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COHORT PROFILE

Cohort Profile: The 2004 Pelotas (Brazil) Birth Cohort Study

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How did the study come about?

The last decades of the 20th century witnessed a major epidemiological and nutritional transition in Latin America.[1–3] Mortality due to infectious diseases and malnutrition declined in most countries and neonatal deaths now account for a growing proportion of infant deaths.[4,5] In Brazil, infant mortality fell from 82.8 per 1000 live births in 1980[6] to 27.4 per 1000 in 2000.[7] There were also marked improvements in undernutrition: 37.1% of Brazilian children <5 years of age were stunted in 1974[8] compared with 10.5% in 1996.[9]

Because of the speed of epidemiological and nutritional changes, and motivated by the successful implementation and follow-up of two previous population-based birth cohorts in 1982 and 1993,[10,11] the research team decided to start a new cohort in 2004 to assess the magnitude of changes in maternal and child health status and their determinants. The existence of three prospective birth cohorts in the same population would provide a unique opportunity to study time trends over a 22-year span.

What does it cover?

The 2004 Pelotas Birth Cohort was planned to collect information compatible with that obtained from the two previous cohorts, and to expand upon these by also addressing emerging health and developmental problems. All births occurring in the city of Pelotas, from 1 January to 31 December 2004, were enrolled and followed up in order to:

(i) assess the prenatal and perinatal conditions of every birth, with special attention to antenatal care characteristics, illnesses during pregnancy, gestational age, birth weight and length, delivery type and care (including personnel and facilities);
(ii) identify all stillbirths, neonatal and post-neonatal deaths, ascertaining causes of death and investigate how these might have been prevented through a death audit;
(iii) describe early life morbidity and nutritional outcomes, with special emphasis on growth, breastfeeding, development, infections and injuries;
(iv) assess health service utilization (hospitalizations, immunizations, use of medicines, preventive and curative outpatient visits);
(v) study maternal health indicators during pregnancy and in the first year postpartum (nutrition, morbidity, mortality, mental health, contraception, health care utilization);
(vi) study infant and child development at different ages;
(vii) identify risk factors associated with the outcomes listed above (i–vi), including health care, socio-economic, demographic, maternal and environmental characteristics;
(viii) assess socio-economic, ethnic group and gender inequities in the above indicators and identify groups with greater need of public health and social interventions, in order to subsidize local, national and global health planning and policy making regarding maternal and child health;
(ix) through a comparison with the previous cohorts, to study time trends in the above outcomes and their determinants;

(x) lay out the basis for future studies of genetic epidemiology, alone or in collaboration with other birth cohorts; and
(xi) lay out the basis for future studies of the long-term effects of early exposures (prenatal, perinatal and postnatal) on adolescent and adult health and behaviours.

Who is in the sample?

Similar recruitment strategies were employed for the three cohorts, which were restricted to hospital births (>98% of all deliveries in the city). All five city hospitals were visited on a daily basis by research team members. Eligible mothers included those living in the urban area of Pelotas according to the 1982 boundaries (part of the original city later became a separate municipality). They were interviewed soon after delivery (perinatal study) using a standardized, pre-coded questionnaire that was compatible with those used in the previous cohorts, but which also included a considerable amount of new information.

How often have they been followed up?

Differently from the previous two cohorts, the 2004 cohort included follow-up visits to the full cohort, rather than sub-samples. So far, visits have been carried out at the ages of 3, 12, 24 and 48 months. Learning from shortcoming of the previous cohorts, very detailed information on how to locate the family was collected since the first contact in the hospital. In addition to the family's address and telephone number, information was collected on workplaces and on the addresses of relatives. The popularization of cell phones made it considerably easier to schedule the follow up visits.

The 12-, 24- and 48-month follow-up rates (defined as the number of subjects traced plus the number of deaths in the period, divided by the total number of live births) were 94.0, 93.5 and 92.0%. A new follow up at the age of 6–7 years is scheduled for 2010–11.

What has been measured?

In the perinatal study, mothers were interviewed with regard to socio-economic, demographic and reproductive characteristics and on health care utilization, breastfeeding practices, lifestyles and morbidity. The interviews and newborn examinations were carried out in the maternity hospitals. The questionnaires, instruments and measurement techniques were highly compatible with those used in the 1982 and 1993 cohorts.

