 11, 2020 to data from infants born pre-pandemic with similar sociodemographic characteristics. We aimed to determine whether risk for developmental delay was elevated among infants born during the pandemic compared to infants born prior to the pandemic.

Methods

The University of Calgary (Alberta, Canada) Research Ethics Board approved the study and informed consent was obtained prior to data collection. The Pregnancy During the COVID-19 Pandemic (PdP) study recruited pregnant individuals ≥17 years and ≤35 weeks gestation at enrollment, living in Canada, and able to read and write in English or French.[4] At infant 1-year of age (adjusted for prematurity), mothers completed the Ages and Stages Questionnaire (ASQ-3),[5] a widely used parent-reported, norm-referenced tool recommended by the American Academy of Pediatrics to screen for delayed developmental milestones.[6] Infants who were multiples (n = 38) or had confirmed COVID-19 infection (n = 18) were excluded from analysis. Mean scores and odds ratios for scoring 1 or 2 SD below the normative sample mean (indicating moderate or high risk for developmental delay, respectively) were compared to infants born pre-

pandemic (see supplemental material for details) from the All Our Families (AOF)[7] study (n = 1275, 1y data collected 2011-12) and the Impact of Maternal and Paternal Postpartum Depression: Assessing Concurrent Depression in the Family (IMPACT) study (n = 3902, 1y data collected 2016-19). Sociodemographic characteristics were similar between cohorts (Supplemental Table 1), with the exception that PdP participants had higher household income, and more were of European descent (i.e., White).

Results

Data were available from 1623 PdP participants. PdP infants had lower mean scores relative to pooled pre-pandemic data on all domains except Problem Solving (Supplemental Table 1). PdP infants also had significantly higher risk for developmental delay (Table 1) in the Communication and Personal-Social domains, where the odds ratios for scoring 2 SD below the mean were 2.5 and 1.5, respectively, relative to pre-pandemic data. When stratified by sex, the odds ratios for risk of developmental delay were generally higher among female infants (Table 2).

Discussion

Risks for developmental delay in the Communication and Personal-Social domains were elevated in infants born during the COVID-19 pandemic compared to pre-pandemic infants, especially among girls. These differences may reflect reduced opportunities for social interactions among pandemic-born infants resulting from COVID-19 restrictions.[8] The findings suggest that a larger portion of infants born during the pandemic will screen at risk of delay and require referral for time consuming and costly developmental assessments, forecasting an additional burden to healthcare and early learning services. Furthermore, if delays are present,

children may require more resources and support in childcare and educational settings. Risk for delay was relatively higher among females compared to males, perhaps reflecting greater susceptibility to the impoverished social environment during the pandemic.[9] However, the percentage of infants below the cut-offs remained relatively small, suggesting that most infants born during the pandemic continue to develop typically without risks for developmental delay.

Compared to the pre-pandemic cohorts, mothers in the PdP cohort had higher education and more were White, both of which reduce risk for developmental delay.[10] The current findings are therefore remarkable because we observed developmental delay despite sociodemographic advantage in the pandemic sample. Consequently, the results may be a conservative estimate of risk for developmental delay in the population of pandemic-born infants. In conclusion, risk for developmental delay is increased among pandemic-born infants, especially among females and within the Communication and Personal-Social domains. Healthcare and education systems will need to be prepared to provide additional resources to support these infants as they develop.

Table 1. Percent of infants below the 1 SD and 2 SD cut-offs and odds ratio for increased risk of developmental delay for PdP infants relative to pre-pandemic infants.

	PdP (n = 1,623)		AOF (n = 1,275)		IMPACT (n = 2,903)		Pooled Sample (n = 4,178)		Odds Ratio for delay	
ASQ-3 Domain	% ↓ 1 SD[a]	% ↓ 2 SD[b]	% ↓ 1 SD[a]	% ↓ 2 SD[b]	% ↓ 1 SD[a]	% ↓ 2 SD[b]	% ↓ 1 SD[a]	% ↓ 2 SD[b]	OR (95% CI) 1 SD cut-off[a]	OR (95% CI) 2 SD cut-off[a]
Communication	10.8	2.2	5.5	0.9	7.6	0.9	7.0	0.9	1.61 (1.32,1.96)***	2.49 (1.56,3.95)***
Gross Motor	23.8	9.0	22.6	9.8	19.4	7.4	20.4	8.1	1.22 (1.06,1.40)**	1.12 (0.91,1.37)
Fine Motor	8.3	1.8	10.0	2.0	7.2	1.7	8.1	1.8	1.02 (0.83,1.26)	1.00 (0.65,1.54)
Problem Solving	15.3	4.9	17.4	5.6	15.8	5.4	16.3	5.5	0.92 (0.79,1.08)	0.88 (0.68,1.15)
Personal-Social	15.6	5.4	13.4	4.2	11.4	3.5	12.0	3.7	1.35 (1.14,1.59)**	1.48 (1.13,1.94)**

