BMJ Open

Comparison of birthweight from maternal reports and medical birth records: Determinants of discrepancies.

Journal:	*BMJ Open*
Manuscript ID:	bmjopen-2015-008628
Article Type:	Research
Date Submitted by the Author:	29-Apr-2015
Complete List of Authors:	Jensen, Camilla; Institute of Preventive Medicine, Gamborg, Michael; Institute of Preventive Medicine, Bispebjerg and Frederiksberg Hospital, The Capital Region, Heitmann, Berit; The Boden Institute of Obesity, Nutrition, Exercise & Eating Disorders, University of Sydney, ; Institute of Preventive Medicine, Bispebjerg and Frederiksberg Hospital, The Capital Region, Sørensen, Thorkild; Institute of Preventive Medicine, ; Novo Nordisk Foundation Centre for Basic Metabolic Research, Section on Metabolic Genetics, Faculty of Health and Medical Sciences Baker, Jennifer; Institute of Preventive Medicine, Bispebjerg and Frederiksberg Hospital, The Capital Region, ; Novo Nordisk Foundation Centre for Basic Metabolic Research, Section on Metabolic Genetics, Faculty of Health and Medical Sciences
Primary Subject Heading:	Epidemiology
Secondary Subject Heading:	Obstetrics and gynaecology
Keywords:	EPIDEMIOLOGY, OBSTETRICS, PUBLIC HEALTH, STATISTICS & RESEARCH METHODS

Comparison of birthweight from maternal reports and medical birth records: Determinants of discrepancies.

Camilla Bjørn Jensen[1,2], Michael Gamborg[1], Berit Heitmann[3,4,5], Thorkild IA Sørensen[1,6,7], Jennifer L. Baker[1,6]

[1] Institute of Preventive Medicine, Bispebjerg and Frederiksberg Hospital, The Capital Region, Copenhagen, Denmark.

[2] Faculty of Health and Medical Sciences, University of Copenhagen, Copenhagen, Denmark.

[3] Research Unit of Dietary Studies, Parker Institute, Bispebjerg and Frederiksberg Hospital, The Capital Region, Copenhagen, Denmark.

[4] The Boden Institute of Obesity, Nutrition, Exercise & Eating Disorders, University of Sydney, Australia

[5] National Institute of Public Health, University of Southern Denmark, Denmark.

[6] Novo Nordisk Foundation Center for Basic Metabolic Research, Faculty of Health and Medical Sciences, University of Copenhagen, Denmark.

[7] MRC Integrative Epidemiology Unit, University of Bristol, Bristol, UK

Correspondence:

Email: Camilla.bjoern.jensen@regionh.dk

Institute of Preventive Medicine, Frederiksberg Hospital

Nordre Fasanvej 57, Hovedvejen, Entrance 5

2000 Frederiksberg, Denmark

Phone: +45 38163101

Word counts

Abstract: 248

Text: 3 321

Running title: Validation of maternal birthweight reports

Abbreviations

BW: Birthweight; CSHRR: The Copenhagen School Health Records Register; MBR: The Danish Medical Birth Register.

Keywords: Birthweight, Denmark, registries, validation studies

Abstract

Objective: To compare maternal reports of birth weight (BW) with BW from medical birth records, and to investigate if maternal and offspring characteristics associate with any discrepancies.

Design: Register-based cohort study

Setting: Denmark, 1973-91.

Participants: The study was based on BW recorded in the Copenhagen School Health Records Register (CSHRR) and in The Medical Birth Register (MBR). The registers were linked via the Danish personal identification number.

Primary and secondary outcome measures: Statistical comparisons of BW in the registers were performed using t-tests, Pearson's correlation coefficients, Bland-Altman plots, and Kappa coefficients. Odds of BW discrepancies >100 grams were examined by logistic regressions.

Results: The study population included 47 534 children. From 1973-1979 when BW was grouped in 500-gram intervals in the MBR, mean BW differed significantly between the registers. During 1979-1991 when BW was recorded in 10-gram and 1-gram intervals, mean BW did not significantly differ between the two registers. BW from both registers was highly correlated (0.93-0.97). Odds of a BW discrepancy significantly increased with parity, the child's age at recall and by marital status (married women had the highest odds).

Conclusion: Overall, maternal reports of BW agreed very well with BW from medical birth records, suggesting that BWs reported by the mother generally are valid.

Strengths and limitations

- Large register based study population
- Medical birth records are not always available and recall information might be the only source of BW. Validation studies as the present is useful in such circumstances.
- Limited information on maternal and offspring characteristics available.

Introduction

Birthweight (BW) has been identified as an important indicator of health for the child at birth, during infancy, and also later in adult life. [1–3] Officially recorded BW information is not always available to support current research into adult onset diseases, and it is therefore important to obtain valid information on BW collected retrospectively.

Because of the identified associations between BW and later disease outcomes, [4] information on BW is often included in epidemiological research. In many cases BW information can be retrieved from birth or medical records, however, this is not always possible and the use of recalled information may be the only option.

In general, mothers recall the BW of their children with a high degree of accuracy, [5–9] however the accuracy varies between studies possibly depending on the recall period (ranging from days to decades) and maternal characteristics. In one study, 58% of the mothers recalled their child's BW to within 100 grams of the recorded BW 6 years after birth [9] versus in two other studies where the rate was 92% at 9 months [5] and 8-18 years after birth. [6]

In this study, we therefore compared maternal reports of BW at the first school examination with the recorded BW from medical birth records, and we investigated if maternal and offspring characteristics predicted the discrepancies between BW values in the two registers.

Methods

Study population

The CSHRR is a population-based register that includes virtually every school child in Copenhagen born between 1930 and 1991 and includes 381 110 records. The register has been established in collaboration between the Institute of Preventive Medicine, Bispebjerg and Frederiksberg Hospital, The Capital Region and the Copenhagen City Archives. The computerized register contains basic information about each child (name, sex, date of birth, personal identification number), along with annual measures of height and weight throughout school ages. From the birth year of 1936 onwards, information on BW was obtained at the school entry examination which typically occurred when the children were 5-7 years of age. BW was reported mainly by the mother, but possibly also by the father or guardian. During many years it was requested that the mother/father/guardian bring the child's infancy health book in which BW was recorded by the visiting health nurse shortly after delivery. The source of the BW information contained in the school health records, however, was not noted. The CSHRR is described in greater detail elsewhere. [10]

The MBR is a national medical register that contains computerized information on all births in Denmark since 1973. Information on births was reported to the Danish Health Authorities on a form filled out by the midwife shortly after delivery. From 1973 to 1977, BW was recorded in 500-gram units in the MBR, however, the rounding procedure was not documented. From 1978 to 1990, BW was recorded in 10-gram units and from 1991 onwards it was recorded in 1-gram units. The MBR also contains information on gestational age which was measured in weeks from 1973 to

1978 and in days from 1978 onwards. The mother's age, parity and civil status was also registered in the MBR. Further details of the register can be obtained elsewhere. [11]

The Danish personal identification number was used to link the two registers during the overlapping period from 1973 to 1991, and children with BW information in both the CSHRR and the MBR were identified.

An access and linkage permission was obtained from the Danish Data Protection Agency (J. no. 2012-41-1156). This type of research based on pre-existing routinely collected data does not require ethical permission in Denmark.

We excluded children with BW values below 500 grams as these were likely to be erroneous based on the chance of survival of very small children during the study period (Pryds, personal communication 2014). Based on the highest BW reported in Denmark of 6 150 grams, values above this level were excluded. [12]

BW was analysed as continuous variable (in grams) and divided into categories of 500-1 499, 1 500-1 999, 2 000-2 750,2 751-3 250, 3 251-3 750, 3 751-4 250, 4 251-5 500, 5 501-6 150 grams, which were chosen to minimize the effects of digit preference. [13]

Information on gestational age is recorded in the MBR but not in the CSHRR. BW is strongly associated with gestational age, and we wanted to explore if reported BW varied by gestational age. We grouped gestational age into term categories (preterm: before 37 weeks, early term: 37 0/7 weeks through 38 6/7 weeks, full term: 39 0/7 weeks through 40 6/7 weeks, late term: 41 0/7 weeks through 41 6/7 weeks, postterm: 42 0/7 weeks and beyond). [14]

Based upon measured values of height and weight taken at the exam when the BW value was reported, we calculated a body mass index (BMI; kg/m^2) for each child. Each child's weight status (under-, normal-, over-weight, obesity and morbid obesity) was classified using age- and sex-specific BMI cut-offs issued by the International Obesity Task Force. [15]

Statistical analyses

To assess if children who were missing BW information differed from those who had it in regards to sex and BW (from the other register), comparisons were made using t-tests and chi-square tests. Likelihood ratio tests were used to evaluate if the association between BW in the two registers could be described linearly or exponentially.

Scatterplots were generated to compare BW values between the two registers. Comparisons of mean (SD) BWs within each register within categories of overall, sex-specific, time periods (1973-1978, 1979-1990, 1991), and gestational age were made using t-tests. Pearson's correlation coefficients were calculated and Bland-Altman plots were created, also by time period within each register. To test the agreement between the two registers we used Kappa coefficients for categories. The Kappa coefficient was not calculated for the period 1973-1978 because of the 500 gram rounding in the MBR.

Using a distribution plot of differences in BW between the two registers we identified outlying values with large discrepancies (> 500 grams). To examine if these subjects differed from the overall population, comparisons by sex and year of birth were performed with chi-square tests.

Logistic regressions were performed to examine if differences of > 100 grams in BW between the two registers were associated with maternal characteristics (maternal age, civil status and parity) from the MBR and offspring characteristics (age and BMI categories at the time of recall and year of birth) obtained from the CSHRR. Interactions between parity, age at BW recall, and civil status were assessed.

Results

Of 381 110 children in the CSHRR, 63 438 were born during 1973-1991 where the two registers overlapped and had a personal identification number. 11 971 children did not have information on BW in the CSHRR, and 3 832 did not have information on BW in the MBR. In the CSHRR there were no statistically significant differences between children with and without BW information in regards to sex and BW (from the MBR) (all $P > 0.05$). In the MBR there were no statistically significant differences in BW (from the CSHRR) between children with and without BW information, but more boys (53% vs. 51%, $P = 0.003$) and fewer girls (47% vs. 49%, $P = 0.003$) had missing BW information. The final study population consisted of 47 534 children after the exclusion of children with BWs below 500 grams or above 6 150 grams (**Figure S1**).

The BW distribution was approximately normal in both the MBR and the CSHRR. Digit preference was present in both registers for all time periods. Unsurprisingly, it was more apparent in the MBR than in the CSHRR during 1973-1979 when BW in the MBR was categorized in 500-gram units (**Figure S2**). Descriptive statistics can be seen in **Table 1**.

Table 1: Descriptive statistics for BW in the CSHRR and the MBR by birth year groups according to MBR procedural changes.

		Birthweight (*grams)*				
Information source and period	**N**	**Mean**	**SD**	**Median**	**Minimum**	**Maximum**
CSHRR						
1973-1991	47 534	3 342	564	3 350	500	6 000
MBR[1]						
1973-1977	15 807	3 036	558	3 000	500	6 000

1979-1990	28 708	3 346	555	3 350	730	5 750
1991	3 019	3 391	564	3 416	634	5 600

[1] From 1973 to 1977, BW was recorded in 500-gram units in the MBR. From 1978 to 1990, BW was recorded in 10-gram units, and from 1991 onwards in 1-gram units

Mean BW was significantly different only in the first period of the MBR (1973-1979) where the mean BW was ~300 grams higher in the CSHRR than in the MBR, likely due to rounding procedures used in the MBR. During the two later periods (1979-1990 and 1991), mean BW was not significantly different in the two registers (**Table 2**). We combined the two later periods in the remaining analyses because there were no notable differences between these periods and because the last period consisted of only one birth year and 3 019 children. There were no statistically significant differences between BW from the two registers when examined by maternal and offspring characteristics (all $P > 0.1$) in the period of 1979-1991 (**Table 2**).

Table 2: Comparison of BW from the CSHRR and the MBR stratified by birth year groups according to MBR procedural changes and by maternal and offspring characteristics.

		Birthweight (grams)				
		CSHRR		**MBR**		
	N	**Mean**	**SD**	**Mean**	**SD**	**P***
1973-1978						
All	15 807	3 323	555	3 036	558	*< 0.0001*
Boys	7 980	3 382	568	3 092	569	*< 0.0001*
Girls	7 827	3 263	535	2 980	540	*< 0.0001*
1979-1990						
All	28 708	3 348	568	3 346	555	*0.67*

Boys	14 782	3 409	580	3 407	566	*0.67*
Girls	13 926	3 283	547	3 282	535	*0.86*
1991						
All	3 019	3 389	577	3 391	564	*0.67*
Boys	1 540	3 446	587	3 446	578	*0.98*
Girls	1 479	3 330	560	3 332	542	*0.90*
Maternal characteristics[§]						
Maternal age						
< 20 y	1 187	3 252	543	3 244	518	*0.69*
20-30 y	19 183	3 337	554	3 334	542	*0.58*
30-40 y	10 772	3 387	592	3 388	579	*0.87*
40-50 y	582	3 401	603	3 406	587	*0.89*
≥ 50 y	3	3 292	525	3 290	524	*0.99*
Civil status						
Married	16 533	3 369	576	3 367	559	*0.68*
Divorced	1 970	3 320	593	3 321	584	*0.98*
Not married	13 224	3 335	555	3 334	547	*0.90*
Parity						
1	17 219	3 308	555	3 304	544	*0.49*
2	10 101	3 400	575	3 402	561	*0.84*
3	2 976	3 403	582	3 402	559	*0.99*

4	892	3 439	623	3 430	604	*0.76*
5	332	3 422	589	3 441	566	*0.68*
≥ 6	207	3 436	626	3 453	614	*0.78*
Offspring characteristics[§]						
Year of birth						
1979-81	6 607	3 322	565	3 322	552	*0.99*
1982-84	6 248	3 306	577	3 305	565	*0.91*
1985-87	7 591	3 344	566	3 341	550	*0.75*
1988-91	11 281	3 401	565	3 399	554	*0.78*
Age at recall						
5-6 y	2 984	3 381	556	3 379	541	*0.87*
6-6.5 y	9 662	3 363	563	3 362	550	*0.90*
6.5-7 y	10 410	3 355	564	3 354	554	*0.93*
7-8 y	7 245	3 327	582	3 323	565	*0.65*
>8 y	1 316	3 326	598	3 328	579	*0.94*
BMI classification at BW recall						
Underweight	2 384	3 100	592	3 097	576	*0.88*
Normalweight	25 186	3 358	558	3 357	545	*0.88*
Overweight	3 104	3 468	560	3 462	541	*0.68*
Obese	542	3 514	614	3 507	598	*0.84*

Morbidly obese	401	3 378	622	3 360	597	*0.68*

*Comparisons made by paired t-tests.

§ Comparison of mean BW by maternal and offspring characteristics are only presented for the period 1979-1991.

BWs in the CSHRR and the MBR were highly correlated. The lowest correlation coefficient was seen in the earliest period (0.93 (95%CI 0.92; 0.93)) compared to the later period (0.97 (95%CI 0.97; 0.97); however, the correlations were still high in all periods.

From **Figure S3** it can be seen that the rounding of BW in 500 gram intervals in the MBR from 1973-1978 was very obvious. The association between BW in the two registers was linear in both periods.

The distribution of the discrepancies in BWs from the two registers can be seen in **Figure S4**. In the first period (1973-1978) most discrepancies were < 0 grams (98%) meaning that BW in the CSHRR was generally higher than BW in the MBR. 95% of the discrepancies were distributed within the interval -500 to 0 grams. 466 observations were distributed outside this interval with a maximal difference of 3 300 grams. In the second period (1979-1991), the discrepancies were distributed almost equally around zero with 95% within the interval of ±500 grams. 438 observations were distributed outside this interval with a maximal difference of 3 514 grams. For both periods, we found no differences with respect to sex (all $P > 0.6$) among the outliers than in rest of the population, but there was a difference in the distribution according to year of birth (all $P < 0.001$). However, there were no obvious patterns in the yearly distribution.

Within each register BW was categorized into eight groups and we compared if each child was assigned to the same BW category by both registers. This was only done for the period

1979-1991 due to the rounding procedures in the MBR during 1973-1978. 94.5% of BWs were placed in the same BW category by both registers, 4.7% were placed in adjacent BW categories and only 0.1% were placed more than 2 BW categories apart. The Kappa coefficient (0.93 showed very high agreement between the two registers (**Table 3**).

Table 3: Cross tabulation of observations in BW categories by the CSHRR and the MBR for birth years 1979-1991.

		MBR								
	Birthweight groups (grams)	**< 1 500**	**1 500-1 999**	**2 000-2 750**	**2 751-3 250**	**3 251-3 750**	**3 751-4 250**	**4 251-5 500**	**> 5 500**	**Total**
CSHRR	**< 1 500**	181	7	8	4	9	2	1	0	212 (0.7%)
	1 500-1 999	8	332	26	4	2	0	0	0	372 (1.3%)
	2 000-2 750	1	18	2 943	133	30	3	1	0	3 129 (10.6%)
	2 751-3 250	2	0	99	7 954	317	29	1	0	8 402 (28.4%)
	3 251-3 750	0	0	15	307	10 272	140	6	0	10 740 (36.3%)
	3 751-4 250	0	0	2	49	226	5 085	35	0	5 397 (18.2%)
	4 251-5 500	0	0	1	12	28	79	1 231	0	1 351 (4.6%)
	> 5 500	0	0	0	1	1	1	4	3	10 (0%)
	Total	192 (0.6%)	357 (1.2%)	3 094 (10.4%)	8 464 (28.6%)	10 885 (36.8%)	5 343 (18.0%)	1 279 (4.3%)	3 (0%)	29 613

Kappa	0.93
Agreement	94.6%

Expected agreement	26.1%

The Bland-Altman plots of the differences in BW between the two registers per average BW showed good agreement especially in the period 1979-1991 (**Figure 1**). The rounding procedures in the MBR were again apparent in the period 1973-1978.

In the period 1973-1978 mean BW within term categories was significantly different in the two registers (**Table S1**). In the period 1979-1991 none of the BWs were significantly different by gestational age categories. There was a statistically significant increasing trend in BW by term status, however, the standard deviations within each of these categories overlapped.

Results from the bivariate logistic regressions of differences in BW of > 100 grams showed that odds of a discrepancy increased with younger maternal age, and higher parity (**Table 4**). Compared with married women, divorced and non-married women had lower odds of a discrepancy. The odds of a discrepancy did not show a discernable pattern by year of the child's birth. Compared with children who had their BW reported at 6.5 to 7 years of age, those who had it reported at the youngest ages (5-6 y) and older ages had a higher odds of a discrepancy. Results from the multivariate logistic regressions showed the same associations for maternal age, civil status, parity and the child's age at BW recall. No statistically significant interactions among these characteristics were identified.

Table 4: Odds ratio (95%CI) of BW discrepancy >100 grams between BW from the CSHRR and the MBR stratified by maternal and offspring characteristics for the birth years 1979-1991.

	OR of BW difference > 100 grams							
	Bivariate model				Multivariable model			
	N	OR	95%CI		N	OR	95%CI	
Maternal age								
< 20 y	1 187	1.22	0.91	1.63	1 185	1.64	1.21	2.20
20 ≤ y < 30	19 183	Reference			19 114	Reference		
30 ≤ y < 40	10 772	1.21	1.08	1.37	10 736	0.92	0.81	1.04
40 ≤ y < 50	582	1.74	1.22	2.47	579	0.92	0.63	1.34
≥ 50 y	3	-	-	-	-	-	-	-
Civil status								
Married	16 533	Reference			16 469	Reference		
Divorced	1 970	0.79	0.62	1.01	1 965	0.76	0.59	0.97
Not married	13 224	0.57	0.51	0.65	13 180	0.78	0.68	0.89
Parity								
1	17 219	Reference			17 154	Reference		
2	10 101	1.85	1.62	2.11	10 073	1.84	1.60	2.12
3	2 976	2.62	2.20	3.11	2 963	2.60	2.15	3.14
4	892	3.05	2.33	3.98	890	2.92	2.19	3.88
5	332	4.64	3.24	6.64	329	4.44	3.05	6.47
≥ 6	207	5.97	3.96	8.98	205	5.73	3.73	8.82

Offspring characteristics*								
Sex								
Boy	16 322	Reference			16 257	Reference		
Girl	15 405	1.08	0.97	1.21	15 357	1.08	0.96	1.21
Year of birth								
1979-81	6 607	Reference			6 598	Reference		
1982-84	6 248	0.87	0.73	1.03	6 228	0.90	0.75	1.07
1985-87	7 591	0.77	0.65	0.92	7 566	0.80	0.67	0.95
1988-91	11 281	0.84	0.73	0.98	11 222	0.89	0.76	1.04
Age at BW recall								
5-6 y	2 984	1.55	1.28	1.88	2 984	1.37	1.13	1.67
6-6.5 y	9 662	1.0	0.86	1.16	9 660	0.97	0.83	1.13
6.5-7 y	10 410	Reference			10 410	Reference		
7-8 y	7 245	1.18	1.01	1.38	7 245	1.21	1.03	1.42
>8 y	1 316	1.81	1.41	2.33	1 315	1.68	1.30	2.16
BMI category at BW recall								
Underweight	2 384	1.0	0.80	1.24	2 384	0.96	0.77	1.19
Normal-weight	25 186	Reference			25 185	Reference		
Overweight	3 104	0.98	0.81	1.19	3 103	0.77	0.47	1.25
Obese	542	0.80	0.49	1.31	541	1.08	0.68	1.74
Morbidly obese	401	1.23	0.77	1.96	401	0.96	0.77	1.19

Discussion

We found that the maternal report of BWs in the CSHRR agreed very well with the recorded BWs in the MBR. The MBR recorded BW in 500-gram units from 1973 to 1978 which was obvious in our results and made the agreement between the two registers poorer than in the remaining study period.