Table 1 shows the groups of variables collected and measurements undertaken at birth (perinatal study) and in each follow-up visit. Newborns were weighed by the hospital staff using digital paediatric scales with 10 g precision, calibrated weekly to standard weights. The research team also measured birth length (using a locally made infantometer), head and chest circumference (using inextensible measuring tape). Gestational age was evaluated through three methods: the date of the last menstrual period, by ultrasound (when available) and by Dubowitz's method.[12]

Follow-up at 3, 12, 24 and 48 months of age

The mother or caretaker was interviewed and the child examined at home. Information was collected on socio-economic and demographic characteristics, health care utilization, feeding practices, lifestyles and child growth, development and morbidity since birth. Separate questionnaires on maternal health and child development were also administered.

Perinatal and infant mortality study

This sub-study was carried out in a partnership with the City Department of Health, and led to the creation of an audit system for perinatal and infant deaths. Deaths occurring among cohort children were recorded and causes of death ascertained by reviewing case notes of outpatient clinics and hospitals. Additionally, family members and the physician who looked after the child were interviewed. During the interviews a full history of the events preceding the death was obtained.

As part of the death audit system, the reviewers also tried to identify potential failures in preventive and curative services that could have contributed to the children's deaths. Feedbacks on the coverage of vital registration and on shortcomings in health care were provided to local policy makers.

What is attrition like?

The cohort profile in Figure 1 shows the number of children enrolled in the cohort and the number followed up at each visit. A total of 94 children had died and 3799 of the 4231 live birth children were visited at the 48 month follow-up. The proportions of children traced at the 48 month follow-up according to maternal socio-economic and demographic characteristics and by child sex and birth weight are shown in Table 2. Follow-up rates were highest (94%) among children born to older mothers ($\geqslant$35 years) and lowest ($\sim$90%) among those from families in the upper and lower extremes of income.

Table 1 Variables collected and measurements undertaken at baseline and follow-ups, 2004 Pelotas Birth Cohort (2004–08)

Information	Birth	3 M	12 M	24 M	48 M
Socio-economic status, housing, sanitation					
Household income, parent's education, occupation and employment, wealth index	■		■	■	■
Source of water, sewage disposal, type and size of the house	■	■			■
Demographic characteristics					
No. of residents, and type of family	■	■	■	■	■
Parents' age	■				
Parents' skin colour	■			■	
No. of siblings	■			■	■
Mother's reproductive history					
No. of pregnancies, abortions, stillbirths, live births, preterm births and low birth-weight births	■			■	■
Birth interval	■			■	■
Pregnancy characteristics					
Morbidity, antenatal care, antenatal procedures	■				
Delivery characteristics					
Type, place, qualification of birth attendant, paediatrician in the delivery room, admission to intensive care/nursery ward/rooming in	■				
Mother's anthropometry					
Weight and height		■	■	■	■
Newborn characteristics					
Sex, Apgar index	■				
Skin colour				■	■
Gestational age	■				
Weight, length, head circumference	■	■	■	■	■
Child's morbidity, use of health services					
Perinatal morbidity	■	■			
Severe morbidity, hospitalization, injuries, immunization history		■	■	■	■
Growth monitoring in health facilities		■	■		
Use of health services: type of services, no. of attendances, lab examinations, etc.		■	■	■	■
Maternal satisfaction with child health services			■		
Use of medicines, health expenditure with the child		■	■	■	■
Maternal health					
Post-partum morbidity and mortality	■	■	■		
Contraception	■	■	■	■	■
Maternal mental health		■	■	■	■
Smoking	■	■	■		
Caffeine and alcohol consumption	■	■			
Physical activity	■	■			■
Childcare and development					
Childcare, use of pacifier, father 's participation in care, child development		■	■	■	■
Child physical activity patterns					■
Infant feeding					
Intention to breastfeed	■				
Length of breastfeeding, causes for stopping breastfeeding, complementary feeding		■	■	■	■

Highlighted boxes mean the follow-ups when information was collected.