Abbreviations: ASQ-3, Ages and Stages Questionnaire-third edition; PdP, Pregnancy During the COVID-19 Pandemic study; AOF, All Our Families study; IMPACT, Impact of Maternal and Paternal Postpartum Depression: Assessing Concurrent Depression in the Family; SD, standard deviation; OR, odds ratio.

Note: Asterisks indicate significant differences from the PdP cohort; #p < 0.10, *p<0.05, **p<0.01, ***p<0.001

Table 2. Percent of male and female infants below the 2 SD cut-off and odds ratio for increased risk of developmental delay for PdP infants compared to pooled pre-pandemic infants (IMPACT and AOF).

	PdP		Pooled Data (AOF & IMPACT)		Odds Ratio for delay	
ASQ-3 Domain	Males (n = 865) % ↓ 2 SD	Females (n = 775) % ↓ 2 SD	Males (n = 2150) % ↓ 2 SD	Females (n = 2026) % ↓ 2 SD	Males OR (95% CI)	Females OR (95% CI)
Communication	2.7	1.6	1.3	0.4	2.01 (1.15,3.49)**	3.98 (1.62,9.78)**
Gross Motor	7.3	10.7	7.3	9.1	1.00 (0.74,1.36)	1.2 (0.91,1.58)
Fine Motor	2.0	1.7	1.8	1.7	1.09 (0.62,1.94)	0.97 (0.51,1.85)
Problem Solving	4.8	4.9	6.4	4.4	0.74 (0.52,1.06)	1.12 (0.76,1.65)
Personal-Social	5.5	5.1	4.3	3.1	1.30 (0.91,1.86)	1.69 (1.13,2.55)**

Abbreviations: ASQ-3, Ages and Stages Questionnaire-third edition; PdP, Pregnancy During the COVID-19 Pandemic study; AOF, All Our Families study; IMPACT, Impact of Maternal and Paternal Postpartum Depression: Assessing Concurrent Depression in the Family; SD, standard deviation; OR, odds ratio.

Note: Asterisks indicate significant differences from the PdP cohort; *p<0.05, **p<0.01, ***p<0.001

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Supplemental Table 1. Means, SD and comparisons to pre-pandemic cohorts (IMPACT and AOF).

	PdP (n = 1,623)		AOF (n = 1,275)		IMPACT (n = 2903)		Pooled Data (n = 4178)	
ASQ-3 Domain	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Communication	48.03	11.57	48.72#	10.74	50.61***	10.63	50.05***	10.66
Gross Motor	46.12	15.84	46.24	15.75	48.19***	14.64	47.91***	14.99
Fine Motor	53.03	7.68	52.69	7.72	54.49***	7.34	53.49*	7.46
Problem Solving	48.01	10.68	47.81	11.09	48.63#	11.12	48.38	11.11
Personal-Social	44.17	11.87	45.49**	11.29	47.32***	11.37	46.76***	11.35

Abbreviations: ASQ-3, Ages and Stages Questionnaire-third edition; PdP, Pregnancy During the COVID-19 Pandemic study; AOF, All Our Families study; IMPACT, Impact of Maternal and Paternal Postpartum Depression: Assessing Concurrent Depression in the Family; SD, standard deviation.

Asterisks indicate significant differences from the PdP cohort; #p < 0.10, *p<0.05, **p<0.01, ***p<0.001

Supplemental Table 2. Participant sociodemographic characteristics in the PdP, AOF and IMPACT study cohorts.