We used several different methods to compare BW in the two registers. Whether BW was compared continuously or categorically the message was the same -- there was a high degree of agreement between the two. We found a high correlation between the MBR and the CSHRR, especially in the period after 1978 (0.97), which is similar to what other validation studies have found (0.97-0.98). [6–8] In total, 94.5% of BWs were placed in the same BW category by the two registers and there were no discernable patterns in the misclassifications. We expect that some of the most extreme discrepancies between the registers could be caused by the use of Danish pounds (equal to 0.5 kg) to report BW in one of the registers. Even though the metric system was introduced in Denmark at the beginning of the 1900s, the use of Danish pounds prevailed for many decades in particular contexts, of which BW reporting was one. However, as all of the BW values in the MBR in question were not twice as large as the ones in the CSHRR (and vice versa), this suggests pound reporting is not a systematic error that can explain all of these outliers. The number of potentially affected values was, however, low.

Other studies have also reported agreement of BW in categories, but there are large differences in the range of the BW categories, the methods used and the nationalities of the populations. The definition of BW groups influences the degree of agreement whereby smaller groups increase the likelihood of misclassification. However, the agreement was high irrespective

of the BW groups used. In another Danish study the BW was categorized as low, normal and high, and the agreement of classification was 98%. [6] Among Israeli mothers, approximately 80% recalled their children's BW correctly within 500-gram BW categories. [9] In a study of American and Canadian mothers, agreement was 93% using four BW categories of <3 kg, 3-3.5 kg, 3.5-4 kg and >4 kg. [7] Another study of American mothers showed that the sensitivity ranged from 90.3-93.6 % and that the specificity ranged from 97.8-99.3% when BW groups were defined as above and below different BW values (1.5, 2, 2.5, 3.5 and 4 kg). [8]

One of the major strengths of this study is that both the MBR and the CSHRR are based on large, unselected populations that minimize the risk of selection bias. One limitation of the CSHRR is the lack of information on child characteristics like socio-economic status and lifestyle factors that could have been included in the analyses and potentially could have predicted discrepancies. [10] The major limitation of the MBR is the rounding procedure used from 1973-1978. [11]

The agreement between the CSHRR and the MBR might be high because a high proportion of the mothers brought the child's infancy health book to the school entry health examination. In the CSHRR we have no indications of the source of the BW and therefore we do not know if it was the majority of parents who brought the book or not. Another possible explanation is that mothers in general remember their children's BW very well. BW is typically reported to family and friends after the birth of the child and this might aid memorization. BW may also have a special psychological importance that enables mothers to accurately remember their child's BW.

In the present study BWs were reported at the school entry examination which occurred when the children were 5-7 years of age with a few exceptions of older children who entered the register when they transferred from other schools. Other studies had other time frames ranging from 9 -18 months to 6-18 years from birth to recall, but overall the conclusion has been that mothers seem to recall their children's BW very well irrespective of the time past since birth. [5–9]

We found that parity and maternal civil status influenced the odds of having a discrepancy between BW in the two registers, where the odds increased with parity and were reduced among non-married women. The pattern we observe for marital status likely reflects that many of the unmarried mothers did have partners, and that in the Danish population it is not always an indicator of a low socioeconomic position. The child's age at recall was also associated with a discrepancy; the odds of a discrepancy were the lowest when the age at recall was between 6-8 years compared to <6 or >8y.

Other studies have also investigated ability to recall BW according to various maternal characteristics. [5–8] Two studies showed higher risks of a discrepancy > 100 grams among non-white women and women who have given birth previously compared with white and primiparous women, respectively. [5,6] One of these studies also found that unemployed women remembered their child's BW less well as compared with working women, and that the lower the BW of the child, the higher the risk of a discrepancy. [5] Another study showed that mothers with less than a high school education had higher risk of discrepancy between recalled and recorded BW [8]. In contrast, another study investigated ability to recall BW by maternal education, age and

race, household income, time from delivery to maternal recall, and birth order of the child, and found no significant differences across any of these demographic subgroups. [7]

Unfortunately, we only had the possibility to look into recall ability according to maternal age, parity and civil status and offspring age and body size at recall and year of birth, but we had an unselected population where all socio-economic groups were represented and the generalizability of our results should apply to a general Danish population.

Medical birth records are not always available because of the studied time period or because retrieving records is too labor demanding; as such, recalled information might be the only source of BW. In such cases a validation study as the present is useful for demonstrating the accuracy of the BW data. Previous and future research based on the CSHRR will gain from the present conclusion that maternal reports of BW agreed very well with BW records in the MBR. Other cohorts or registers from similar populations can however, also draw on the present conclusion that maternal reports of BWs are accurate and can be used as a reasonable substitute when medical birth records are unavailable.

Conclusion

Overall, maternal reports of BW agreed very well and accurately with recorded values from medical birth records, suggesting that mothers generally are able to recall BW of their children. Discrepancies in BW were more often seen among married women, women with several children, and among children who were below 6 and above 8 years at recall. These results suggest that research on associations between BW and adult onset diseases will not be biased by the use of recalled information on BW that is obtained during childhood.

Acknowledgments

Contributorship statement

The authors' responsibilities were as follows – TIAS and JLB conceived the research idea; CBJ and JLB designed research; CBJ performed statistical analysis; CBJ, GM, BLH, TIAS and JLB interpreted the results, CBJ drafted the manuscript, and GM, BLH, TIAS and JLB commented on it; CBJ and JLB had primary responsibility for the final content. All authors read and approved the final manuscript.

Competing interests

The authors declare no conflict of interest or competing interests.

Funding

The project was funded by the Danish Agency for Science Technology and Innovation, the Ministry of Science, Innovation and Higher Education, under the instruments "Strategic research projects" and by a research grant from the Danish PhD School of Molecular Metabolism funded by the Novo Nordisk Foundation. This research was financially supported by the European Research Council under the European Union's Seventh Framework Programme (FP/2007-2013)/ERC Grant Agreement no. 281418, childgrowth2cancer awarded to JLB.

The supporting bodies for this project had no role in the design, implementation, analysis and interpretation of the data presented.

Data sharing statement

Data will not be shared.

References

1 Risnes KR, Vatten LJ, Baker JL, *et al.* Birthweight and mortality in adulthood: a systematic review and meta-analysis. *Int J Epidemiol* 2011;**40**:647–61. doi:10.1093/ije/dyq267

2 Black SE, Devereux PJ, Salvanes KG. From the cradle to the labor market? The effect of birth weight on adult outcomes. *Q J Econ* 2007;**122**:409–39.

3 Rogers I. The influence of birthweight and intrauterine environment on adiposity and fat distribution in later life. *Int J Obes Relat Metab Disord* 2003;**27**:755–77. doi:10.1038/sj.ijo.0802316

4 Hanson M a., Gluckman PD. Early Developmental Conditioning of Later Health and Disease: Physiology or Pathophysiology? *Physiol Rev* 2014;**94**:1027–76. doi:10.1152/physrev.00029.2013

5 Tate AR, Dezateux C, Cole TJ, *et al.* Factors affecting a mother's recall of her baby's birth weight. *Int J Epidemiol* 2005;**34**:688–95. doi:10.1093/ije/dyi029

6 Adegboye ARA, Heitmann B. Accuracy and correlates of maternal recall of birthweight and gestational age. *BJOG* 2008;**115**:886–93.http://www.pubmedcentral.nih.gov/articlerender.fcgi?artid=2438372&tool=pmcentrez&rendertype=abstract (accessed 14 Aug2014).

7 Olson JE, Shu XO, Ross JA, *et al.* Medical record validation of maternally reported birth characteristics and pregnancy-related events: a report from the Children's Cancer Group. *Am J Epidemiol* 1997;**145**:58–67.http://www.ncbi.nlm.nih.gov/pubmed/8982023 (accessed 14 Aug2014).

8 Lucia VC, Luo Z, Gardiner JC, *et al.* Reports of birthweight by adolescents and their mothers: comparing accuracy and identifying correlates. *Paediatr Perinat Epidemiol* 2006;**20**:520–7. doi:10.1111/j.1365-3016.2006.00757.x

9 Gofin R, Neumark YD, Adler B. Birthweight recall by mothers of Israeli children. *Public Health* 2000;**114**:161–3.http://www.ncbi.nlm.nih.gov/pubmed/10878741 (accessed 14 Aug2014).

10 Baker JL, Olsen LW, Andersen I, *et al.* Cohort profile: the Copenhagen School Health Records Register. *Int J Epidemiol* 2009;**38**:656–62.http://www.pubmedcentral.nih.gov/articlerender.fcgi?artid=2722813&tool=pmcentrez&rendertype=abstract (accessed 20 Mar2014).

11 Knudsen LB, Olsen J. The Danish Medical Birth Registry. *Dan Med Bull* 1998;**45**:320–3.http://www.ncbi.nlm.nih.gov/pubmed/9675544 (accessed 13 May2014).

12 Milsgaard M. Ny rekord på fødestuen. Fødte en gigantisk baby. [New record in the delivery room. Gave birth to a gigantic baby.]. *Ude og Hjemme* 2013.http://www.udeoghjemme.dk/Artikler/Kaerlighed-og-sorg/2013/07/31-foedte-en-gigantisk-baby.aspx

13 Baker JL, Olsen LW, Sørensen TIA. Weight at birth and all-cause mortality in adulthood. *Epidemiology* 2008;**19**:197–203. doi:10.1097/EDE.0b013e31816339c6

14 American College of Obstetricians and Gynecologists. Definition of term pregnancy. Committee Opinion No. 579. *Obs Gynecol* 2013;:1139–40.

15 Cole TJ, Lobstein T. Extended international (IOTF) body mass index cut-offs for thinness, overweight and obesity. *Pediatr Obes* 2012;**7**:284–94. doi:10.1111/j.2047-6310.2012.00064.x

Figures

Figure 1: Bland-Altman plots of birthweight (grams) in the CSHRR and the MBR according to MBR procedural changes.

Supporting information

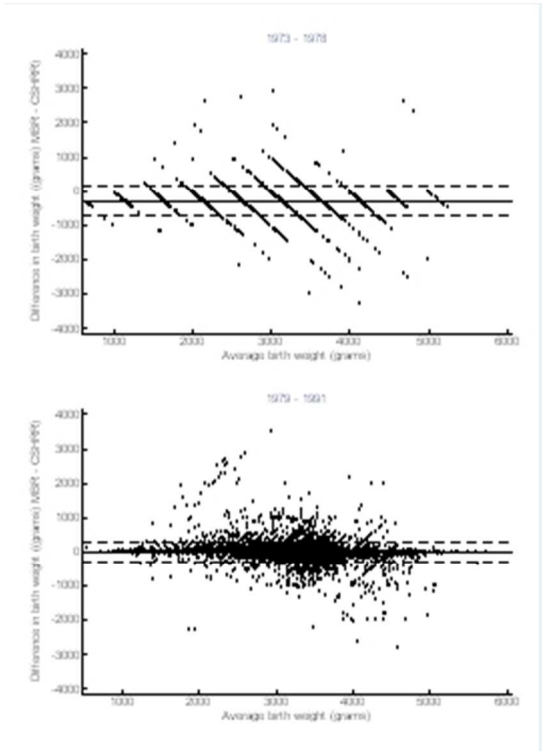
Table S 1: Comparison of BW from the CSHRR and the MBR stratified by gestational age and birth year groups according to MBR procedural changes (the two latter periods (1979-1991 and 1991) were combined).

Figure S 1: Flow chart

Figure S 2: Histograms of birthweight (g) distributions in the Copenhagen School Health Records Register (CSHRR) and the Medical Birth Register (MBR).

Figure S 3: Birthweight in the CSHRR plotted against birthweight in the MBR by birth year groups according to MBR procedural changes.

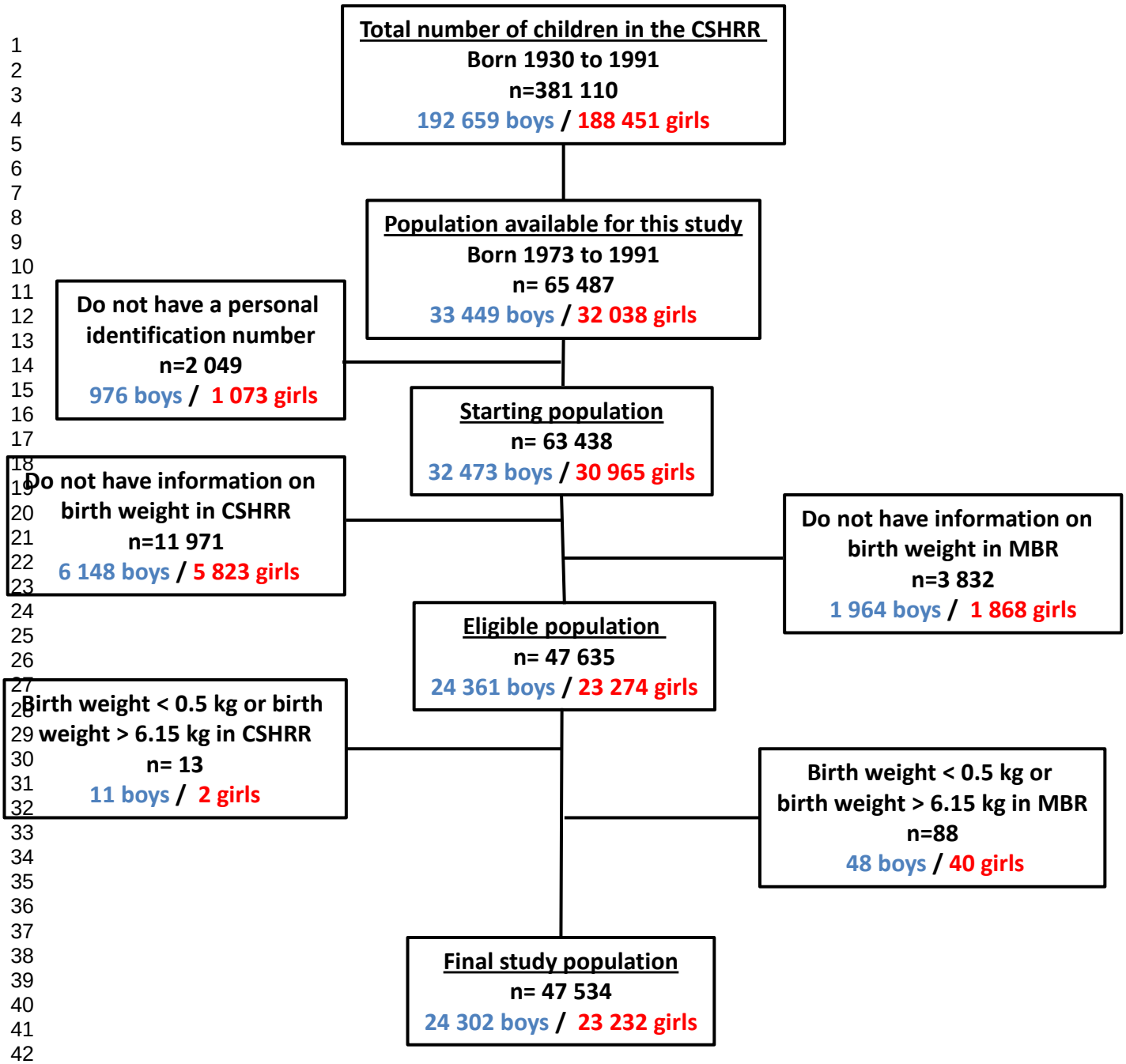
Figure S 4: Distribution of discrepancy in birthweight (grams) between the MBR and the CSHRR according to MBR procedural changes. Differences of zero grams (306 observations (2%) during 1973-1978 and 23 605 observations (74%) during 1979-1991) are not included in the plots.

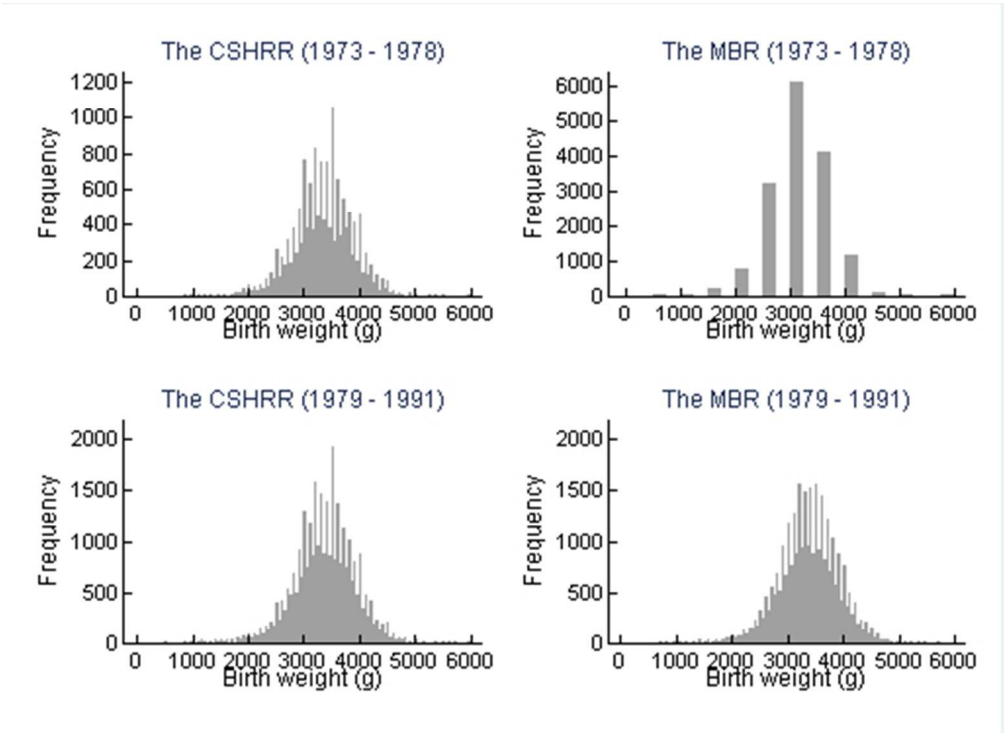


Bland-Altman plots of birthweight (grams) in the CSHRR and the MBR according to MBR procedural changes.
94x131mm (72 x 72 DPI)

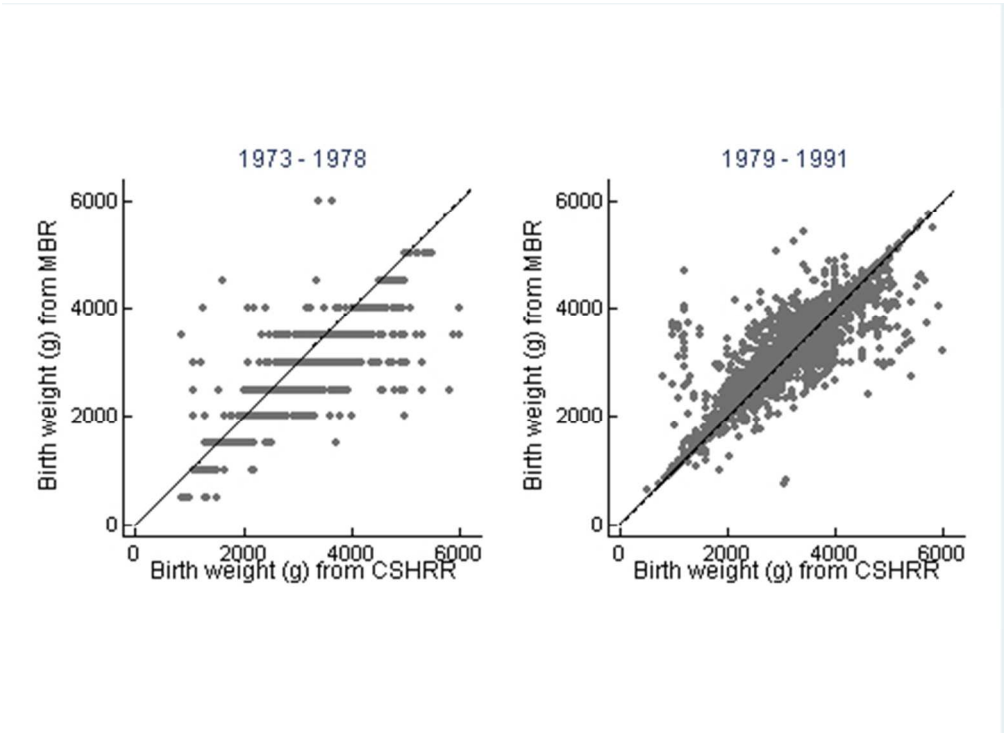
Table S 1: Comparison of BW from the CSHRR and the MBR stratified by gestational age and birth year groups according to MBR procedural changes (the two latter periods (1979-1991 and 1991) were combined).