What has it found? Key findings and publications

A complete list of publications may be found at http://www.epidemio-ufpel.org.br/blog/estudos-decoortes/coorte-2004. Comparative analyses of the three Pelotas cohorts are available in a special journal supplement.[13] These cover the perinatal period and the first year of life. Tables 3 and 4 (extracted from a previous publication)[14] contain a summary of the main results of the comparison of the three birth cohorts.

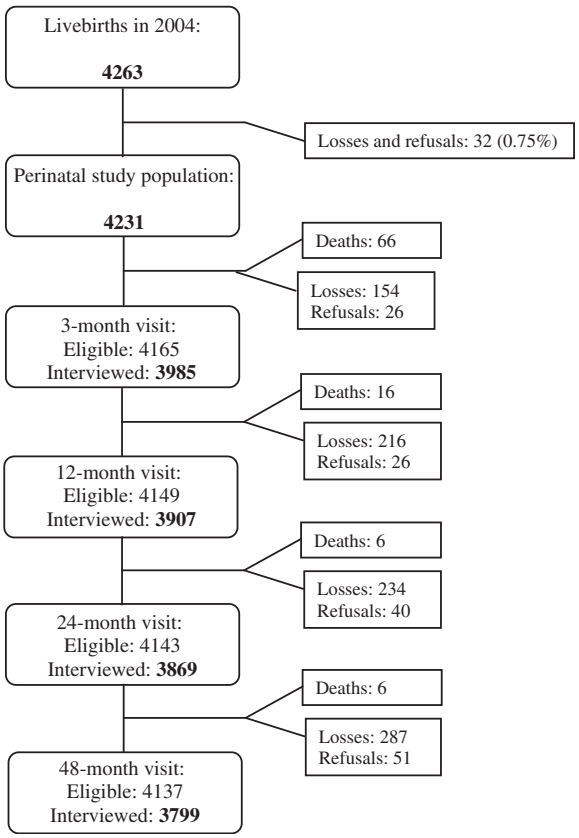

Figure 1 Flow chart of the 2004 Pelotas Birth Cohort

Maternal education improved—the mean number of years of schooling increased from 6.5 in 1982 to 6.7 in 1993 and 8.1 in 2004. On the other hand, the proportion of mothers from families earning less than one minimum wage was greater in 2004 than in 1982. This finding must be interpreted in light of the increased value of the minimum wage—~US$50 in 1982 and US$280 in 2004. Pre-pregnancy weight increased in the period, while mean maternal stature was 1 cm shorter in 2004 than in 1993; these two trends resulted in an increase in the body mass index, with 22% of the mothers being classified as overweight or obese (body mass index >25 kg/m^2) in 1982 and 34% in 2004. Birth intervals increased markedly in the period and there was an important reduction in the proportion of women who smoked during pregnancy—from 36% in 1982 to 25% in 2004.

Antenatal care coverage increased over time and, by 2004, <2% of women had no attendances. The number of attendances also increased significantly, and the first appointment took place earlier during the pregnancy.[15]

Skilled attendance at labour and delivery care is almost universal; there was also an increase in the proportion of deliveries in which a paediatrician was present at the time of birth. In 2004 there was a significant increase in operative deliveries; caesarean sections were performed in 45% of all deliveries (36% among deliveries financed by the Unified National Health System, 83% among those financed by health plans and 88% among private patients).

Perhaps the most impressive result emerging from the comparison of the three cohorts was the marked increase in preterm deliveries, which in 2004 accounted for 14.7% of all births, a phenomenon also reported in other parts of Brazil.[16] Preterm births increased so much that they offset gains in maternal smoking and nutrition—and as a result the percentage of children born weighing <2500 g, instead of decreasing, actually increased from 9 to 10% in the

Table 2 Socio-demographic characteristics of mothers and children enrolled in the 2004 Pelotas Birth Cohort and percentage located at the last follow-up (48 months)