	PdP Study (n = 1,623)		AOF Study (n =1,275)		IMPACT Study (n =2,903)	
	M (*SD*)	Range	*M* (*SD*)	Range	*M* (*SD*)	Range
Maternal Age (years)	32.9 (4.1)	18.8-49.0	32.4 (4.4)*	19 - 45	32.0 (4.1)*	18-48.6
Pregnancy Outcomes						
Birthweight (grams)	3426.4 (532.7)	350.0 – 5600	3366.7 (567.3)*	595 - 7257.5	3278.5 (508.8)*	1360.8-6803.9
Gestational age at birth (weeks)	39.1 (1.6)	29 – 42.5	39.1 (1.9)	24 - 43	39.6 (1.4)	30-43
	n	%	n	%	n	%
Delivery Mode			*		*	
Caesarean	477	29.4	380	24.1	718	24.8
Missing	96	5.9	59	3.8	2	0.1
Admission to NICU	135	8.3	97	6.7	261	9.0
Missing	96	5.9	0	0	3	0.1
Parity						
Nulliparous	940	58.0	751	47.7	1705	58.8
Missing	1	0.1	14	0.9	3	0.1
Pre-pregnancy BMI class			*		*	
Underweight	44	2.7	52	3.3	105	3.6
Normal weight	815	50.2	944	60.0	1617	55.7
Overweight	402	24.8	345	22.0	626	21.6
Obese	342	21.1	210	13.3	442	15.2
Missing	20	1.2	23	1.5	113	3.9
Marital Status						
Single	38	2.3	15	1.0	-	-
Married/Cohabitating	1569	96.7	1498	95.2	2797	96.6
Divorced	1	.1	4	0.3	-	-
Widowed	1	.1	-	-	3	0.1
Separated	2	.1	1	0.1	10	0.3

Other			50	3.2	33	1.1
Missing	12	0.7	6	0.4	60	2.1
Education						
Bachelor's degree or higher	1248	76.9	1207	76.7	2154	74.2
Completed Trade/Technical Degree	282	17.4			532	18.3
Completed High School Diploma	75	4.6	327	20.8	200	6.9
Less Than High School Diploma	5	.3	33	2.1	15	.5
Missing	13	0.8	7	0.4	2	0.1
Ethnicity			*		*	
White (Caucasian)	1408	86.8	1292	82.1	1848	63.7
First Nations, Metis, Inuit	23	1.4	10	0.6	77	2.7
Black	13	.8	25	1.6	91	3.1
West Asian	10	.6	3	0.2	-	-
East Asian	32	2.0	64	4.0	235	8.1
South Asian	23	1.4	37	2.4	161	5.6
Southeast Asian	17	1.0	53	3.4	69	2.4
Hispanic/Latinx	25	1.5	30	1.9	107	3.7
Biracial or other	50	3.1	38	2.4	312	10.8
Missing	22	1.4	6	0.4	3	0.1
Annual Household Income			*		*	
$100,000+/Year	1137	70.0	807	51.3	1557	53.6
$70,000 – $99,999/Year	252	15.5	394	25.0	631	21.7
$40,000 – $69,999/Year	149	9.2	208	13.2	431	14.8
$20,000 – $39,999/Year	52	3.2	37	2.4	175	6.0
Less Than $20,000/Year	12	.7	69	4.4	54	1.9
Missing	21	1.3	59	3.8	55	1.9
Province/Territory			*		*	
British Columbia	251	15.5	-	-	269	9.3
Alberta	458	28.2	1275	100	243	8.4
Saskatchewan	51	3.1	-	-	44	1.5

Manitoba	58	3.6	-	-	65	2.2
Ontario	517	31.9	-	-	1687	58.1
Quebec	206	12.7	-	-	76	2.6
New Brunswick	12	0.7	-	-	34	1.2
Prince Edward Island	7	.4	-	-	20	.7
Nova Scotia	43	2.6	-	-	65	2.2
Newfoundland	12	0.7	-	-	22	.8
Yukon	3	.2	-	-	7	.2
Northwest Territories	5	.3	-	-	4	.1
Nunavut	0	0	-	-	0	0
Missing	0	0	-	-	367	12.6

Note: PdP, Pregnancy During the COVID-19 Pandemic study; AOF, All Our Families study; IMPACT, Impact of Maternal and Paternal Postpartum Depression: Assessing Concurrent Depression in the Family.