		Birth weight (*grams)*				
		CSHRR		MBR		
	N	Mean	SD	Mean	SD	P
1973-1978						
Preterm (before 37 weeks)	101	2 308	537	2 020	552	0.0002
Early term (37 0/7 through 38 6/7 weeks)	255	3 008	538	2 733	552	0.0001
Term (39 0/7 through 40 6/7 weeks)	1 240	3 427	466	3 131	469	0.0001
Late term (41 0/7 through 41 6/7 weeks)	345	3 606	462	3 307	446	0.0001
Postterm (42 0/7 weeks and beyond)	165	3 562	445	3 306	457	0.0001
Missing	13 701	3 317	554	3 031	557	0.0001
1979-1991						
Preterm (before 37 weeks)	1 609	2 283	592	2 284	585	0.97
Early term (37 0/7 through 38 6/7 weeks)	4 498	3 055	492	3 052	474	0.8
Term (39 0/7 through 40 6/7 weeks)	16 961	3 416	468	3 413	451	0.64
Late term (41 0/7 through 41 6/7 weeks)	5 447	3 581	472	3 579	460	0.88
Postterm (42 0/7 weeks and beyond)	2 361	3 679	491	3 682	476	0.8
Missing	851	3 303	579	3 298	549	0.84

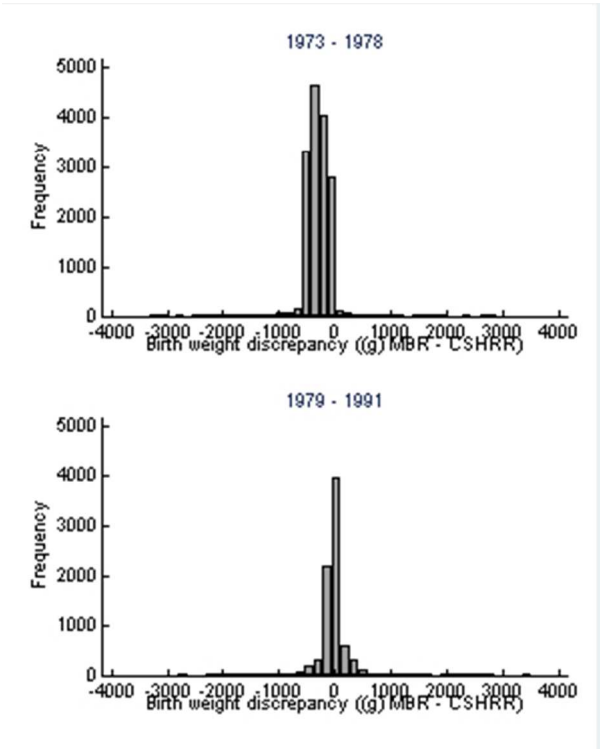

Total number of children in the CSHRR
Born 1930 to 1991
n=381 110
192 659 boys / 188 451 girls
Population available for this study
Born 1973 to 1991
n= 65 487
33 449 boys / 32 038 girls
Do not have a personal identification number
n=2 049
976 boys / 1 073 girls
Starting population
n= 63 438
32 473 boys / 30 965 girls
Do not have information on birth weight in CSHRR
n=11 971
6 148 boys / 5 823 girls
Do not have information on birth weight in MBR
n=3 832
1 964 boys / 1 868 girls
Eligible population
n= 47 635
24 361 boys / 23 274 girls
Birth weight < 0.5 kg or birth weight > 6.15 kg in CSHRR
n= 13
11 boys / 2 girls
Birth weight < 0.5 kg or birth weight > 6.15 kg in MBR
n=88
48 boys / 40 girls
Final study population
n= 47 534
24 302 boys / 23 232 girls



Histograms of birthweight (g) distributions in the Copenhagen School Health Records Register (CSHRR) and the Medical Birth Register (MBR).
180x131mm (72 x 72 DPI)



Birthweight in the CSHRR plotted against birthweight in the MBR by birth year groups according to MBR procedural changes.
180x131mm (72 x 72 DPI)



Distribution of discrepancy in birthweight (grams) between the MBR and the CSHRR according to MBR procedural changes. Differences of zero grams (306 observations (2%) during 1973-1978 and 23 605 observations (74%) during 1979-1991) are not included in the plots.
105x131mm (72 x 72 DPI)

STROBE Statement—checklist of items that should be included in reports of observational studies

	Item No	Recommendation	Page number
Title and abstract	1	(*a*) Indicate the study's design with a commonly used term in the title or the abstract	4
		(*b*) Provide in the abstract an informative and balanced summary of what was done and what was found	4
Introduction			
Background/rationale	2	Explain the scientific background and rationale for the investigation being reported	5
Objectives	3	State specific objectives, including any prespecified hypotheses	5
Methods			
Study design	4	Present key elements of study design early in the paper	6-7
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection	6-7
Participants	6	(*a*) *Cohort study*—Give the eligibility criteria, and the sources and methods of selection of participants. Describe methods of follow-up *Case-control study*—Give the eligibility criteria, and the sources and methods of case ascertainment and control selection. Give the rationale for the choice of cases and controls *Cross-sectional study*—Give the eligibility criteria, and the sources and methods of selection of participants	6-7
		(*b*) *Cohort study*—For matched studies, give matching criteria and number of exposed and unexposed *Case-control study*—For matched studies, give matching criteria and the number of controls per case	N/A
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable	6-8
Data sources/ measurement	8*	For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group	6-8
Bias	9	Describe any efforts to address potential sources of bias	N/A
Study size	10	Explain how the study size was arrived at	9
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why	8
Statistical methods	12	(*a*) Describe all statistical methods, including those used to control for confounding	8
		(*b*) Describe any methods used to examine subgroups and interactions	8
		(*c*) Explain how missing data were addressed	8-9
		(*d*) *Cohort study*—If applicable, explain how loss to follow-up was addressed *Case-control study*—If applicable, explain how matching of cases and controls was addressed *Cross-sectional study*—If applicable, describe analytical methods taking account of sampling strategy	N/A
		(*e*) Describe any sensitivity analyses	8

Continued on next page

Results			
Participants	13*	(a) Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed	9
		(b) Give reasons for non-participation at each stage	9
		(c) Consider use of a flow diagram	9
Descriptive data	14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders	9-11
		(b) Indicate number of participants with missing data for each variable of interest	9-11
		(c) *Cohort study*—Summarise follow-up time (eg, average and total amount)	N/A
Outcome data	15*	*Cohort study*—Report numbers of outcome events or summary measures over time	9-11
		Case-control study—Report numbers in each exposure category, or summary measures of exposure	N/A
		Cross-sectional study—Report numbers of outcome events or summary measures	N/A
Main results	16	(*a*) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included	9-11
		(*b*) Report category boundaries when continuous variables were categorized	9-11
		(*c*) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period	N/A
Other analyses	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses	9-11
Discussion			
Key results	18	Summarise key results with reference to study objectives	12
Limitations	19	Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias	12-15
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence	12-15
Generalisability	21	Discuss the generalisability (external validity) of the study results	12-15
Other information			
Funding	22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based	16

*Give information separately for cases and controls in case-control studies and, if applicable, for exposed and unexposed groups in cohort and cross-sectional studies.

Note: An Explanation and Elaboration article discusses each checklist item and gives methodological background and published examples of transparent reporting. The STROBE checklist is best used in conjunction with this article (freely available on the Web sites of PLoS Medicine at http://www.plosmedicine.org/, Annals of Internal Medicine at http://www.annals.org/, and Epidemiology at http://www.epidem.com/). Information on the STROBE Initiative is available at www.strobe-statement.org.

BMJ Open

Comparison of birthweight between school health records and medical birth records in Denmark: Determinants of discrepancies.

Journal:	*BMJ Open*
Manuscript ID	bmjopen-2015-008628.R1
Article Type:	Research
Date Submitted by the Author:	22-Sep-2015
Complete List of Authors:	Jensen, Camilla; Institute of Preventive Medicine, Gamborg, Michael; Institute of Preventive Medicine, Bispebjerg and Frederiksberg Hospital, The Capital Region, Heitmann, Berit; The Boden Institute of Obesity, Nutrition, Exercise & Eating Disorders, University of Sydney, ; Institute of Preventive Medicine, Bispebjerg and Frederiksberg Hospital, The Capital Region, Sørensen, Thorkild; Institute of Preventive Medicine, ; Novo Nordisk Foundation Centre for Basic Metabolic Research, Section on Metabolic Genetics, Faculty of Health and Medical Sciences Baker, Jennifer; Institute of Preventive Medicine, Bispebjerg and Frederiksberg Hospital, The Capital Region, ; Novo Nordisk Foundation Centre for Basic Metabolic Research, Section on Metabolic Genetics, Faculty of Health and Medical Sciences
Primary Subject Heading:	Epidemiology
Secondary Subject Heading:	Obstetrics and gynaecology
Keywords:	EPIDEMIOLOGY, OBSTETRICS, PAEDIATRICS

Comparison of birthweight between school health records and medical birth records in Denmark: Determinants of discrepancies.

Camilla Bjørn Jensen[1,2], Michael Gamborg[1], Berit Heitmann[3,4,5], Thorkild IA Sørensen[1,6,7], Jennifer L. Baker[1,6]

[1] Institute of Preventive Medicine, Bispebjerg and Frederiksberg Hospital, The Capital Region, Copenhagen, Denmark.

[2] Faculty of Health and Medical Sciences, University of Copenhagen, Copenhagen, Denmark.

[3] Research Unit of Dietary Studies, Parker Institute, Bispebjerg and Frederiksberg Hospital, The Capital Region, Copenhagen, Denmark.

[4] The Boden Institute of Obesity, Nutrition, Exercise & Eating Disorders, University of Sydney, Australia

[5] National Institute of Public Health, University of Southern Denmark, Denmark.

[6] Novo Nordisk Foundation Center for Basic Metabolic Research, Faculty of Health and Medical Sciences, University of Copenhagen, Denmark.

[7] MRC Integrative Epidemiology Unit, University of Bristol, Bristol, UK

Correspondence:

Email: Camilla.bjoern.jensen@regionh.dk

Institute of Preventive Medicine, Frederiksberg Hospital

Nordre Fasanvej 57, Hovedvejen, Entrance 5

2000 Frederiksberg, Denmark

Phone: +45 38163101

Word counts

Abstract: 220

Text: 3 348

Running title: Validation of maternal birthweight reports

Abbreviations

BW: Birthweight; CSHRR: The Copenhagen School Health Records Register; MBR: The Danish Medical Birth Register.

Keywords: Birthweight, Denmark, registries, validation studies

Abstract

Objective: To compare reported birth weight (BW) information in school health records with BW from medical birth records, and to investigate if maternal and offspring characteristics were associated with any discrepancies.

Design: Register-based cohort study

Setting: Denmark, 1973-1991.

Participants: The study was based on BW recorded in the Copenhagen School Health Records Register (CSHRR) and in The Medical Birth Register (MBR). The registers were linked via the Danish personal identification number.

Primary and secondary outcome measures: Statistical comparisons of BW in the registers were performed using t-tests, Pearson's correlation coefficients, Bland-Altman plots, and Kappa coefficients. Odds of BW discrepancies >100 grams were examined by logistic regressions.

Results: The study population included 47 534 children. From 1973-1979 when BW was grouped in 500-gram intervals in the MBR, mean BW differed significantly between the registers. During 1979-1991 when BW was recorded in 10-gram and 1-gram intervals, mean BW did not significantly differ between the two registers. BW from both registers was highly correlated (0.93-0.97). Odds of a BW discrepancy significantly increased with parity, the child's age at recall and by marital status (children of married women had the highest odds).

Conclusion: Overall, BW information in school health records agreed very well with BW from medical birth records, suggesting that reports of BWs in school health records in Copenhagen, Denmark generally are valid.

Strengths and limitations

- Large register based study population
- Medical birth records are not always available but other sources of information might exist. Validation studies as the present is useful in such circumstances.
- Limited information on maternal and offspring characteristics was available.

Introduction

Birthweight (BW) has been identified as an important indicator of health for the child at birth, during infancy, and also later in adult life. [1–3] Officially recorded BW information is not always available to support current research into adult onset diseases, and it is therefore important to obtain valid information on BW collected retrospectively.

Because of the identified associations between BW and later disease outcomes, [4] information on BW is often included in epidemiological research. In many cases BW information can be retrieved from birth or medical records, however, this is not always possible and the use of recalled information may be the only option.

In general, mothers recall the BW of their children with a high degree of accuracy, [5–9] however the accuracy varies between studies possibly depending on the recall period (ranging from days to decades) and maternal characteristics. In one study, 58% of the mothers recalled their child's BW to within 100 grams of the recorded BW 6 years after birth [9] versus in two other studies where the rate was 92% at 9 months [5] and 8-18 years after birth. [6] As such, it is possible that parents recall their children's birth weights very well, or that there is publication bias in this area as studies demonstrating low correlations or poor agreement were not identified in the literature.

Therefore, in this study, we compared reports of BW obtained at the first school examination and recorded in health records with the recorded BW from medical birth records, and we investigated if maternal and offspring characteristics predicted the discrepancies between BW values in the two registers.

Methods

Study population

The CSHRR is a population-based register that includes virtually every school child in Copenhagen born between 1930 and 1991 and includes 381 110 records. The register has been established in collaboration between the Institute of Preventive Medicine, Bispebjerg and Frederiksberg Hospital, The Capital Region and the Copenhagen City Archives. The computerized register contains basic information about each child (name, sex, date of birth, personal identification number), along with annual measures of height and weight throughout school ages. From the birth year of 1936 onwards, information on BW was obtained at the time of the school entry examination which typically occurred when the children were 5-7 years of age. During the years included in this study (1973-1991), BW was either obtained at the first school examination or via a returned health questionnaire. The source of the BW information contained in the school health records, however, was not noted. The CSHRR is described in greater detail elsewhere. [10]

The MBR is a national medical register that contains computerized information on all births in Denmark since 1973. Information on births was reported to the Danish Health Authorities on a form filled out by the midwife shortly after delivery. From 1973 to 1977, BW was recorded in 500-gram units in the MBR, however, the rounding procedure was not documented. From 1978 to 1990, BW was recorded in 10-gram units and from 1991 onwards it was recorded in 1-gram units. The MBR also contains information on gestational age which was measured in weeks from 1973 to 1978 and in days from 1978 onwards. The mother's age, parity and civil status was also registered in the MBR. Further details of the register can be obtained elsewhere. [11]

The Danish personal identification number was used to link the two registers during the overlapping period from 1973 to 1991, and children with BW information in both the CSHRR and the MBR were identified.

An access and linkage permission was obtained from the Danish Data Protection Agency (J. no. 2012-41-1156). This type of research based on pre-existing routinely collected data does not require ethical permission in Denmark.

We excluded children with BW values below 500 grams as these were likely to be erroneous based on the chance of survival of very small children during the study period (Pryds, personal communication 2014). Based on the highest BW reported in Denmark of 6 150 grams, values above this level were excluded. [12]

BW was analysed as continuous variable (in grams) and divided into categories of 500-1 499, 1 500-1 999, 2 000-2 750, 2 751-3 250, 3 251-3 750, 3 751-4 250, 4 251-5 500, 5 501-6 150 grams, which were chosen to minimize the effects of digit preference. [13]

Information on gestational age is recorded in the MBR but not in the CSHRR. BW is strongly associated with gestational age, and we wanted to explore if reported BW varied by gestational age. We grouped gestational age into term categories (preterm: before 37 weeks, early term: 37 0/7 weeks through 38 6/7 weeks, full term: 39 0/7 weeks through 40 6/7 weeks, late term: 41 0/7 weeks through 41 6/7 weeks, post-term: 42 0/7 weeks and beyond). [14]

Based upon measured values of height and weight taken at the exam when the BW value was reported, we calculated a body mass index (BMI; kg/m^2) for each child. Each child's

weight status (under-, normal-, over-weight, obesity and morbid obesity) was classified using age- and sex-specific BMI cut-offs issued by the International Obesity Task Force. [15]

Statistical analyses

To assess if children who were missing BW information differed from those who had it in regards to sex and BW (from the other register), comparisons were made using t-tests and chi-square tests. Likelihood ratio tests were used to evaluate if the association between BW in the two registers could be described linearly or exponentially.

Scatterplots were generated to compare BW values between the two registers. Comparisons of mean (SD) BWs within each register within categories of overall, sex-specific, time periods (1973-1978, 1979-1990, 1991), and gestational age were made using t-tests. Pearson's correlation coefficients were calculated by time period. To graphically illustrate the agreement in BW values between the two registers, Bland-Altman plots were generated, also by time period. Within the Bland Altman plots, the limits of agreement were drawn at ±1.96 standard deviations. To test the agreement between the two registers we used Kappa coefficients for categories. The Kappa coefficient was not calculated for the period 1973-1978 because of the 500 gram rounding in the MBR.

Using a distribution plot of differences in BW between the two registers we identified outlying values with large discrepancies (> 500 grams). To examine if these subjects differed from the overall population, comparisons by sex and year of birth were performed with chi-square tests.

Logistic regressions were performed to examine if differences of > 100 grams in BW between the two registers were associated with maternal characteristics (maternal age, civil status and parity) from the MBR and offspring characteristics (age and BMI categories at the time of recall and year of birth) obtained from the CSHRR. Interactions between parity, age at BW recall, and civil status were assessed.

Results

Of 381 110 children in the CSHRR, 63 438 (16.6%) were born during 1973-1991 where the two registers overlapped and had a personal identification number. 11 971 (18.9%) children did not have information on BW in the CSHRR, and 3 832 (6.0%) did not have information on BW in the MBR. In the CSHRR there were no statistically significant differences between children with and without BW information in regards to sex and BW (from the MBR) (all $P > 0.05$). In the MBR there were no statistically significant differences in BW (from the CSHRR) between children with and without BW information, but more boys (53% vs. 51%, $P = 0.003$) and fewer girls (47% vs. 49%, $P = 0.003$) had missing BW information. The final study population consisted of 47 534 children (74.9% of the eligible population) after the exclusion of children with BWs below 500 grams or above 6 150 grams (**Figure S1**).

The BW distribution was approximately normal in both the MBR and the CSHRR. Digit preference was present in both registers for all time periods. Unsurprisingly, it was more apparent in the MBR than in the CSHRR during 1973-1979 when BW in the MBR was categorized in 500-gram units (**Figure S2**). Descriptive statistics can be seen in **Table 1**.

Table 1: Descriptive statistics for BW in the CSHRR and the MBR by birth year groups according to MBR procedural changes.

		Birthweight (*grams)*				
Information source and period	**N**	**Mean**	**SD**	**Median**	**Minimum**	**Maximum**
CSHRR						
1973-1991	47 534	3 342	564	3 350	500	6 000
MBR[1]						

1973-1977	15 807	3 036	558	3 000	500	6 000
1979-1990	28 708	3 346	555	3 350	730	5 750
1991	3 019	3 391	564	3 416	634	5 600

[1] From 1973 to 1977, BW was recorded in 500-gram units in the MBR. From 1978 to 1990, BW was recorded in 10-gram units, and from 1991 onwards in 1-gram units

Mean BW was significantly different only in the first period of the MBR (1973-1979) where the mean BW was ~300 grams higher in the CSHRR than in the MBR, likely due to rounding procedures used in the MBR. During the two later periods (1979-1990 and 1991), mean BW was not significantly different in the two registers (**Table 2**). We combined the two later periods in the remaining analyses because there were no notable differences between these periods and because the last period consisted of only one birth year and 3 019 children. There were no statistically significant differences between BW from the two registers when examined by maternal and offspring characteristics (all $P > 0.1$) in the period of 1979-1991 (**Table 2**).

Table 2: Comparison of BW from the CSHRR and the MBR stratified by birth year groups according to MBR procedural changes and by maternal and offspring characteristics.