Characteristics	Original cohort ($N=4231$)	Percentage located[a] (%)	P[b]
Maternal age, years			0.02
<19	593 (14.0)	92.4	
19–34	3073 (72.7)	91.3	
⩾35	563 (13.3)	94.7	
Maternal education, years			0.29
0	43 (1.0)	93.0	
1–4	612 (14.6)	90.4	
5–8	1731 (41.4)	92.7	
⩾9	1802 (43.0)	91.6	
Maternal skin colour			0.23
White	3090 (73.0)	91.6	
Non-white	1141 (27.0)	92.7	
Family income (quintiles)			0.0005
1 (poorest)	872 (20.6)	90.6	
2	855 (20.2)	91.9	
3	816 (19.3)	94.0	
4	858 (20.3)	93.9	
5 (wealthiest)	830 (19.6)	89.2	
Birth weight			0.73
<2500	424 (10.0)	92.5	
2500–3499	2694 (63.7)	91.7	
⩾3500	1110 (26.3)	92.3	
Gender			0.4
Boys	2196 (51.9)	92.2	
Girls	2035 (48.1)	91.5	
Preterm birth			0.26
Yes	647 (15.3)	93.2	
No	3571 (84.7)	91.9	

[a]Subjects known to have died were considered as traced.
[b]Chi-square test.

Table 3 Changes that took place in the maternal population and in antenatal care in Pelotas, Southern Brazil, between 1982 and 2004

Change[a]	Population	Health care
Improvement	↑ Education	↑ Early onset of antenatal care
	↑ Water supply, sanitation, housing	↑ Coverage and number of antenatal appointments
	↑ Weight gain during pregnancy	↑ Deliveries performed by qualified professionals
	↓ Fecundity	↑ Presence of a paediatrician during delivery
	↑ Birth intervals	↑ Deliveries financed by health plans
	↓ Multiparity	
	↓ Smoking	
Stagnation or decline	↓ Stature (1993–2004)	↑ Use of ultrasonography (of doubtful quality)
	↑ Maternal overweight and obesity	
	↑ Mothers without partner	↑ Interruption of pregnancy (caesarean sections and induction of labour)
	↑ Adolescent mothers (<17 years)	
	↑ Primiparity	

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[a]Changes expressed as: increase (↑) and reduction (↓).

Table 4 Changes that took place in infant population and in health care in Pelotas, Southern Brazil, between 1982 and 2004

Change[a]	Population	Health care
Improvement	↓ Intrauterine growth retardation	↑ Vaccine coverage
	↓ Perinatal mortality	↑ Childcare appointments
	↑ Exclusive and total breastfeeding	↑ Death reporting
	↑ Neuro-psychomotor development	↓ Hospitalizations due to diarrhoea
	↓ Malnutrition at 12 months	
	↓ Deaths due to diarrhoea	
	↓ Deaths by asphyxia	
	↓ Infant mortality (1982–93)	
Stagnation or decline	↑ Preterm births	
	↓ Birth weight	
	↑ Deaths due to immaturity	
	↑ Overweight at 12 months	
	= Infant mortality (1993–2004)	= Total hospitalizations

Reproduced from ref.[11] with permission.
[a]Changes expressed as: increase (↑), little or no change (=), and reduction (↓).

22-year period, with a corresponding decrease in mean birth weight.

Two-thirds of all preterm births were late preterm children (34–36 weeks of pregnancy), and this increased from 5% in 1982 to 11% in 2004. Some of our recent publications focus on this group. Compared with term births, late preterm births showed increased risk of depression at birth, perinatal morbidity and delayed onset of breastfeeding. Their rates of neonatal and infant mortality were, respectively, five and two times higher than those of term newborns.[17]

Late preterm children were also compared with term children (37–42 weeks) in terms of weight-for-age, length-for-age and weight-for-length *z*-scores at 12 or 24 months of age.[18] The adjusted odds of being underweight among late preterm children was about three times higher both at 12 and 24 months of age; of being stunted, two times higher at both ages; and of being wasted, four and two times higher at 12 and 24 months, respectively.

The association between sustained maternal depression at 12, 24 and 48 months post-partum and child anthropometry at age of 4 years (weight-for-age,

height-for-age and weight-for-height *z*-scores at 48 months according to the WHO growth standards) was also explored in the cohort. Maternal depression was assessed through the Edinburgh Postnatal Depression Scale (EPDS), and 4.7% of all mothers were persistently depressed (EPDS $\geqslant$ 13) at the 12-, 24- and 48-month visits. After adjustment for confounding factors, long-lasting maternal depression at 12, 24 and 48 months post-partum was not associated with impaired child growth or overweight at age of 4 years.[19]