* = significant difference from PdP cohort at familywise $p < 0.05$.

Supplemental study methods for the pre-pandemic cohorts

Maternal and Paternal Postpartum Depression: Assessing Concurrent Depression in the Family (IMPACT) study

IMPACT is a prospective cohort study of postpartum women and their male partners in Canada. Women and their partners were recruited in the immediate postpartum period in three hospital childbirth units in Toronto, using postpartum outreach, and via self-referral from social media advertisements (e.g., Twitter, Facebook) between 2015 and 2018. Participants were from Alberta, British Columbia, Manitoba, New Brunswick, Newfoundland and Labrador, Northwest Territories, Nova Scotia, Ontario, Prince Edward Island, Quebec, Saskatchewan, and Yukon. Hospital recruitment occurred through trained research assistants who assessed parents for eligibility and obtained informed consent. Participants recruited through postpartum outreach and self-referral were telephoned by a trained research assistant who obtained informed consent and administered the baseline questionnaire. Women up to 3 weeks postpartum were eligible to participate if: (1) they had a singleton live birth at >33 weeks gestational age; (2) their partner was a male who was also willing to participate; (3) both parents could read and understand English; and (4) both parents had access to a telephone or the internet. Women and their partners were excluded if they had: (1) schizophrenia, bipolar disorder, or active psychosis based on a self-reported clinical diagnosis or (2) active thoughts of self-harm or suicide based on a positive response to item 10 on the Edinburgh Postnatal Depression Scale and confirmed through additional questions. Ethics approval for the study was granted by the University of Toronto Research Ethics Board and the participating hospitals.

All Our Families (AOF) study

The AOF study (originally referred to as All Our Babies) is a prospective cohort study of approximately 3200 women and their children in Calgary, Alberta, Canada. A complete description of the AOF study has been previously published.[1] AOF was designed to examine maternal and infant outcomes during the perinatal period and to identify current barriers and facilitators to accessing health care services. Pregnant individuals were recruited between 2008 and 2010 via a community-based recruitment strategy, involving primary health care offices, community posters, and the public health laboratory service (Calgary Laboratory Service CLS). All women who attended CLS for a pregnancy confirmation lab test were eligible to participate (~ 97% of the population). Research staff were onsite in the primary health care office waiting rooms to provide women with information about the study, assess eligibility, and obtain informed consent. Community posters also enabled women to self-identify by emailing or calling the research team. Through telephone calls, research staff provided these women with information about the study, assessed eligibility, and obtained consent to participate. Women were eligible to participate in the AOF study if they were less than 24 weeks and six days gestation at the time of enrolment, they were 18 years of age or older, they lived in the greater Calgary area, and they were able to complete the written questionnaires in English. Women were excluded from the AOB study if they planned to move outside the greater Calgary area during their pregnancy. Women who agreed to participate were asked to complete questionnaires and biological samples during pregnancy, and at 12 months postpartum, women who agreed to be contacted for future research and whose child was less than 13 months of age were invited to participate in the AOF 12-month follow-up study. Ethics approval for the study was granted by the University of Calgary Conjoint Health Research Ethics Board.

Comparison of the PdP study to AOF and IMPACT.

All three cohorts are community-based longitudinal prospective studies with the objective of generalizing to the population of pregnant individuals and their children in North America. Analysis of sociodemographic characteristics of the AOF sample suggest that participants are generally representative

of the pregnancy and parenting population at the local (city) and provincial levels.[2] There are some methodological differences between the cohorts that may contribute to differences in sociodemographic characteristics of the samples. Most of these differences are unimportant, for example differences in maternal age, are trivial but statistically different. There are more substantial differences in ethnicity and income, where more PdP participants were White and had higher income relative to the pre-pandemic cohorts. These differences would be expected to reduce the occurrence of developmental delay among PdP infants because infants living in lower income and/or minority homes tend to have greater risk for developmental delay. The fact that the risk for developmental delay was increased in PdP infants relative to their pre-pandemic counterparts, despite the sociodemographic advantages of the PdP cohort, suggest that any sociodemographic advantage represented by the PdP cohort is insufficient to protect against increased risk for developmental delay associated with the experiences of living through the pandemic.

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