		Birthweight (grams)				
		CSHRR		**MBR**		
	N	**Mean**	**SD**	**Mean**	**SD**	**P***
1973-1978						
All	15 807	3 323	555	3 036	558	*< 0.0001*
Boys	7 980	3 382	568	3 092	569	*< 0.0001*
Girls	7 827	3 263	535	2 980	540	*< 0.0001*
1979-1990						

All	28 708	3 348	568	3 346	555	*0.67*
Boys	14 782	3 409	580	3 407	566	*0.67*
Girls	13 926	3 283	547	3 282	535	*0.86*
1991						
All	3 019	3 389	577	3 391	564	*0.67*
Boys	1 540	3 446	587	3 446	578	*0.98*
Girls	1 479	3 330	560	3 332	542	*0.90*
Maternal characteristics[§]						
Maternal age						
< 20 y	1 187	3 252	543	3 244	518	*0.69*
20-30 y	19 183	3 337	554	3 334	542	*0.58*
30-40 y	10 772	3 387	592	3 388	579	*0.87*
40-50 y	582	3 401	603	3 406	587	*0.89*
≥ 50 y	3	3 292	525	3 290	524	*0.99*
Civil status						
Married	16 533	3 369	576	3 367	559	*0.68*
Divorced	1 970	3 320	593	3 321	584	*0.98*
Not married	13 224	3 335	555	3 334	547	*0.90*
Parity						
1	17 219	3 308	555	3 304	544	*0.49*
2	10 101	3 400	575	3 402	561	*0.84*

3	2 976	3 403	582	3 402	559	*0.99*
4	892	3 439	623	3 430	604	*0.76*
5	332	3 422	589	3 441	566	*0.68*
≥ 6	207	3 436	626	3 453	614	*0.78*
Offspring characteristics[§]						
Year of birth						
1979-81	6 607	3 322	565	3 322	552	*0.99*
1982-84	6 248	3 306	577	3 305	565	*0.91*
1985-87	7 591	3 344	566	3 341	550	*0.75*
1988-91	11 281	3 401	565	3 399	554	*0.78*
Age at recall						
5-6 y	2 984	3 381	556	3 379	541	*0.87*
6-6.5 y	9 662	3 363	563	3 362	550	*0.90*
6.5-7 y	10 410	3 355	564	3 354	554	*0.93*
7-8 y	7 245	3 327	582	3 323	565	*0.65*
>8 y	1 316	3 326	598	3 328	579	*0.94*
BMI classification at BW recall						
Underweight	2 384	3 100	592	3 097	576	*0.88*
Normalweight	25 186	3 358	558	3 357	545	*0.88*
Overweight	3 104	3 468	560	3 462	541	*0.68*

Obese	542	3 514	614	3 507	598	*0.84*
Morbidly obese	401	3 378	622	3 360	597	*0.68*

*Comparisons made by paired t-tests.

§ Comparison of mean BW by maternal and offspring characteristics are only presented for the period 1979-1991.

BWs in the CSHRR and the MBR were highly correlated. The lowest correlation coefficient was seen in the earliest period (0.93 [95%CI 0.92; 0.93]) compared to the later period (0.97 [95%CI 0.97; 0.97]); however, the correlations were still high in all periods.

From **Figure S3** it can be seen that the rounding of BW in 500 gram intervals in the MBR from 1973-1978 was very obvious. The association between BW in the two registers was linear in both periods.

The distribution of the discrepancies in BWs from the two registers can be seen in **Figure S4**. In the first period (1973-1978) most discrepancies were < 0 grams (98%) meaning that BW in the CSHRR was generally higher than BW in the MBR. 95% of the discrepancies were distributed within the interval -500 to 0 grams. 466 observations were distributed outside this interval with a maximal difference of 3 300 grams. In the second period (1979-1991), the discrepancies were distributed almost equally around zero with 95% within the interval of ±500 grams. 438 observations were distributed outside this interval with a maximal difference of 3 514 grams. For both periods, we found no differences with respect to sex (all $P > 0.6$) among the outliers than in rest of the population, but there was a difference in the distribution according to year of birth (all $P < 0.001$). However, there were no obvious patterns in the yearly distribution.

Within each register BW was categorized into eight groups and we compared if each child was assigned to the same BW category by both registers. This was only done for the period 1979-1991 due to the rounding procedures in the MBR during 1973-1978. 94.5% of BWs were placed in the same BW category by both registers, 4.7% were placed in adjacent BW categories and only 0.1% were placed more than 2 BW categories apart. The Kappa coefficient (0.93) showed very high agreement between the two registers (**Table 3**).

Table 3: Cross tabulation of observations in BW categories by the CSHRR and the MBR for birth years 1979-1991.

		MBR								
	Birthweight groups (grams)	**< 1 500**	**1 500-1 999**	**2 000-2 750**	**2 751-3 250**	**3 251-3 750**	**3 751-4 250**	**4 251-5 500**	**> 5 500**	**Total**
CSHRR	**< 1 500**	181	7	8	4	9	2	1	0	212 (0.7%)
	1 500-1 999	8	332	26	4	2	0	0	0	372 (1.3%)
	2 000-2 750	1	18	2 943	133	30	3	1	0	3 129 (10.6%)
	2 751-3 250	2	0	99	7 954	317	29	1	0	8 402 (28.4%)
	3 251-3 750	0	0	15	307	10 272	140	6	0	10 740 (36.3%)
	3 751-4 250	0	0	2	49	226	5 085	35	0	5 397 (18.2%)
	4 251-5 500	0	0	1	12	28	79	1 231	0	1 351 (4.6%)
	> 5 500	0	0	0	1	1	1	4	3	10 (0%)
	Total	192 (0.6%)	357 (1.2%)	3 094 (10.4%)	8 464 (28.6%)	10 885 (36.8%)	5 343 (18.0%)	1 279 (4.3%)	3 (0%)	29 613

Kappa	0.93
Agreement	94.6%

Expected agreement	26.1%

The Bland-Altman plots of the differences in BW between the two registers per average BW generally showed good agreement (**Figure 1**). In the 1973-1978 period, the rounding procedures in the MBR were apparent. In this period, the plot illustrates that the MBR reports were, on average, lower than in the CSHRR.

In the 1979-1991 period, the Bland-Altman plot did not reveal any systematic patterns of deviations between BWs in the two registers. For the majority of BWs (n= 30 528, 96.2%) the difference between two registers fell within the range of -287 to 284 grams (corresponding to ±1.96 standard deviations, indicated by the dashed lines in **Figure 1**). Few values fell above these limits (n = 584, 1.8%) and few fell below (n = 615, 1.9%).

In the period 1973-1978 mean BW within term categories was significantly different in the two registers (**Table S1**). In the period 1979-1991 none of the BWs were significantly different by gestational age categories. There was a statistically significant increasing trend in BW by term status, however, the standard deviations within each of these categories overlapped.

Results from the bivariate logistic regressions of differences in BW of > 100 grams showed that odds of a discrepancy increased with younger maternal age, and higher parity (**Table 4**). Compared with married women, divorced and non-married women had lower odds of a discrepancy. The odds of a discrepancy did not show a discernable pattern by year of the child's birth. Compared with children who had their BW reported at 6.5 to 7 years of age, those who had it reported at the youngest ages (5-6 years) and older ages had a higher odds of a discrepancy. Results from the multivariate logistic regressions showed the same associations for maternal age, civil status, parity and the child's age when the BW was reported. No statistically significant interactions among these characteristics were identified.

Table 4: Odds ratio (95%CI) of BW discrepancy >100 grams between BW from the CSHRR and the MBR stratified by maternal and offspring characteristics for the birth years 1979-1991.

	OR of BW difference > 100 grams							
	Bivariate model				Multivariable model			
	N	OR	95%CI		N	OR	95%CI	
Maternal age								
< 20 y	1 187	1.22	0.91	1.63	1 185	1.64	1.21	2.20
20 ≤ y < 30	19 183	Reference			19 114	Reference		
30 ≤ y < 40	10 772	1.21	1.08	1.37	10 736	0.92	0.81	1.04
40 ≤ y < 50	582	1.74	1.22	2.47	579	0.92	0.63	1.34
≥ 50 y	3	-	-	-	-	-	-	-
Civil status								
Married	16 533	Reference			16 469	Reference		
Divorced	1 970	0.79	0.62	1.01	1 965	0.76	0.59	0.97
Not married	13 224	0.57	0.51	0.65	13 180	0.78	0.68	0.89
Parity								
1	17 219	Reference			17 154	Reference		
2	10 101	1.85	1.62	2.11	10 073	1.84	1.60	2.12
3	2 976	2.62	2.20	3.11	2 963	2.60	2.15	3.14
4	892	3.05	2.33	3.98	890	2.92	2.19	3.88
5	332	4.64	3.24	6.64	329	4.44	3.05	6.47
≥ 6	207	5.97	3.96	8.98	205	5.73	3.73	8.82

Offspring characteristics*								
Sex								
Boy	16 322	Reference			16 257	Reference		
Girl	15 405	1.08	0.97	1.21	15 357	1.08	0.96	1.21
Year of birth								
1979-81	6 607	Reference			6 598	Reference		
1982-84	6 248	0.87	0.73	1.03	6 228	0.90	0.75	1.07
1985-87	7 591	0.77	0.65	0.92	7 566	0.80	0.67	0.95
1988-91	11 281	0.84	0.73	0.98	11 222	0.89	0.76	1.04
Age at BW recall								
5-6 y	2 984	1.55	1.28	1.88	2 984	1.37	1.13	1.67
6-6.5 y	9 662	1.0	0.86	1.16	9 660	0.97	0.83	1.13
6.5-7 y	10 410	Reference			10 410	Reference		
7-8 y	7 245	1.18	1.01	1.38	7 245	1.21	1.03	1.42
>8 y	1 316	1.81	1.41	2.33	1 315	1.68	1.30	2.16
BMI category at BW recall								
Underweight	2 384	1.0	0.80	1.24	2 384	0.96	0.77	1.19
Normal-weight	25 186	Reference			25 185	Reference		
Overweight	3 104	0.98	0.81	1.19	3 103	0.77	0.47	1.25
Obese	542	0.80	0.49	1.31	541	1.08	0.68	1.74
Morbidly obese	401	1.23	0.77	1.96	401	0.96	0.77	1.19

Discussion

We found that reports of BWs in the CSHRR agreed very well with the recorded BWs in the MBR. The MBR recorded BW in 500-gram units from 1973 to 1978 which was obvious in our results and made the agreement between the two registers poorer than in the remaining study period.

We used several different methods to compare BW in the two registers. Whether BW was compared continuously or categorically the message was the same -- there was a high degree of agreement between the two. We found a high correlation between the MBR and the CSHRR, especially in the period after 1978 (0.97), which is similar to what other validation studies have found (0.97-0.98). [6–8] In total, 94.5% of BWs were placed in the same BW category by the two registers and there were no discernable patterns in the misclassifications.

Other studies have also reported agreement of BW in categories, but there are large differences in the range of the BW categories, the methods used and the nationalities of the populations. The definition of BW groups influences the degree of agreement whereby smaller groups increase the likelihood of misclassification. However, the agreement was high irrespective of the BW groups used. In another Danish study the BW was categorized as low, normal and high, and the agreement of classification was 98%. [6] Among Israeli mothers, approximately 80% recalled their children's BW correctly within 500-gram BW categories. [9] In a study of American and Canadian mothers, agreement was 93% using four BW categories of <3 kg, 3-3.5 kg, 3.5-4 kg and >4 kg. [7] Another study of American mothers showed that the sensitivity ranged from 90.3-93.6 % and that the specificity ranged from 97.8-99.3% when BW groups were defined as above and below different BW values (1.5, 2, 2.5, 3.5 and 4 kg). [8]

One of the major strengths of this study is that both the MBR and the CSHRR are based on large, unselected populations that minimize the risk of selection bias. One limitation of the CSHRR is the lack of information on child characteristics like socio-economic status and lifestyle factors that could have been included in the analyses and potentially could have predicted discrepancies. [10] The major limitation of the MBR is the rounding procedure used from 1973-1978. [11] The analyses were restricted to BW values from 500 to 6150 g to avoid overtly erroneous values. A comparison of BW values based upon gestational age categories (taken from the MBR) did not reveal any significant differences in the 1978-1991 period suggesting that these BW values are reasonable given the infant's gestational age.

Although BW was most likely reported by the mother in the CSHRR during the years included in this study, it is a possibility that it was reported by the father or another adult with parental responsibility. In Copenhagen, each child was issued an infancy health book in which BW was recorded by the visiting health nurse shortly after delivery. These books were commonly used as a continuous health record for children, so it is possible that some parents either used this book when filling in the questionnaire or brought it with them to the examination, thus contributing to the high agreement between BW values in the CSHRR and the MBR. In the CSHRR we have no indications of the source of the BW and therefore we do not know if it was the majority of parents who brought the book or not. Another possible explanation is that parents (and mothers in particular) remember their children's BW very well. BW is typically reported to family and friends after the birth of the child and this might aid memorization. BW may also have a special psychological importance that enables parents to accurately remember their child's BW.

In the present study, BWs were obtained at the school entry examination which occurred when the children were 5-7 years of age with a few exceptions of older children who entered the register when they transferred from other schools. Other studies had other time frames ranging from 9 -18 months to 6-18 years from birth to recall, but overall the conclusion has been that mothers seem to recall their children's BW very well irrespective of the time past since birth. [5–9] Our results fit well with these findings, even though we cannot be certain of whether a mother or other adult with parental responsibility reported the BW.

We found that parity and maternal civil status influenced the odds of having a discrepancy between BW in the two registers, where the odds increased with parity and were reduced among non-married women. The pattern we observe for marital status likely reflects that many of the unmarried mothers did have partners, and that in the Danish population it is not always an indicator of a low socioeconomic position. The child's age at recall was also associated with a discrepancy; the odds of a discrepancy were the lowest when the age at recall was between 6-8 years compared to <6 or >8y.

Other studies have also investigated ability to recall BW according to various maternal characteristics. [5–8] Two studies showed higher risks of a discrepancy > 100 grams among non-white women and women who have given birth previously compared with white and primiparous women, respectively. [5,6] One of these studies also found that unemployed women remembered their child's BW less well as compared with working women, and that the lower the BW of the child, the higher the risk of a discrepancy. [5] Another study showed that mothers with less than a high school education had higher risk of discrepancy between recalled and recorded BW [8]. In contrast, another study investigated ability to recall BW by maternal education, age and

race, household income, time from delivery to maternal recall, and birth order of the child, and found no significant differences across any of these demographic subgroups. [7]

Unfortunately, we only had the possibility to look into recall ability according to maternal age, parity and civil status and offspring age and body size at recall and year of birth, but we had an unselected population where all socio-economic groups were represented and the generalizability of our results should apply to a general Danish population.

Medical birth records are not always available because of the studied time period or because retrieving records is too labor demanding; as such, recalled information might be the only source of BW. In such cases a validation study as the present is useful for demonstrating the accuracy of the BW data. Previous and future research based on the CSHRR will gain from the present conclusion that reports of BW in the CSHRR agreed very well with BW records in the MBR. Other cohorts or registers from similar populations can however, also draw on the present conclusion that maternal reports of BWs are accurate and can be used as a reasonable substitute when medical birth records are unavailable.

Conclusion

Overall, reported BWs in the CSHRR agreed very well and accurately with recorded values from medical birth records, suggesting that these values are valid. Discrepancies in BW were more often seen among married women, women with several children, and among children who were below 6 or above 8 years at recall. These results suggest that research on associations between BW and adult onset diseases will not be biased by the use of information on BW that is obtained during childhood from school health records.

Acknowledgments

Contributorship statement

The authors' responsibilities were as follows – TIAS and JLB conceived the research idea; CBJ and JLB designed research; CBJ performed statistical analysis; CBJ, GM, BLH, TIAS and JLB interpreted the results, CBJ drafted the manuscript, and GM, BLH, TIAS and JLB commented on it; CBJ and JLB had primary responsibility for the final content. All authors read and approved the final manuscript.

Competing interests

The authors declare no conflict of interest or competing interests.

Funding

The project was funded by the Danish Agency for Science Technology and Innovation, the Ministry of Science, Innovation and Higher Education, under the instrument "Strategic research projects" and by a research grant from the Danish PhD School of Molecular Metabolism funded by the Novo Nordisk Foundation. This research was financially supported by the European Research Council under the European Union's Seventh Framework Programme (FP/2007-2013)/ERC Grant Agreement no. 281419, childgrowth2cancer awarded to JLB.

The supporting bodies for this project had no role in the design, implementation, analysis and interpretation of the data presented.

Data sharing statement

No additional data available.

References

1 Risnes KR, Vatten LJ, Baker JL, *et al.* Birthweight and mortality in adulthood: a systematic review and meta-analysis. *Int J Epidemiol* 2011;**40**:647–61. doi:10.1093/ije/dyq267

2 Black SE, Devereux PJ, Salvanes KG. From the cradle to the labor market? The effect of birth weight on adult outcomes. *Q J Econ* 2007;**122**:409–39.

3 Rogers I. The influence of birthweight and intrauterine environment on adiposity and fat distribution in later life. *Int J Obes Relat Metab Disord* 2003;**27**:755–77. doi:10.1038/sj.ijo.0802316

4 Hanson M a., Gluckman PD. Early Developmental Conditioning of Later Health and Disease: Physiology or Pathophysiology? *Physiol Rev* 2014;**94**:1027–76. doi:10.1152/physrev.00029.2013

5 Tate AR, Dezateux C, Cole TJ, *et al.* Factors affecting a mother's recall of her baby's birth weight. *Int J Epidemiol* 2005;**34**:688–95. doi:10.1093/ije/dyi029

6 Adegboye ARA, Heitmann B. Accuracy and correlates of maternal recall of birthweight and gestational age. *BJOG* 2008;**115**:886–93.http://www.pubmedcentral.nih.gov/articlerender.fcgi?artid=2438372&tool=pmcentrez&rendertype=abstract (accessed 14 Aug2014).

7 Olson JE, Shu XO, Ross JA, *et al.* Medical record validation of maternally reported birth characteristics and pregnancy-related events: a report from the Children's Cancer Group. *Am J Epidemiol* 1997;**145**:58–67.http://www.ncbi.nlm.nih.gov/pubmed/8982023 (accessed 14 Aug2014).

8 Lucia VC, Luo Z, Gardiner JC, *et al.* Reports of birthweight by adolescents and their mothers: comparing accuracy and identifying correlates. *Paediatr Perinat Epidemiol* 2006;**20**:520–7. doi:10.1111/j.1365-3016.2006.00757.x

9 Gofin R, Neumark YD, Adler B. Birthweight recall by mothers of Israeli children. *Public Health* 2000;**114**:161–3.http://www.ncbi.nlm.nih.gov/pubmed/10878741 (accessed 14 Aug2014).

10 Baker JL, Olsen LW, Andersen I, *et al.* Cohort profile: the Copenhagen School Health Records Register. *Int J Epidemiol* 2009;**38**:656–62.http://www.pubmedcentral.nih.gov/articlerender.fcgi?artid=2722813&tool=pmcentrez&rendertype=abstract (accessed 20 Mar2014).

11 Knudsen LB, Olsen J. The Danish Medical Birth Registry. *Dan Med Bull* 1998;**45**:320–3.http://www.ncbi.nlm.nih.gov/pubmed/9675544 (accessed 13 May2014).

12 Milsgaard M. Ny rekord på fødestuen. Fødte en gigantisk baby. [New record in the delivery room. Gave birth to a gigantic baby.]. *Ude og Hjemme* 2013.http://www.udeoghjemme.dk/Artikler/Kaerlighed-og-sorg/2013/07/31-foedte-en-gigantisk-baby.aspx

13 Baker JL, Olsen LW, Sørensen TIA. Weight at birth and all-cause mortality in adulthood. *Epidemiology* 2008;**19**:197–203. doi:10.1097/EDE.0b013e31816339c6

14 American College of Obstetricians and Gynecologists. Definition of term pregnancy. Committee Opinion No. 579. *Obs Gynecol* 2013;:1139–40.

15 Cole TJ, Lobstein T. Extended international (IOTF) body mass index cut-offs for thinness, overweight and obesity. *Pediatr Obes* 2012;**7**:284–94. doi:10.1111/j.2047-6310.2012.00064.x

Figures

Figure 1: Bland-Altman plots of birthweight (grams) in the CSHRR and the MBR according to MBR procedural changes. The solid line illustrates the mean difference and the dashed lines represent the ±1.96 standard deviations.. In the 1973-1978 plot, the mean difference was -287 grams, with a standard deviation of 215 grams. In the 1979-1991 plot, the mean difference was -2 grams, with a standard deviation of 146 grams.