Still in terms of comparing the three cohorts, one of the most important improvements in maternal and child health indicators was the marked increase in the median duration of any breastfeeding, from 3 months in 1982 to almost 7 months in 2004. Results comparing nutritional status at 12 months between the three cohorts provide evidence of a nutritional transition, with a reduction in malnutrition, as measured by weight-for-age or length-for-age, and a concomitant increase in infant overweight. The increase in overweight was markedly higher among poorer children. It is a cause for concern that the obesity epidemic is affecting both Pelotas mothers and their children. Finally, another important finding was the marked reduction in the prevalence of suspected developmental delay, from 37% in 1993 to 21% in 2004. Simple domestic interventions (like having child books at home and telling stories to the child) seem to have played an important role on the improving of child development throughout the two decades.[20–22]

Systematically, children and mothers from poor families are worse off than those from wealthy families. This was true for almost all indicators evaluated, including maternal characteristics (schooling, stature, parity, etc.), use of antenatal and delivery care services, perinatal mortality, hospitalization and the prevalence of growth and developmental delay. Social differences tended to persist throughout these 22 years, despite improvements in many indicators within each social group. There were few exceptions to this rule. The clear reverse association between family income and the frequency of low birth weight observed in 1982 disappeared in 2004, likely due to the epidemic of preterm deliveries.

What are the main strengths and weaknesses?

As investigators, the major advantage of the 2004 cohort was our ability to learn from the experience of the previous cohorts, and apply these lessons to improve the instruments and methods. For example, follow-up rates were higher in 2004 than in the earlier cohorts because of improved collection of information on how to locate the families. Also, follow-up visits covered the full cohort, unlike the previous studies in which sub-samples were used for several visits, with resulting sample size limitations for longitudinal analyses. The second advantage is being able to compare these findings with those from the earlier cohorts—a situation that is not common elsewhere.

Early growth is currently considered as an important determinant of complex chronic diseases in adulthood.[23] The 2004 cohort study collected anthropometric indicators in all five visits so far (from birth to 48 months of age) and body composition will be assessed on 6-year olds (in the next follow-up in 2010–11) using more sophisticated methods than those employed in the earlier cohorts, including whole-body dual X-ray absorptiometry (DXA),[24] air displacement plethysmograph (BOD POD)[25] and 3D photonic scan (3DPS).[26]

Feedback to local decision makers is also an important characteristic of our cohort. The mortality audit system described above was institutionalized and became a permanent committee at the City Department of Health. Differences in mortality rates between hospitals were identified,[27] and analysed in partnership with the heads of maternities and neonatal intensive care units. This has led to annual conferences aimed at reducing infant mortality, to which all health professionals are invited to discuss time trends, effective interventions and their delivery to the neediest mothers and children.

Major difficulties in longitudinal studies are losses during follow-up, but, as mentioned, >94% of all participants were reached at the age of 4 years. A second limitation is that the cohort started at delivery rather than at the beginning of pregnancy. We considered this possibility but because there are close to 100 different facilities (public or private) providing antenatal care in the city, it was not feasible to identify mothers soon after they became pregnant.

An additional limitation is that—with the exception of a few measures, such as weight and length at birth, Dubowitz gestational age, weight and height at follow-ups, and child development tests—the vast majority of information was obtained through maternal reports. The quality of reported information will therefore depend on characteristics of the mother being interviewed (such as age and schooling), and also on the nature of the variable being collected (e.g. how sensitive the information may be, and what is the duration of recall).

Can I get hold of the data? Where can I find more?

Joint analyses of the cohort data are welcome and we have collaborated successfully with investigators from the UK (University of Bristol) in these early analyses. The most fruitful collaborative experiences from our older cohorts including having doctoral or post-doctoral fellows from other institutions spend a

period of time in Pelotas, or for our students or fellows to spend time in other institutions, thus helping build local capacity.

For interested young researchers from Latin America, the Wellcome Trust sponsored post-graduate programme in Life Course Epidemiology was launched in 2005 and has so far trained 15 MSc and PhD students from Latin America and Africa. They receive full scholarships to work on the cohorts. Applications are welcome. For further information contact the program website at http://www.epidemio-ufpel.org.br/projetos_de_pesquisas/estudos/coorte_2004 or e-mail the corresponding author.

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