Supporting information

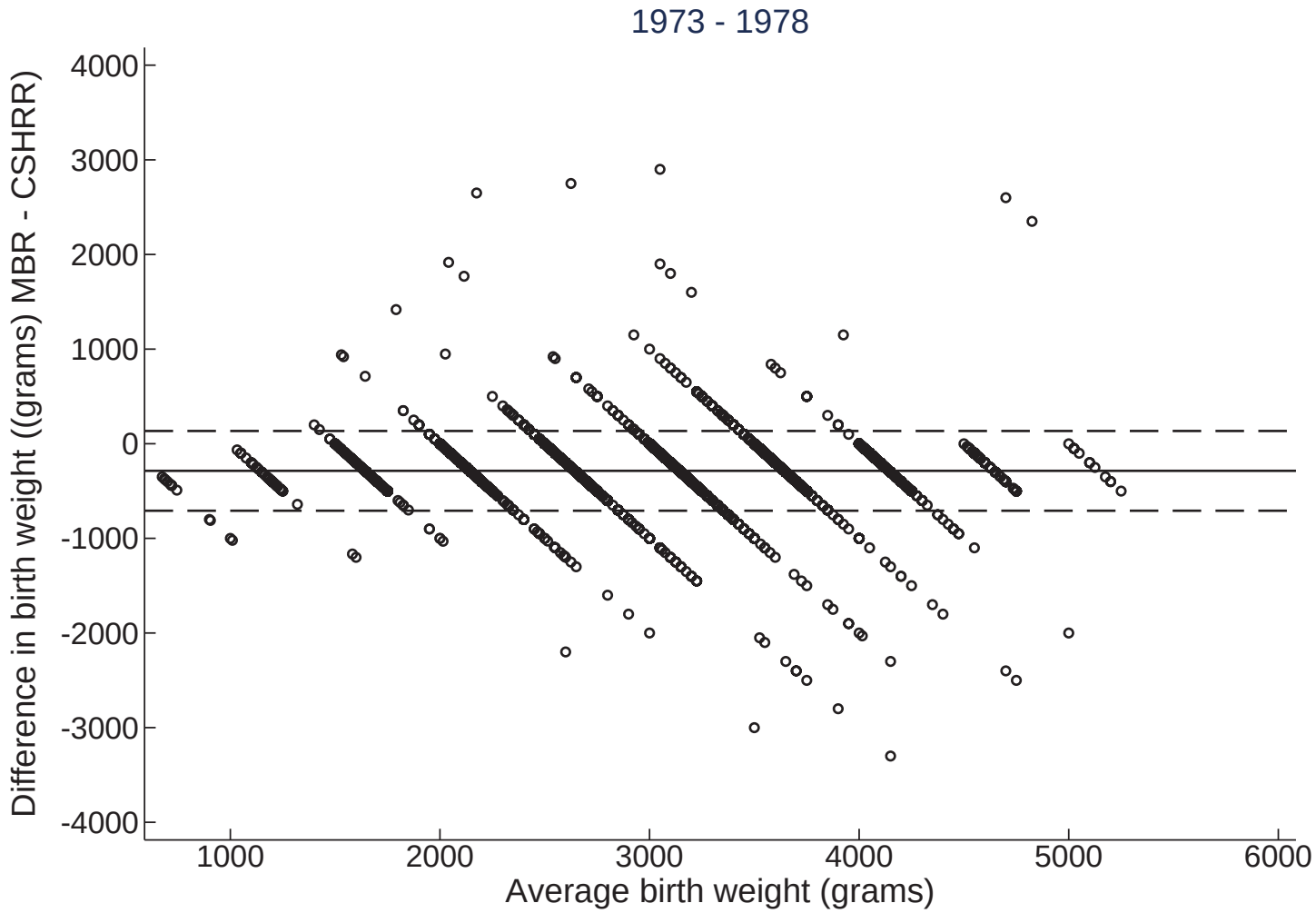
Table S 1: Comparison of BW from the CSHRR and the MBR stratified by gestational age and birth year groups according to MBR procedural changes (the two latter periods (1979-1991 and 1991) were combined).

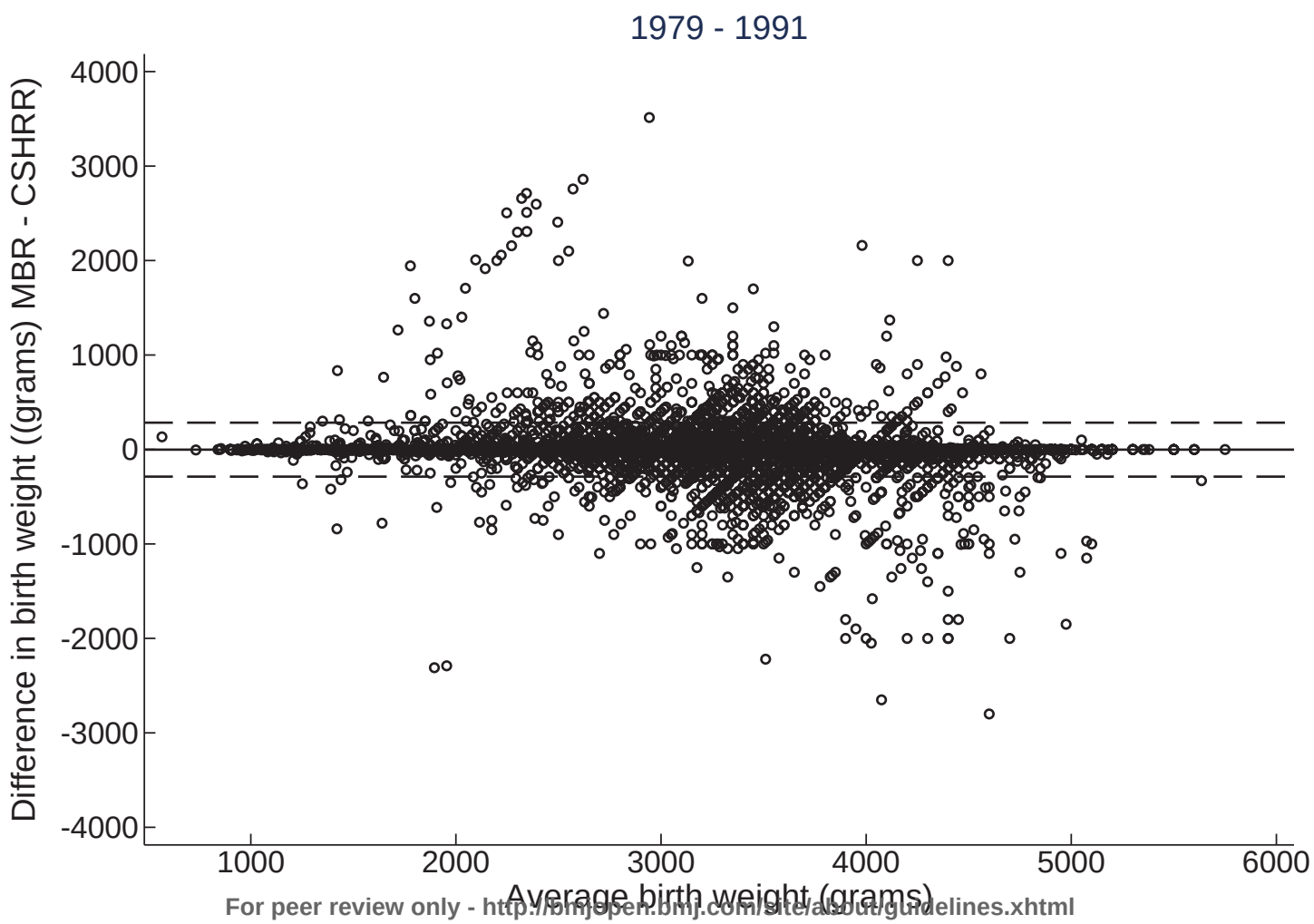
Figure S 1: Flow chart

Figure S 2: Histograms of birthweight (g) distributions in the Copenhagen School Health Records Register (CSHRR) and the Medical Birth Register (MBR).

Figure S 3: Birthweight in the CSHRR plotted against birthweight in the MBR by birth year groups according to MBR procedural changes.

Figure S 4: Distribution of discrepancy in birthweight (grams) between the MBR and the CSHRR according to MBR procedural changes. Differences of zero grams (306 observations (2%) during 1973-1978 and 23 605 observations (74%) during 1979-1991) are not included in the plots.


1973 - 1978
Difference in birth weight ((grams) MBR - CSHRR)
4000
3000
2000
1000
0
-1000
-2000
-3000
-4000
1000
2000
3000
4000
5000
6000
Average birth weight (grams)


1979 - 1991
Difference in birth weight ((grams) MBR - CSHRR)
4000
3000
2000
1000
0
-1000
-2000
-3000
-4000
1000
2000
3000
4000
5000
6000
Average birth weight (grams)

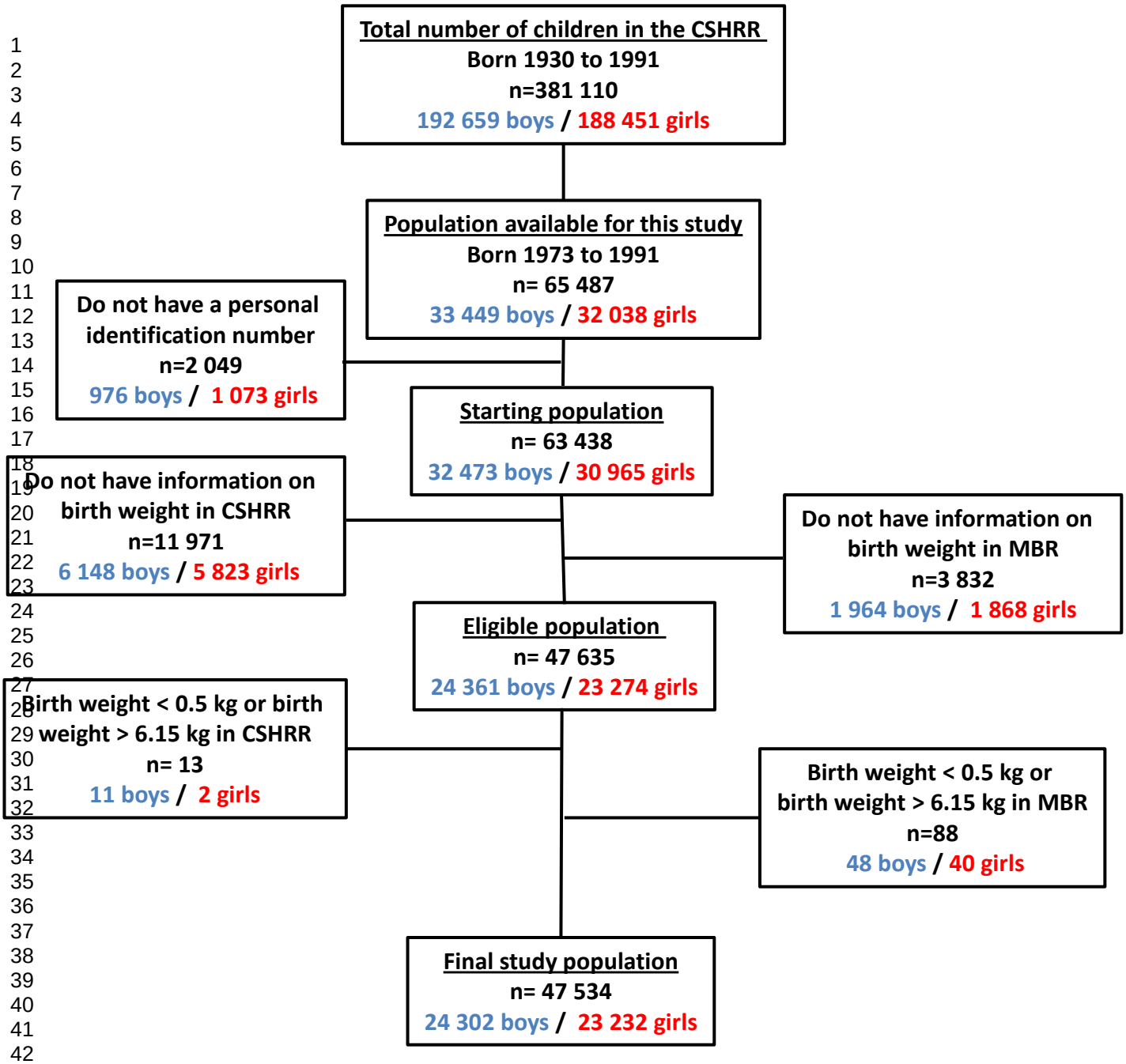

Total number of children in the CSHRR
Born 1930 to 1991
n=381 110
192 659 boys / 188 451 girls
Population available for this study
Born 1973 to 1991
n= 65 487
33 449 boys / 32 038 girls
Do not have a personal identification number
n=2 049
976 boys / 1 073 girls
Starting population
n= 63 438
32 473 boys / 30 965 girls
Do not have information on birth weight in CSHRR
n=11 971
6 148 boys / 5 823 girls
Do not have information on birth weight in MBR
n=3 832
1 964 boys / 1 868 girls
Eligible population
n= 47 635
24 361 boys / 23 274 girls
Birth weight < 0.5 kg or birth weight > 6.15 kg in CSHRR
n= 13
11 boys / 2 girls
Birth weight < 0.5 kg or birth weight > 6.15 kg in MBR
n=88
48 boys / 40 girls
Final study population
n= 47 534
24 302 boys / 23 232 girls

Figure S2.

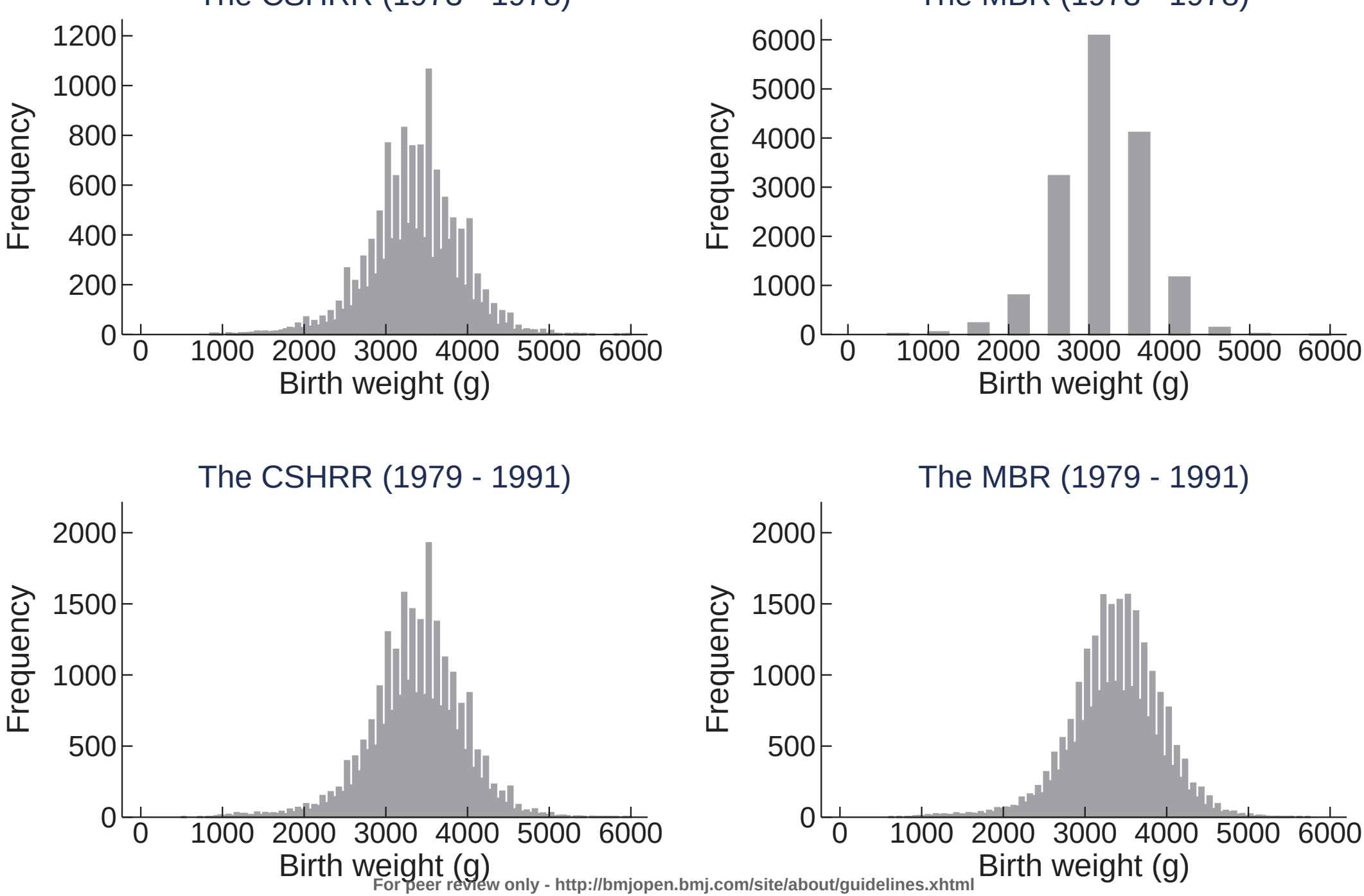


Figure S3.

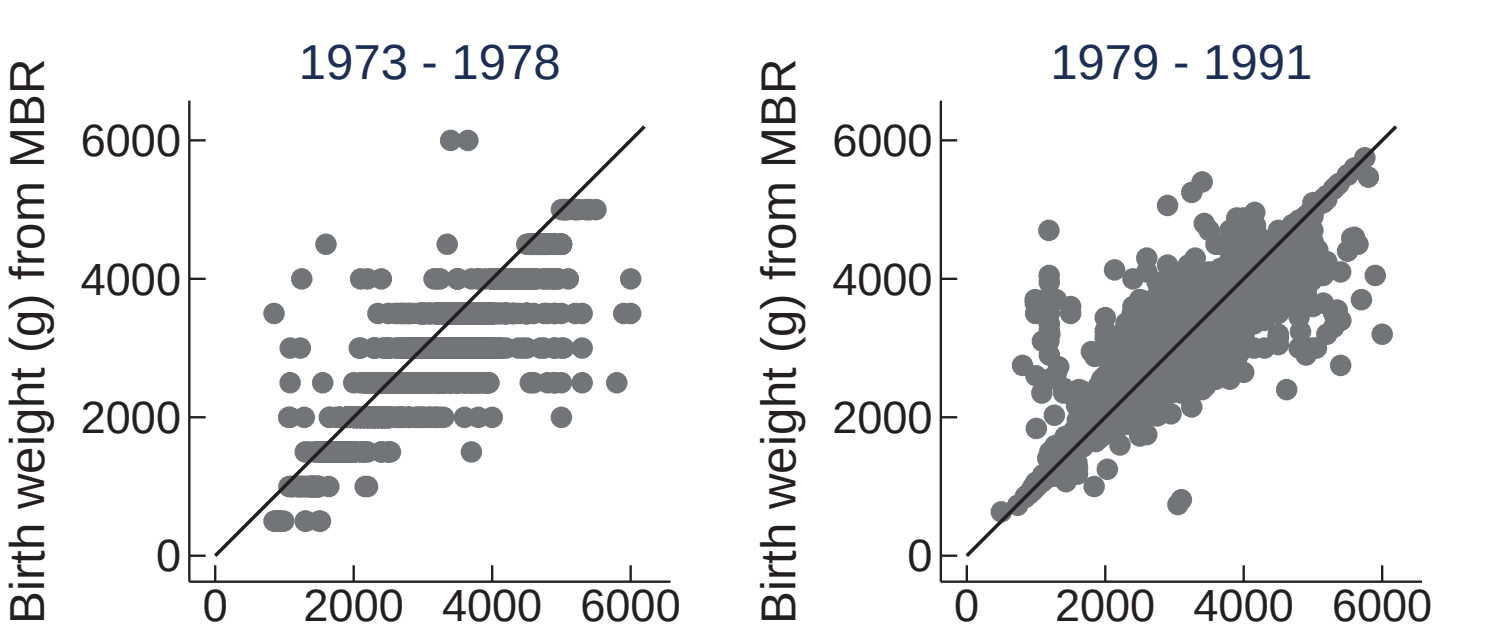
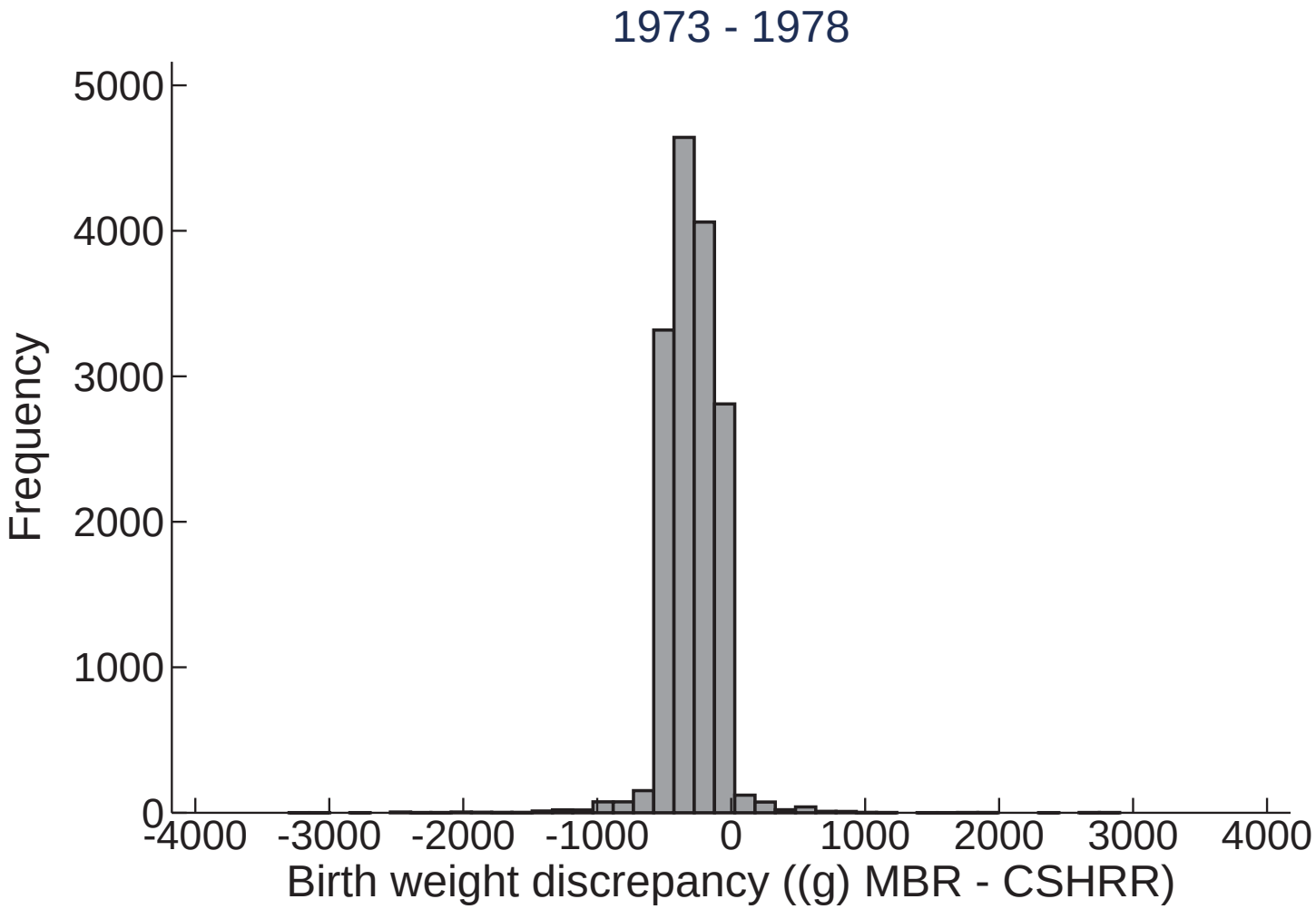

1973 - 1978
1979 - 1991
Birth weight (g) from MBR
Birth weight (g) from CSHR
Birth weight (g) from CSHRR
0
2000
4000
6000

Figure 2



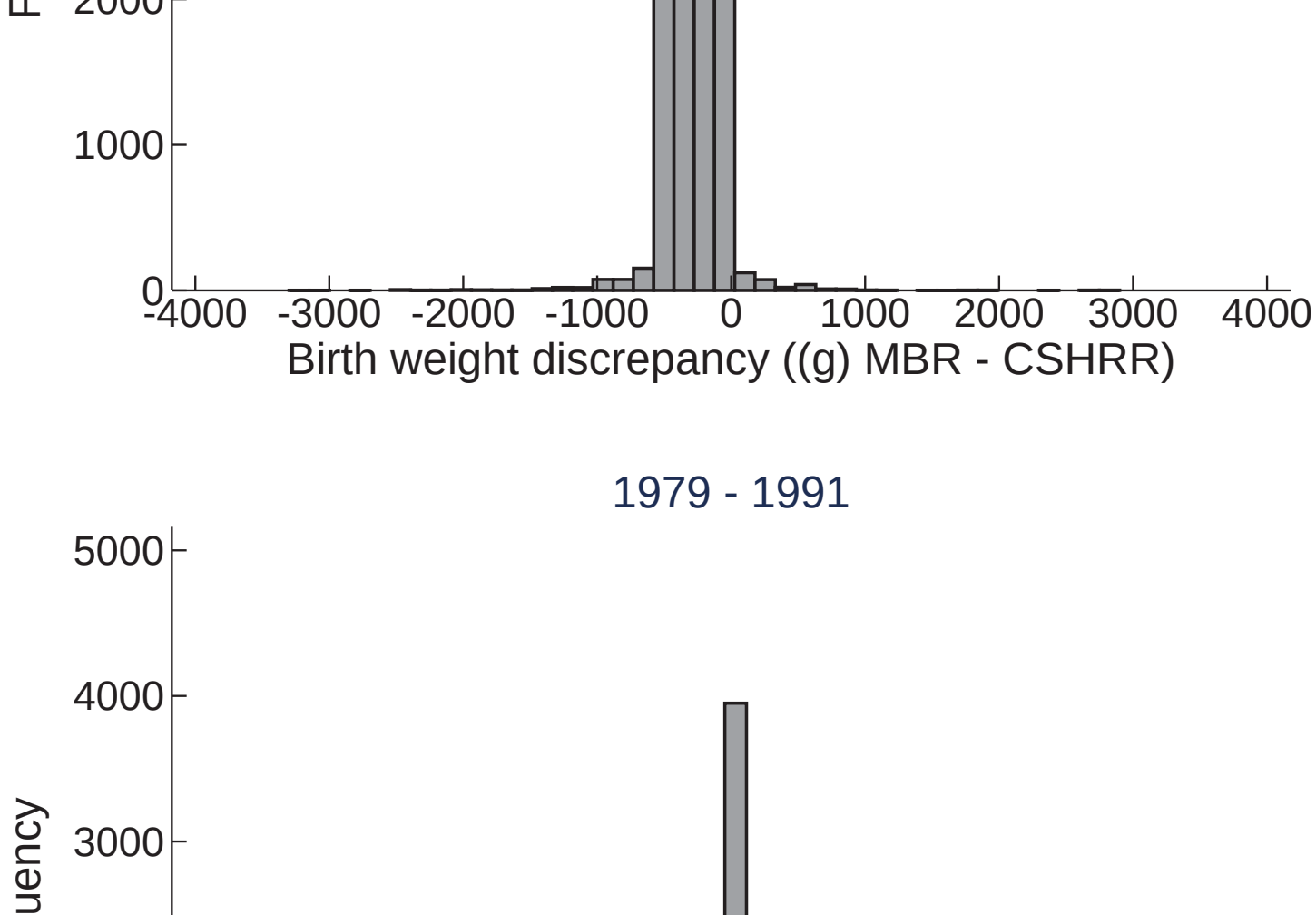


Table S 1: Comparison of BW from the CSHRR and the MBR stratified by gestational age and birth year groups according to MBR procedural changes (the two latter periods (1979-1991 and 1991) were combined).

		Birth weight (*grams)*				
		CSHRR		MBR		
	N	Mean	SD	Mean	SD	P
1973-1978						
Preterm (before 37 weeks)	101	2 308	537	2 020	552	0.0002
Early term (37 0/7 through 38 6/7 weeks)	255	3 008	538	2 733	552	0.0001
Term (39 0/7 through 40 6/7 weeks)	1 240	3 427	466	3 131	469	0.0001
Late term (41 0/7 through 41 6/7 weeks)	345	3 606	462	3 307	446	0.0001
Postterm (42 0/7 weeks and beyond)	165	3 562	445	3 306	457	0.0001
Missing	13 701	3 317	554	3 031	557	0.0001
1979-1991						
Preterm (before 37 weeks)	1 609	2 283	592	2 284	585	0.97
Early term (37 0/7 through 38 6/7 weeks)	4 498	3 055	492	3 052	474	0.8
Term (39 0/7 through 40 6/7 weeks)	16 961	3 416	468	3 413	451	0.64
Late term (41 0/7 through 41 6/7 weeks)	5 447	3 581	472	3 579	460	0.88
Postterm (42 0/7 weeks and beyond)	2 361	3 679	491	3 682	476	0.8
Missing	851	3 303	579	3 298	549	0.84

STROBE Statement—checklist of items that should be included in reports of observational studies

	Item No	Recommendation	Page number
Title and abstract	1	(*a*) Indicate the study's design with a commonly used term in the title or the abstract	4
		(*b*) Provide in the abstract an informative and balanced summary of what was done and what was found	4
Introduction			
Background/rationale	2	Explain the scientific background and rationale for the investigation being reported	5
Objectives	3	State specific objectives, including any prespecified hypotheses	5
Methods			
Study design	4	Present key elements of study design early in the paper	6-7
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection	6-7
Participants	6	(*a*) *Cohort study*—Give the eligibility criteria, and the sources and methods of selection of participants. Describe methods of follow-up *Case-control study*—Give the eligibility criteria, and the sources and methods of case ascertainment and control selection. Give the rationale for the choice of cases and controls *Cross-sectional study*—Give the eligibility criteria, and the sources and methods of selection of participants	6-7
		(*b*) *Cohort study*—For matched studies, give matching criteria and number of exposed and unexposed *Case-control study*—For matched studies, give matching criteria and the number of controls per case	N/A
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable	6-8
Data sources/ measurement	8*	For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group	6-8
Bias	9	Describe any efforts to address potential sources of bias	N/A
Study size	10	Explain how the study size was arrived at	9
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why	8
Statistical methods	12	(*a*) Describe all statistical methods, including those used to control for confounding	8
		(*b*) Describe any methods used to examine subgroups and interactions	8
		(*c*) Explain how missing data were addressed	8-9
		(*d*) *Cohort study*—If applicable, explain how loss to follow-up was addressed *Case-control study*—If applicable, explain how matching of cases and controls was addressed *Cross-sectional study*—If applicable, describe analytical methods taking account of sampling strategy	N/A
		(*e*) Describe any sensitivity analyses	8

Continued on next page

Results			
Participants	13*	(a) Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed	9
		(b) Give reasons for non-participation at each stage	9
		(c) Consider use of a flow diagram	9
Descriptive data	14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders	9-11
		(b) Indicate number of participants with missing data for each variable of interest	9-11
		(c) *Cohort study*—Summarise follow-up time (eg, average and total amount)	N/A
Outcome data	15*	*Cohort study*—Report numbers of outcome events or summary measures over time	9-11
		Case-control study—Report numbers in each exposure category, or summary measures of exposure	N/A
		Cross-sectional study—Report numbers of outcome events or summary measures	N/A
Main results	16	(*a*) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included	9-11
		(*b*) Report category boundaries when continuous variables were categorized	9-11
		(*c*) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period	N/A
Other analyses	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses	9-11
Discussion			
Key results	18	Summarise key results with reference to study objectives	12
Limitations	19	Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias	12-15
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence	12-15
Generalisability	21	Discuss the generalisability (external validity) of the study results	12-15
Other information			
Funding	22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based	16

*Give information separately for cases and controls in case-control studies and, if applicable, for exposed and unexposed groups in cohort and cross-sectional studies.

Note: An Explanation and Elaboration article discusses each checklist item and gives methodological background and published examples of transparent reporting. The STROBE checklist is best used in conjunction with this article (freely available on the Web sites of PLoS Medicine at http://www.plosmedicine.org/, Annals of Internal Medicine at http://www.annals.org/, and Epidemiology at http://www.epidem.com/). Information on the STROBE Initiative is available at www.strobe-statement.org.

BMJ Open

Comparison of birthweight between school health records and medical birth records in Denmark: Determinants of discrepancies.

Journal:	*BMJ Open*
Manuscript ID	bmjopen-2015-008628.R2
Article Type:	Research
Date Submitted by the Author:	28-Oct-2015
Complete List of Authors:	Jensen, Camilla; Institute of Preventive Medicine, Gamborg, Michael; Institute of Preventive Medicine, Bispebjerg and Frederiksberg Hospital, The Capital Region, Heitmann, Berit; The Boden Institute of Obesity, Nutrition, Exercise & Eating Disorders, University of Sydney, ; Institute of Preventive Medicine, Bispebjerg and Frederiksberg Hospital, The Capital Region, Sørensen, Thorkild; Institute of Preventive Medicine, ; Novo Nordisk Foundation Centre for Basic Metabolic Research, Section on Metabolic Genetics, Faculty of Health and Medical Sciences Baker, Jennifer; Institute of Preventive Medicine, Bispebjerg and Frederiksberg Hospital, The Capital Region, ; Novo Nordisk Foundation Centre for Basic Metabolic Research, Section on Metabolic Genetics, Faculty of Health and Medical Sciences
Primary Subject Heading:	Epidemiology
Secondary Subject Heading:	Obstetrics and gynaecology
Keywords:	EPIDEMIOLOGY, OBSTETRICS, PAEDIATRICS

Comparison of birthweight between school health records and medical birth records in Denmark: Determinants of discrepancies.

Camilla Bjørn Jensen[1,2], Michael Gamborg[1], Berit Heitmann[3,4,5], Thorkild IA Sørensen[1,6,7], Jennifer L. Baker[1,6]

[1] Institute of Preventive Medicine, Bispebjerg and Frederiksberg Hospital, The Capital Region, Copenhagen, Denmark.

[2] Faculty of Health and Medical Sciences, University of Copenhagen, Copenhagen, Denmark.

[3] Research Unit of Dietary Studies, Parker Institute, Bispebjerg and Frederiksberg Hospital, The Capital Region, Copenhagen, Denmark.

[4] The Boden Institute of Obesity, Nutrition, Exercise & Eating Disorders, University of Sydney, Australia

[5] National Institute of Public Health, University of Southern Denmark, Denmark.

[6] Novo Nordisk Foundation Center for Basic Metabolic Research, Faculty of Health and Medical Sciences, University of Copenhagen, Denmark.

[7] MRC Integrative Epidemiology Unit, University of Bristol, Bristol, UK

Correspondence:

Email: Camilla.bjoern.jensen@regionh.dk

Institute of Preventive Medicine, Frederiksberg Hospital

Nordre Fasanvej 57, Hovedvejen, Entrance 5

2000 Frederiksberg, Denmark

Phone: +45 38163101

Word counts

Abstract: 220

Text: 3 348

Running title: Validation of maternal birthweight reports

Abbreviations

BW: Birthweight; CSHRR: The Copenhagen School Health Records Register; MBR: The Danish Medical Birth Register.

Keywords: Birthweight, Denmark, registries, validation studies

Abstract

Objective: To compare reported birth weight (BW) information in school health records with BW from medical birth records, and to investigate if maternal and offspring characteristics were associated with any discrepancies.

Design: Register-based cohort study

Setting: Denmark, 1973-1991.

Participants: The study was based on BW recorded in the Copenhagen School Health Records Register (CSHRR) and in The Medical Birth Register (MBR). The registers were linked via the Danish personal identification number.

Primary and secondary outcome measures: Statistical comparisons of BW in the registers were performed using t-tests, Pearson's correlation coefficients, Bland-Altman plots, and Kappa coefficients. Odds of BW discrepancies >100 grams were examined by logistic regressions.

Results: The study population included 47 534 children. From 1973-1979 when BW was grouped in 500-gram intervals in the MBR, mean BW differed significantly between the registers. During 1979-1991 when BW was recorded in 10-gram and 1-gram intervals, mean BW did not significantly differ between the two registers. BW from both registers was highly correlated (0.93-0.97). Odds of a BW discrepancy significantly increased with parity, the child's age at recall and by marital status (children of married women had the highest odds).

Conclusion: Overall, BW information in school health records agreed very well with BW from medical birth records, suggesting that reports of BWs in school health records in Copenhagen, Denmark generally are valid.

Strengths and limitations

- Large register based study population
- Medical birth records are not always available but other sources of information might exist. Validation studies as the present is useful in such circumstances.
- Limited information on maternal and offspring characteristics was available.

Introduction

Birthweight (BW) has been identified as an important indicator of health for the child at birth, during infancy, and also later in adult life. [1–3] Officially recorded BW information is not always available to support current research into adult onset diseases, and it is therefore important to obtain valid information on BW collected retrospectively.

Because of the identified associations between BW and later disease outcomes, [4] information on BW is often included in epidemiological research. In many cases BW information can be retrieved from birth or medical records, however, this is not always possible and the use of recalled information may be the only option.

In general, mothers recall the BW of their children with a high degree of accuracy, [5–9] however the accuracy varies between studies possibly depending on the recall period (ranging from days to decades) and maternal characteristics. In one study, 58% of the mothers recalled their child's BW to within 100 grams of the recorded BW 6 years after birth [9] versus in two other studies where the rate was 92% at 9 months [5] and 8-18 years after birth. [6] As such, it is possible that parents recall their children's birth weights very well, or that there is publication bias in this area as studies demonstrating low correlations or poor agreement were not identified in the literature.

Therefore, in this study, we compared reports of BW obtained at the first school examination and recorded in health records with the recorded BW from medical birth records, and we investigated if maternal and offspring characteristics predicted the discrepancies between BW values in the two registers.

Methods

Study population

The CSHRR is a population-based register that includes virtually every school child in Copenhagen born between 1930 and 1991 and includes 381 110 records. The register has been established in collaboration between the Institute of Preventive Medicine, Bispebjerg and Frederiksberg Hospital, The Capital Region and the Copenhagen City Archives. The computerized register contains basic information about each child (name, sex, date of birth, personal identification number), along with annual measures of height and weight throughout school ages. From the birth year of 1936 onwards, information on BW was obtained at the time of the school entry examination which typically occurred when the children were 5-7 years of age. During the years included in this study (1973-1991), BW was either obtained at the first school examination or via a returned health questionnaire. The source of the BW information contained in the school health records, however, was not noted. The CSHRR is described in greater detail elsewhere. [10]

The MBR is a national medical register that contains computerized information on all births in Denmark since 1973. Information on births was reported to the Danish Health Authorities on a form filled out by the midwife shortly after delivery. From 1973 to 1977, BW was recorded in 500-gram units in the MBR, however, the rounding procedure was not documented. From 1978 to 1990, BW was recorded in 10-gram units and from 1991 onwards it was recorded in 1-gram units. The MBR also contains information on gestational age which was measured in weeks from 1973 to 1978 and in days from 1978 onwards. The mother's age, parity and civil status was also registered in the MBR. Further details of the register can be obtained elsewhere. [11]

The Danish personal identification number was used to link the two registers during the overlapping period from 1973 to 1991, and children with BW information in both the CSHRR and the MBR were identified.

An access and linkage permission was obtained from the Danish Data Protection Agency (J. no. 2012-41-1156). This type of research based on pre-existing routinely collected data does not require ethical permission in Denmark.

We excluded children with BW values below 500 grams as these were likely to be erroneous based on the chance of survival of very small children during the study period (Pryds, personal communication 2014). Based on the highest BW reported in Denmark of 6 150 grams, values above this level were excluded. [12]

BW was analysed as continuous variable (in grams) and divided into categories of 500-1 499, 1 500-1 999, 2 000-2 750, 2 751-3 250, 3 251-3 750, 3 751-4 250, 4 251-5 500, 5 501-6 150 grams, which were chosen to minimize the effects of digit preference. [13]

Information on gestational age is recorded in the MBR but not in the CSHRR. BW is strongly associated with gestational age, and we wanted to explore if reported BW varied by gestational age. We grouped gestational age into term categories (preterm: before 37 weeks, early term: 37 0/7 weeks through 38 6/7 weeks, full term: 39 0/7 weeks through 40 6/7 weeks, late term: 41 0/7 weeks through 41 6/7 weeks, post-term: 42 0/7 weeks and beyond). [14]

Based upon measured values of height and weight taken at the exam when the BW value was reported, we calculated a body mass index (BMI; kg/m^2) for each child. Each child's

weight status (under-, normal-, over-weight, obesity and morbid obesity) was classified using age- and sex-specific BMI cut-offs issued by the International Obesity Task Force. [15]

Statistical analyses

To assess if children who were missing BW information differed from those who had it in regards to sex and BW (from the other register), comparisons were made using t-tests and chi-square tests. Likelihood ratio tests were used to evaluate if the association between BW in the two registers could be described linearly or exponentially.

Scatterplots were generated to compare BW values between the two registers. Comparisons of mean (SD) BWs within each register within categories of overall, sex-specific, time periods (1973-1978, 1979-1990, 1991), and gestational age were made using t-tests. Pearson's correlation coefficients were calculated by time period. To graphically illustrate the agreement in BW values between the two registers, Bland-Altman plots were generated, also by time period. Within the Bland Altman plots, the limits of agreement were drawn at ±1.96 standard deviations. To test the agreement between the two registers we used Kappa coefficients for categories. The Kappa coefficient was not calculated for the period 1973-1978 because of the 500 gram rounding in the MBR.

Using a distribution plot of differences in BW between the two registers we identified outlying values with large discrepancies (> 500 grams). To examine if these subjects differed from the overall population, comparisons by sex and year of birth were performed with chi-square tests.

Logistic regressions were performed to examine if differences of > 100 grams in BW between the two registers were associated with maternal characteristics (maternal age, civil status and parity) from the MBR and offspring characteristics (age and BMI categories at the time of recall and year of birth) obtained from the CSHRR. Interactions between parity, age at BW recall, and civil status were assessed.

Results

Of 381 110 children in the CSHRR, 63 438 (16.6%) were born during 1973-1991 where the two registers overlapped and had a personal identification number. 11 971 (18.9%) children did not have information on BW in the CSHRR, and 3 832 (6.0%) did not have information on BW in the MBR. In the CSHRR there were no statistically significant differences between children with and without BW information in regards to sex and BW (from the MBR) (all $P > 0.05$). In the MBR there were no statistically significant differences in BW (from the CSHRR) between children with and without BW information, but more boys (53% vs. 51%, $P = 0.003$) and fewer girls (47% vs. 49%, $P = 0.003$) had missing BW information. The final study population consisted of 47 534 children (74.9% of the eligible population) after the exclusion of children with BWs below 500 grams or above 6 150 grams (**Figure S1**).

The BW distribution was approximately normal in both the MBR and the CSHRR. Digit preference was present in both registers for all time periods. Unsurprisingly, it was more apparent in the MBR than in the CSHRR during 1973-1979 when BW in the MBR was categorized in 500-gram units (**Figure S2**). Descriptive statistics can be seen in **Table 1**.

Table 1: Descriptive statistics for BW in the CSHRR and the MBR by birth year groups according to MBR procedural changes.

		Birthweight (*grams)*				
Information source and period	**N**	**Mean**	**SD**	**Median**	**Minimum**	**Maximum**
CSHRR						
1973-1991	47 534	3 342	564	3 350	500	6 000
MBR[1]						

1973-1977	15 807	3 036	558	3 000	500	6 000
1979-1990	28 708	3 346	555	3 350	730	5 750
1991	3 019	3 391	564	3 416	634	5 600

[1] From 1973 to 1977, BW was recorded in 500-gram units in the MBR. From 1978 to 1990, BW was recorded in 10-gram units, and from 1991 onwards in 1-gram units

Mean BW was significantly different only in the first period of the MBR (1973-1979) where the mean BW was ~300 grams higher in the CSHRR than in the MBR, likely due to rounding procedures used in the MBR. During the two later periods (1979-1990 and 1991), mean BW was not significantly different in the two registers (**Table 2**). We combined the two later periods in the remaining analyses because there were no notable differences between these periods and because the last period consisted of only one birth year and 3 019 children. There were no statistically significant differences between BW from the two registers when examined by maternal and offspring characteristics (all $P > 0.1$) in the period of 1979-1991 (**Table 2**).

Table 2: Comparison of BW from the CSHRR and the MBR stratified by birth year groups according to MBR procedural changes and by maternal and offspring characteristics.

		Birthweight (grams)				
		CSHRR		**MBR**		
	N	**Mean**	**SD**	**Mean**	**SD**	**P***
1973-1978						
All	15 807	3 323	555	3 036	558	*< 0.0001*
Boys	7 980	3 382	568	3 092	569	*< 0.0001*
Girls	7 827	3 263	535	2 980	540	*< 0.0001*
1979-1990						

All	28 708	3 348	568	3 346	555	*0.67*
Boys	14 782	3 409	580	3 407	566	*0.67*
Girls	13 926	3 283	547	3 282	535	*0.86*
1991						
All	3 019	3 389	577	3 391	564	*0.67*
Boys	1 540	3 446	587	3 446	578	*0.98*
Girls	1 479	3 330	560	3 332	542	*0.90*
Maternal characteristics[§]						
Maternal age						
< 20 y	1 187	3 252	543	3 244	518	*0.69*
20-30 y	19 183	3 337	554	3 334	542	*0.58*
30-40 y	10 772	3 387	592	3 388	579	*0.87*
40-50 y	582	3 401	603	3 406	587	*0.89*
≥ 50 y	3	3 292	525	3 290	524	*0.99*
Civil status						
Married	16 533	3 369	576	3 367	559	*0.68*
Divorced	1 970	3 320	593	3 321	584	*0.98*
Not married	13 224	3 335	555	3 334	547	*0.90*
Parity						
1	17 219	3 308	555	3 304	544	*0.49*
2	10 101	3 400	575	3 402	561	*0.84*

3	2 976	3 403	582	3 402	559	*0.99*
4	892	3 439	623	3 430	604	*0.76*
5	332	3 422	589	3 441	566	*0.68*
≥ 6	207	3 436	626	3 453	614	*0.78*
Offspring characteristics[§]						
Year of birth						
1979-81	6 607	3 322	565	3 322	552	*0.99*
1982-84	6 248	3 306	577	3 305	565	*0.91*
1985-87	7 591	3 344	566	3 341	550	*0.75*
1988-91	11 281	3 401	565	3 399	554	*0.78*
Age at recall						
5-6 y	2 984	3 381	556	3 379	541	*0.87*
6-6.5 y	9 662	3 363	563	3 362	550	*0.90*
6.5-7 y	10 410	3 355	564	3 354	554	*0.93*
7-8 y	7 245	3 327	582	3 323	565	*0.65*
>8 y	1 316	3 326	598	3 328	579	*0.94*
BMI classification at BW recall						
Underweight	2 384	3 100	592	3 097	576	*0.88*
Normalweight	25 186	3 358	558	3 357	545	*0.88*
Overweight	3 104	3 468	560	3 462	541	*0.68*

Obese	542	3 514	614	3 507	598	*0.84*
Morbidly obese	401	3 378	622	3 360	597	*0.68*

*Comparisons made by paired t-tests.

§ Comparison of mean BW by maternal and offspring characteristics are only presented for the period 1979-1991.

BWs in the CSHRR and the MBR were highly correlated. The lowest correlation coefficient was seen in the earliest period (0.93 [95%CI 0.92; 0.93]) compared to the later period (0.97 [95%CI 0.97; 0.97]); however, the correlations were still high in all periods.

From **Figure S3** it can be seen that the rounding of BW in 500 gram intervals in the MBR from 1973-1978 was very obvious. The association between BW in the two registers was linear in both periods.

The distribution of the discrepancies in BWs from the two registers can be seen in **Figure S4**. In the first period (1973-1978) most discrepancies were < 0 grams (98%) meaning that BW in the CSHRR was generally higher than BW in the MBR. 95% of the discrepancies were distributed within the interval -500 to 0 grams. 466 observations were distributed outside this interval with a maximal difference of 3 300 grams. In the second period (1979-1991), the discrepancies were distributed almost equally around zero with 95% within the interval of ±500 grams. 438 observations were distributed outside this interval with a maximal difference of 3 514 grams. For both periods, we found no differences with respect to sex (all $P > 0.6$) among the outliers than in rest of the population, but there was a difference in the distribution according to year of birth (all $P < 0.001$). However, there were no obvious patterns in the yearly distribution.

Within each register BW was categorized into eight groups and we compared if each child was assigned to the same BW category by both registers. This was only done for the period 1979-1991 due to the rounding procedures in the MBR during 1973-1978. 94.5% of BWs were placed in the same BW category by both registers, 4.7% were placed in adjacent BW categories and only 0.1% were placed more than 2 BW categories apart. The Kappa coefficient (0.93) showed very high agreement between the two registers (**Table 3**).

Table 3: Cross tabulation of observations in BW categories by the CSHRR and the MBR for birth years 1979-1991.

		MBR								
	Birthweight groups (grams)	**< 1 500**	**1 500-1 999**	**2 000-2 750**	**2 751-3 250**	**3 251-3 750**	**3 751-4 250**	**4 251-5 500**	**> 5 500**	**Total**
CSHRR	**< 1 500**	181	7	8	4	9	2	1	0	212 (0.7%)
	1 500-1 999	8	332	26	4	2	0	0	0	372 (1.3%)
	2 000-2 750	1	18	2 943	133	30	3	1	0	3 129 (10.6%)
	2 751-3 250	2	0	99	7 954	317	29	1	0	8 402 (28.4%)
	3 251-3 750	0	0	15	307	10 272	140	6	0	10 740 (36.3%)
	3 751-4 250	0	0	2	49	226	5 085	35	0	5 397 (18.2%)
	4 251-5 500	0	0	1	12	28	79	1 231	0	1 351 (4.6%)
	> 5 500	0	0	0	1	1	1	4	3	10 (0%)
	Total	192 (0.6%)	357 (1.2%)	3 094 (10.4%)	8 464 (28.6%)	10 885 (36.8%)	5 343 (18.0%)	1 279 (4.3%)	3 (0%)	29 613

Kappa	0.93
Agreement	94.6%

Expected agreement	26.1%

The Bland-Altman plots of the differences in BW between the two registers per average BW generally showed good agreement (**Figure 1**). In the 1973-1978 period, the rounding procedures in the MBR were apparent. In this period, the plot illustrates that the MBR reports were, on average, lower than in the CSHRR.

In the 1979-1991 period, the Bland-Altman plot did not reveal any systematic patterns of deviations between BWs in the two registers. For the majority of BWs (n= 30 528, 96.2%) the difference between two registers fell within the range of -287 to 284 grams (corresponding to ±1.96 standard deviations, indicated by the dashed lines in **Figure 1**). Few values fell above these limits (n = 584, 1.8%) and few fell below (n = 615, 1.9%).

In the period 1973-1978 mean BW within term categories was significantly different in the two registers (**Table S1**). In the period 1979-1991 none of the BWs were significantly different by gestational age categories. There was a statistically significant increasing trend in BW by term status, however, the standard deviations within each of these categories overlapped.

Results from the bivariate logistic regressions of differences in BW of > 100 grams showed that odds of a discrepancy increased with younger maternal age, and higher parity (**Table 4**). Compared with married women, divorced and non-married women had lower odds of a discrepancy. The odds of a discrepancy did not show a discernable pattern by year of the child's birth. Compared with children who had their BW reported at 6.5 to 7 years of age, those who had it reported at the youngest ages (5-6 years) and older ages had a higher odds of a discrepancy. Results from the multivariate logistic regressions showed the same associations for maternal age, civil status, parity and the child's age when the BW was reported. No statistically significant interactions among these characteristics were identified.

Table 4: Odds ratio (95%CI) of BW discrepancy >100 grams between BW from the CSHRR and the MBR stratified by maternal and offspring characteristics for the birth years 1979-1991.

	OR of BW difference > 100 grams							
	Bivariate model				Multivariable model			
	N	OR	95%CI		N	OR	95%CI	
Maternal age								
< 20 y	1 187	1.22	0.91	1.63	1 185	1.64	1.21	2.20
20 ≤ y < 30	19 183	Reference			19 114	Reference		
30 ≤ y < 40	10 772	1.21	1.08	1.37	10 736	0.92	0.81	1.04
40 ≤ y < 50	582	1.74	1.22	2.47	579	0.92	0.63	1.34
≥ 50 y	3	-	-	-	-	-	-	-
Civil status								
Married	16 533	Reference			16 469	Reference		
Divorced	1 970	0.79	0.62	1.01	1 965	0.76	0.59	0.97
Not married	13 224	0.57	0.51	0.65	13 180	0.78	0.68	0.89
Parity								
1	17 219	Reference			17 154	Reference		
2	10 101	1.85	1.62	2.11	10 073	1.84	1.60	2.12
3	2 976	2.62	2.20	3.11	2 963	2.60	2.15	3.14
4	892	3.05	2.33	3.98	890	2.92	2.19	3.88
5	332	4.64	3.24	6.64	329	4.44	3.05	6.47
≥ 6	207	5.97	3.96	8.98	205	5.73	3.73	8.82

Offspring characteristics*								
Sex								
Boy	16 322	Reference			16 257	Reference		
Girl	15 405	1.08	0.97	1.21	15 357	1.08	0.96	1.21
Year of birth								
1979-81	6 607	Reference			6 598	Reference		
1982-84	6 248	0.87	0.73	1.03	6 228	0.90	0.75	1.07
1985-87	7 591	0.77	0.65	0.92	7 566	0.80	0.67	0.95
1988-91	11 281	0.84	0.73	0.98	11 222	0.89	0.76	1.04
Age at BW recall								
5-6 y	2 984	1.55	1.28	1.88	2 984	1.37	1.13	1.67
6-6.5 y	9 662	1.0	0.86	1.16	9 660	0.97	0.83	1.13
6.5-7 y	10 410	Reference			10 410	Reference		
7-8 y	7 245	1.18	1.01	1.38	7 245	1.21	1.03	1.42
>8 y	1 316	1.81	1.41	2.33	1 315	1.68	1.30	2.16
BMI category at BW recall								
Underweight	2 384	1.0	0.80	1.24	2 384	0.96	0.77	1.19
Normal-weight	25 186	Reference			25 185	Reference		
Overweight	3 104	0.98	0.81	1.19	3 103	0.77	0.47	1.25
Obese	542	0.80	0.49	1.31	541	1.08	0.68	1.74
Morbidly obese	401	1.23	0.77	1.96	401	0.96	0.77	1.19

Discussion

We found that reports of BWs in the CSHRR agreed very well with the recorded BWs in the MBR. The MBR recorded BW in 500-gram units from 1973 to 1978 which was obvious in our results and made the agreement between the two registers poorer than in the remaining study period.

We used several different methods to compare BW in the two registers. Whether BW was compared continuously or categorically the message was the same -- there was a high degree of agreement between the two. We found a high correlation between the MBR and the CSHRR, especially in the period after 1978 (0.97), which is similar to what other validation studies have found (0.97-0.98). [6–8] In total, 94.5% of BWs were placed in the same BW category by the two registers and there were no discernable patterns in the misclassifications.

Other studies have also reported agreement of BW in categories, but there are large differences in the range of the BW categories, the methods used and the nationalities of the populations. The definition of BW groups influences the degree of agreement whereby smaller groups increase the likelihood of misclassification. However, the agreement was high irrespective of the BW groups used. In another Danish study the BW was categorized as low, normal and high, and the agreement of classification was 98%. [6] Among Israeli mothers, approximately 80% recalled their children's BW correctly within 500-gram BW categories. [9] In a study of American and Canadian mothers, agreement was 93% using four BW categories of <3 kg, 3-3.5 kg, 3.5-4 kg and >4 kg. [7] Another study of American mothers showed that the sensitivity ranged from 90.3-93.6 % and that the specificity ranged from 97.8-99.3% when BW groups were defined as above and below different BW values (1.5, 2, 2.5, 3.5 and 4 kg). [8]

One of the major strengths of this study is that both the MBR and the CSHRR are based on large, unselected populations that minimize the risk of selection bias. One limitation of the CSHRR is the lack of information on child characteristics like socio-economic status and lifestyle factors that could have been included in the analyses and potentially could have predicted discrepancies. [10] The major limitation of the MBR is the rounding procedure used from 1973-1978. [11] The analyses were restricted to BW values from 500 to 6150 g to avoid overtly erroneous values. A comparison of BW values based upon gestational age categories (taken from the MBR) did not reveal any significant differences in the 1978-1991 period suggesting that these BW values are reasonable given the infant's gestational age.

Although BW was most likely reported by the mother in the CSHRR during the years included in this study, it is a possibility that it was reported by the father or another adult with parental responsibility. In Copenhagen, each child was issued an infancy health book in which BW was recorded by the visiting health nurse shortly after delivery. These books were commonly used as a continuous health record for children, so it is possible that some parents either used this book when filling in the questionnaire or brought it with them to the examination, thus contributing to the high agreement between BW values in the CSHRR and the MBR. In the CSHRR we have no indications of the source of the BW and therefore we do not know if it was the majority of parents who brought the book or not. Another possible explanation is that parents (and mothers in particular) remember their children's BW very well. BW is typically reported to family and friends after the birth of the child and this might aid memorization. BW may also have a special psychological importance that enables parents to accurately remember their child's BW.

In the present study, BWs were obtained at the school entry examination which occurred when the children were 5-7 years of age with a few exceptions of older children who entered the register when they transferred from other schools. Other studies had other time frames ranging from 9 -18 months to 6-18 years from birth to recall, but overall the conclusion has been that mothers seem to recall their children's BW very well irrespective of the time past since birth. [5–9] Our results fit well with these findings, even though we cannot be certain of whether a mother or other adult with parental responsibility reported the BW.

We found that parity and maternal civil status influenced the odds of having a discrepancy between BW in the two registers, where the odds increased with parity and were reduced among non-married women. The pattern we observe for marital status likely reflects that many of the unmarried mothers did have partners, and that in the Danish population it is not always an indicator of a low socioeconomic position. The child's age at recall was also associated with a discrepancy; the odds of a discrepancy were the lowest when the age at recall was between 6-8 years compared to <6 or >8y.

Other studies have also investigated ability to recall BW according to various maternal characteristics. [5–8] Two studies showed higher risks of a discrepancy > 100 grams among non-white women and women who have given birth previously compared with white and primiparous women, respectively. [5,6] One of these studies also found that unemployed women remembered their child's BW less well as compared with working women, and that the lower the BW of the child, the higher the risk of a discrepancy. [5] Another study showed that mothers with less than a high school education had higher risk of discrepancy between recalled and recorded BW [8]. In contrast, another study investigated ability to recall BW by maternal education, age and

race, household income, time from delivery to maternal recall, and birth order of the child, and found no significant differences across any of these demographic subgroups. [7]

We examined birth weight recall during the birth years of 1973-1991 among Danes, and it is a possibility that recall may have changed since then or that it differs depending on which population is being investigated. In our study, we only had the possibility to look into recall ability according to maternal age, parity, civil status, offspring age and body size at recall and year of birth. Nonetheless, we had an unselected population where all socio-economic groups were represented; the generalizability of our results should apply to a general Danish population.

Medical birth records are not always available because of the studied time period or because retrieving records is too labor demanding; as such, recalled information might be the only source of BW. In such cases a validation study as the present is useful for demonstrating the accuracy of the BW data. Previous and future research based on the CSHRR will gain from the present conclusion that reports of BW in the CSHRR agreed very well with BW records in the MBR. Other cohorts or registers from similar populations can however, also draw on the present conclusion that maternal reports of BWs are accurate and can be used as a reasonable substitute when medical birth records are unavailable.

Conclusion

Overall, reported BWs in the CSHRR agreed very well and accurately with recorded values from medical birth records, suggesting that these values are valid. Discrepancies in BW were more often seen among married women, women with several children, and among children who were below 6 or above 8 years at recall. These results suggest that research on associations

between BW and adult onset diseases will not be biased by the use of information on BW that is obtained during childhood from school health records.

Acknowledgments

Contributorship statement

The authors' responsibilities were as follows – TIAS and JLB conceived the research idea; CBJ and JLB designed research; CBJ performed statistical analysis; CBJ, GM, BLH, TIAS and JLB interpreted the results, CBJ drafted the manuscript, and GM, BLH, TIAS and JLB commented on it; CBJ and JLB had primary responsibility for the final content. All authors read and approved the final manuscript.

Competing interests

The authors declare no conflict of interest or competing interests.

Funding

The project was funded by the Danish Agency for Science Technology and Innovation, the Ministry of Science, Innovation and Higher Education, under the instrument "Strategic research projects" and by a research grant from the Danish PhD School of Molecular Metabolism funded by the Novo Nordisk Foundation. This research was financially supported by the European Research Council under the European Union's Seventh Framework Programme (FP/2007-2013)/ERC Grant Agreement no. 281419, childgrowth2cancer awarded to JLB.

The supporting bodies for this project had no role in the design, implementation, analysis and interpretation of the data presented.

Data sharing statement

No additional data available.

References

1 Risnes KR, Vatten LJ, Baker JL, *et al.* Birthweight and mortality in adulthood: a systematic review and meta-analysis. *Int J Epidemiol* 2011;**40**:647–61. doi:10.1093/ije/dyq267

2 Black SE, Devereux PJ, Salvanes KG. From the cradle to the labor market? The effect of birth weight on adult outcomes. *Q J Econ* 2007;**122**:409–39.

3 Rogers I. The influence of birthweight and intrauterine environment on adiposity and fat distribution in later life. *Int J Obes Relat Metab Disord* 2003;**27**:755–77. doi:10.1038/sj.ijo.0802316

4 Hanson M a., Gluckman PD. Early Developmental Conditioning of Later Health and Disease: Physiology or Pathophysiology? *Physiol Rev* 2014;**94**:1027–76. doi:10.1152/physrev.00029.2013

5 Tate AR, Dezateux C, Cole TJ, *et al.* Factors affecting a mother's recall of her baby's birth weight. *Int J Epidemiol* 2005;**34**:688–95. doi:10.1093/ije/dyi029

6 Adegboye ARA, Heitmann B. Accuracy and correlates of maternal recall of birthweight and gestational age. *BJOG* 2008;**115**:886–93.http://www.pubmedcentral.nih.gov/articlerender.fcgi?artid=2438372&tool=pmcentrez&rendertype=abstract (accessed 14 Aug2014).

7 Olson JE, Shu XO, Ross JA, *et al.* Medical record validation of maternally reported birth characteristics and pregnancy-related events: a report from the Children's Cancer Group. *Am J Epidemiol* 1997;**145**:58–67.http://www.ncbi.nlm.nih.gov/pubmed/8982023 (accessed 14 Aug2014).

8 Lucia VC, Luo Z, Gardiner JC, *et al.* Reports of birthweight by adolescents and their mothers: comparing accuracy and identifying correlates. *Paediatr Perinat Epidemiol* 2006;**20**:520–7. doi:10.1111/j.1365-3016.2006.00757.x

9 Gofin R, Neumark YD, Adler B. Birthweight recall by mothers of Israeli children. *Public Health* 2000;**114**:161–3.http://www.ncbi.nlm.nih.gov/pubmed/10878741 (accessed 14 Aug2014).

10 Baker JL, Olsen LW, Andersen I, *et al.* Cohort profile: the Copenhagen School Health Records Register. *Int J Epidemiol* 2009;**38**:656–62.http://www.pubmedcentral.nih.gov/articlerender.fcgi?artid=2722813&tool=pmcentrez&rendertype=abstract (accessed 20 Mar2014).

11 Knudsen LB, Olsen J. The Danish Medical Birth Registry. *Dan Med Bull* 1998;**45**:320–3.http://www.ncbi.nlm.nih.gov/pubmed/9675544 (accessed 13 May2014).

12 Milsgaard M. Ny rekord på fødestuen. Fødte en gigantisk baby. [New record in the delivery room. Gave birth to a gigantic baby.]. *Ude og Hjemme* 2013.http://www.udeoghjemme.dk/Artikler/Kaerlighed-og-sorg/2013/07/31-foedte-en-gigantisk-baby.aspx

13 Baker JL, Olsen LW, Sørensen TIA. Weight at birth and all-cause mortality in adulthood. *Epidemiology* 2008;**19**:197–203. doi:10.1097/EDE.0b013e31816339c6

14 American College of Obstetricians and Gynecologists. Definition of term pregnancy. Committee Opinion No. 579. *Obs Gynecol* 2013;:1139–40.

15 Cole TJ, Lobstein T. Extended international (IOTF) body mass index cut-offs for thinness, overweight and obesity. *Pediatr Obes* 2012;**7**:284–94. doi:10.1111/j.2047-6310.2012.00064.x

Figures

Figure 1: Bland-Altman plots of birthweight (grams) in the CSHRR and the MBR according to MBR procedural changes. The solid line illustrates the mean difference and the dashed lines represent the ±1.96 standard deviations.. In the 1973-1978 plot, the mean difference was -287 grams, with a standard deviation of 215 grams. In the 1979-1991 plot, the mean difference was -2 grams, with a standard deviation of 146 grams.

Supporting information

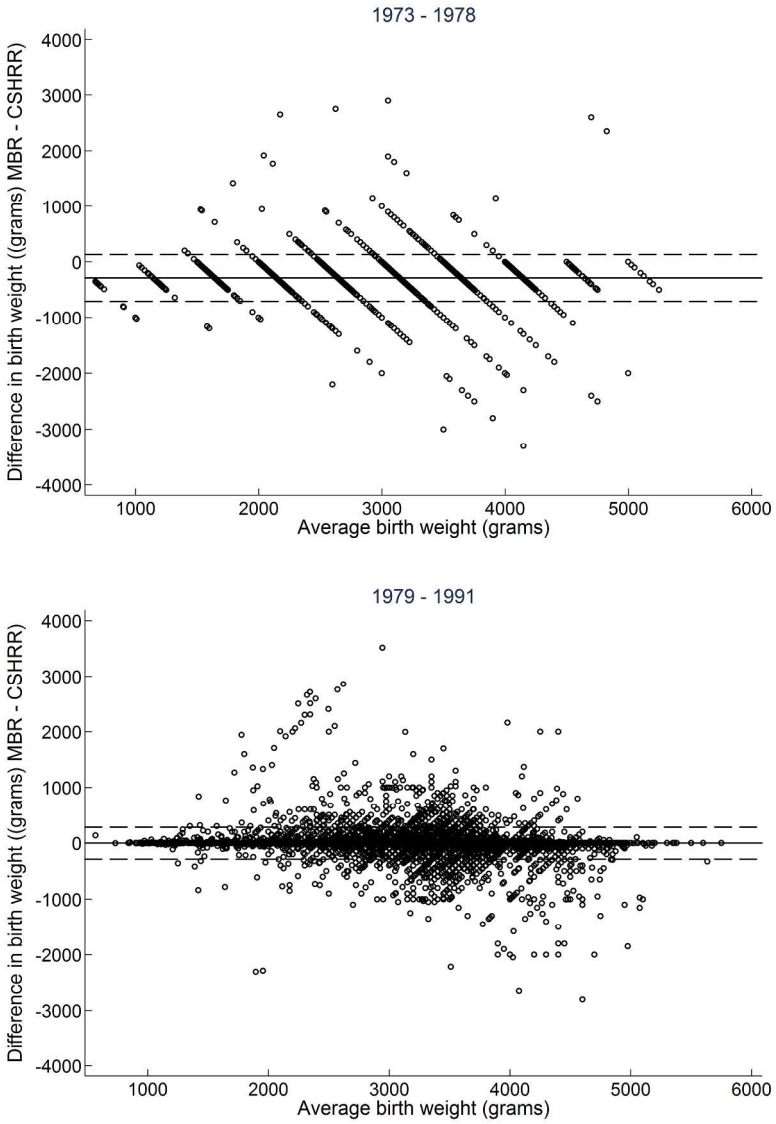
Table S 1: Comparison of BW from the CSHRR and the MBR stratified by gestational age and birth year groups according to MBR procedural changes (the two latter periods (1979-1991 and 1991) were combined).

Figure S 1: Flow chart

Figure S 2: Histograms of birthweight (g) distributions in the Copenhagen School Health Records Register (CSHRR) and the Medical Birth Register (MBR).

Figure S 3: Birthweight in the CSHRR plotted against birthweight in the MBR by birth year groups according to MBR procedural changes.

Figure S 4: Distribution of discrepancy in birthweight (grams) between the MBR and the CSHRR according to MBR procedural changes. Differences of zero grams (306 observations (2%) during 1973-1978 and 23 605 observations (74%) during 1979-1991) are not included in the plots.



209x299mm (300 x 300 DPI)

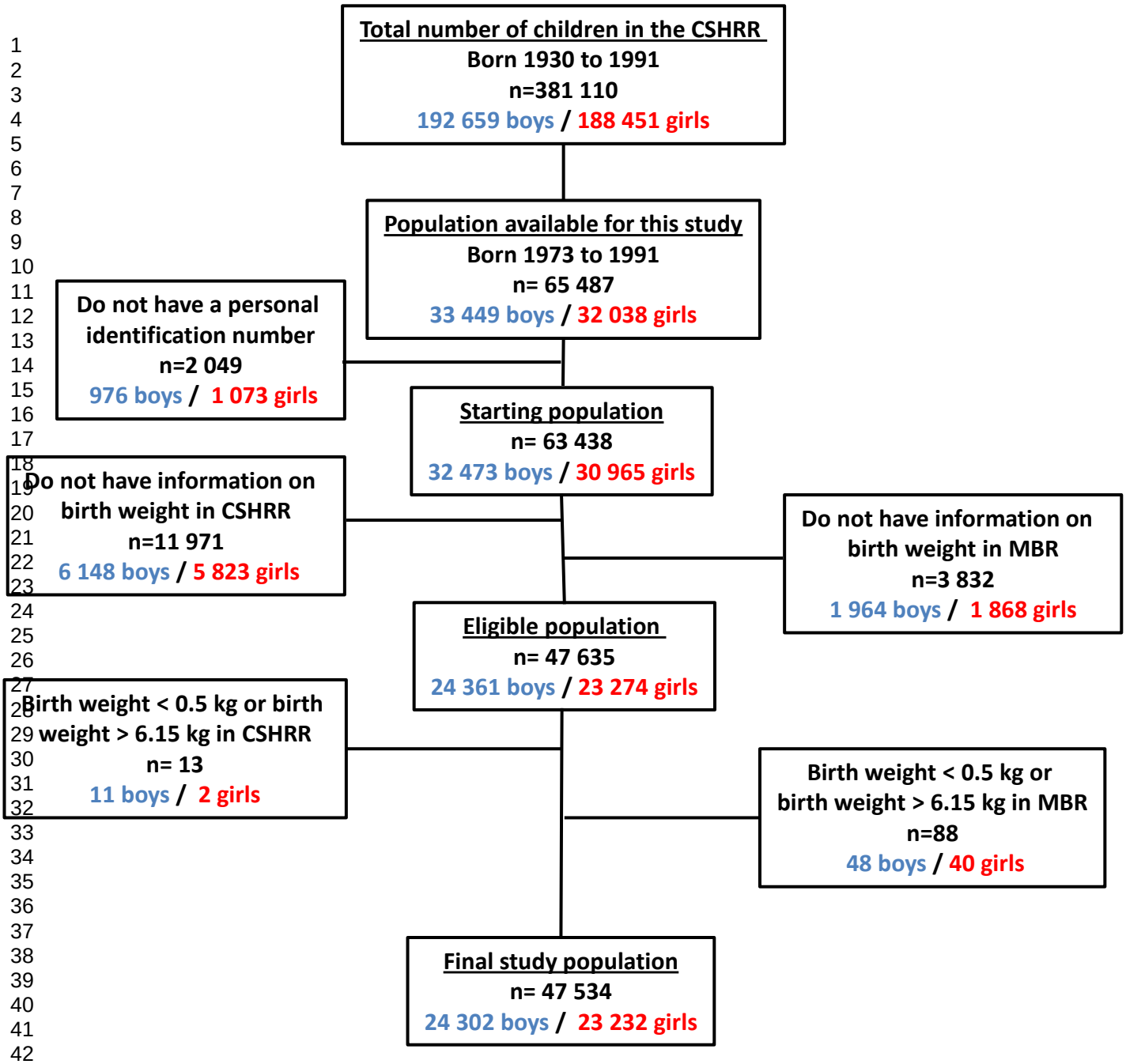

Total number of children in the CSHRR
Born 1930 to 1991
n=381 110
192 659 boys / 188 451 girls
Population available for this study
Born 1973 to 1991
n= 65 487
33 449 boys / 32 038 girls
Do not have a personal identification number
n=2 049
976 boys / 1 073 girls
Starting population
n= 63 438
32 473 boys / 30 965 girls
Do not have information on birth weight in CSHRR
n=11 971
6 148 boys / 5 823 girls
Do not have information on birth weight in MBR
n=3 832
1 964 boys / 1 868 girls
Eligible population
n= 47 635
24 361 boys / 23 274 girls
Birth weight < 0.5 kg or birth weight > 6.15 kg in CSHRR
n= 13
11 boys / 2 girls
Birth weight < 0.5 kg or birth weight > 6.15 kg in MBR
n=88
48 boys / 40 girls
Final study population
n= 47 534
24 302 boys / 23 232 girls

Figure S2.

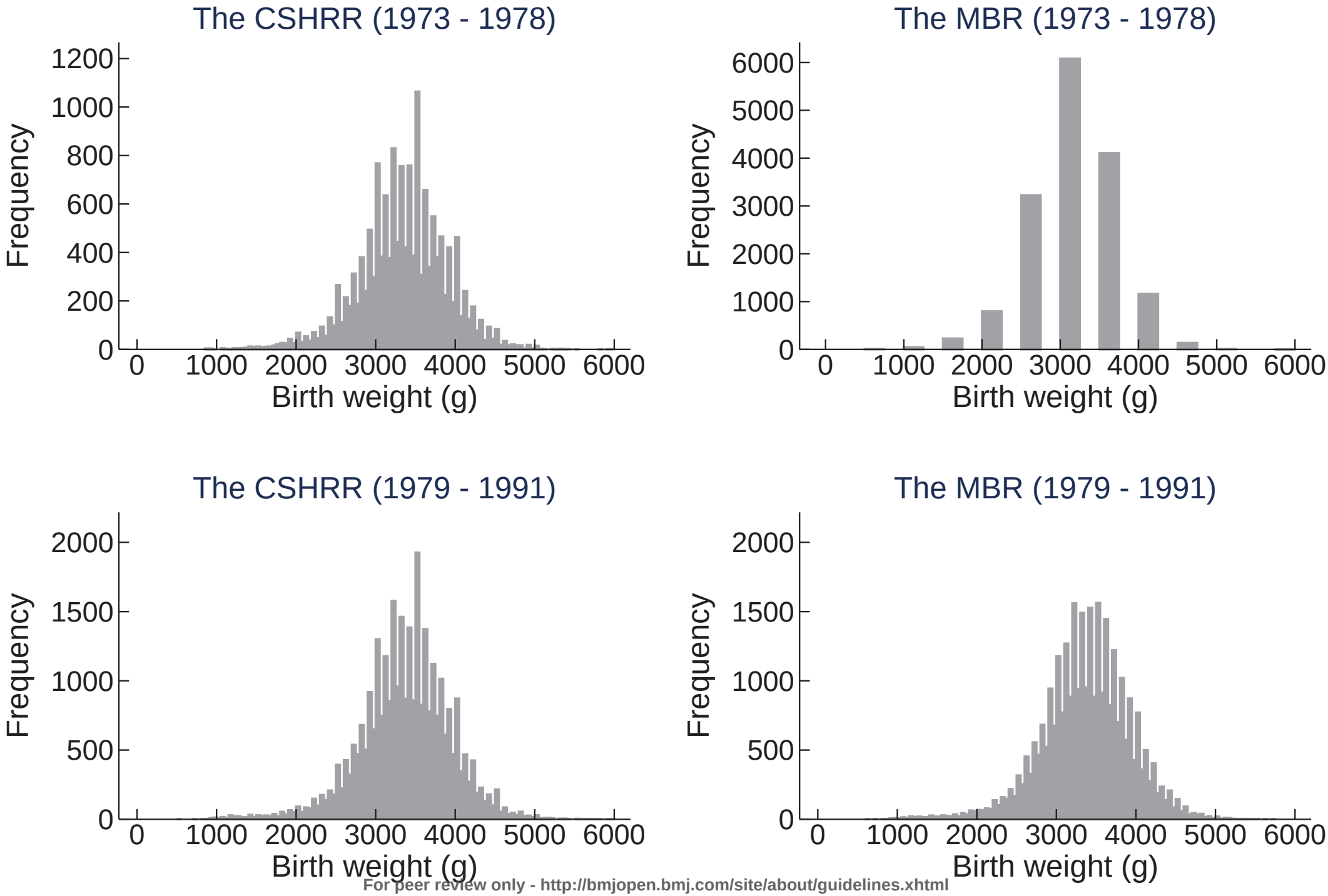
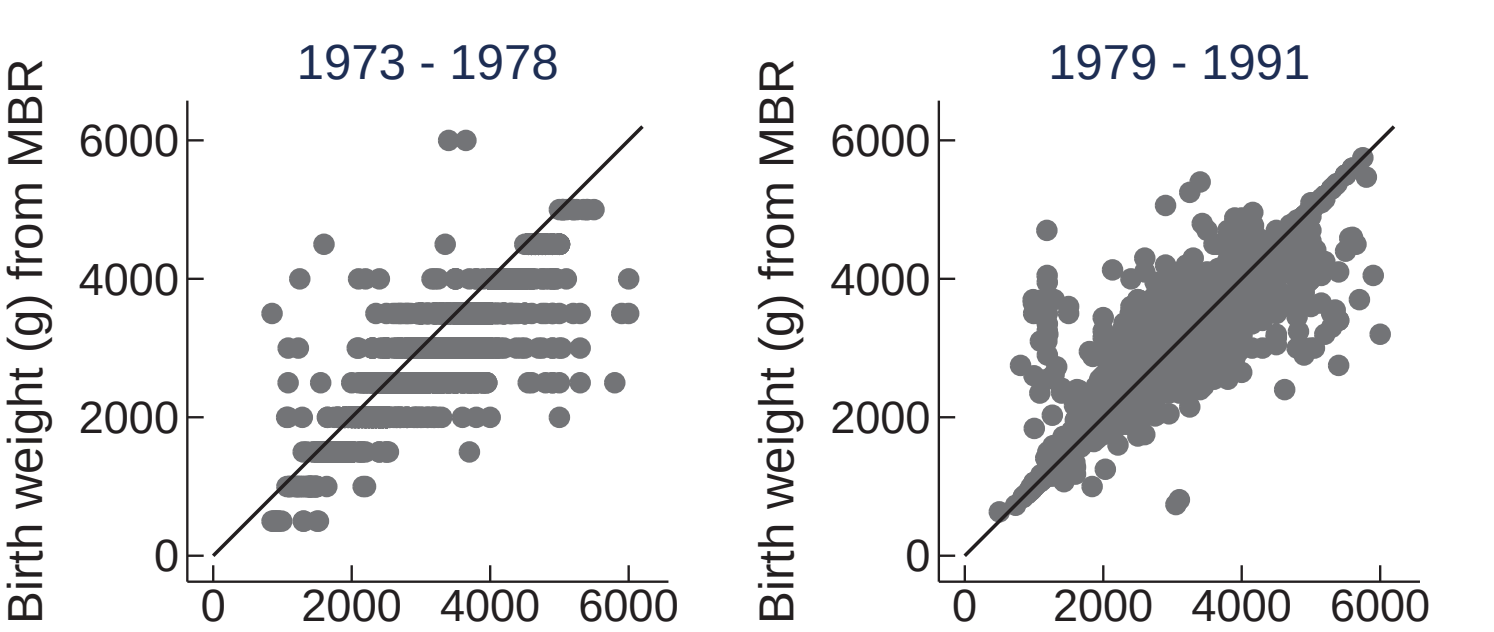
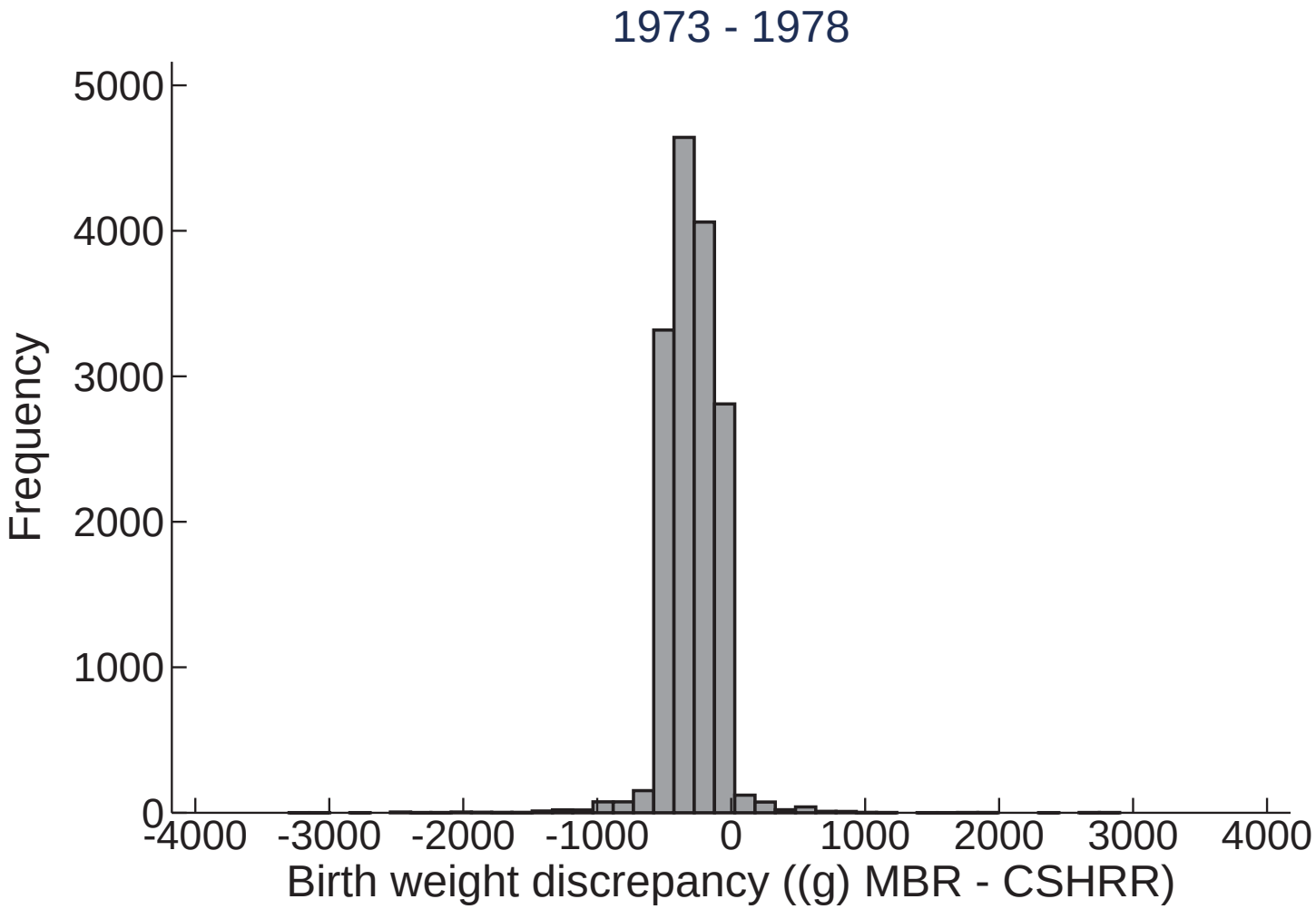


Figure S3.


1973 - 1978
1979 - 1991
Birth weight (g) from MBR
Birth weight (g) from CSHR
Birth weight (g) from CSHRR
0
2000
4000
6000



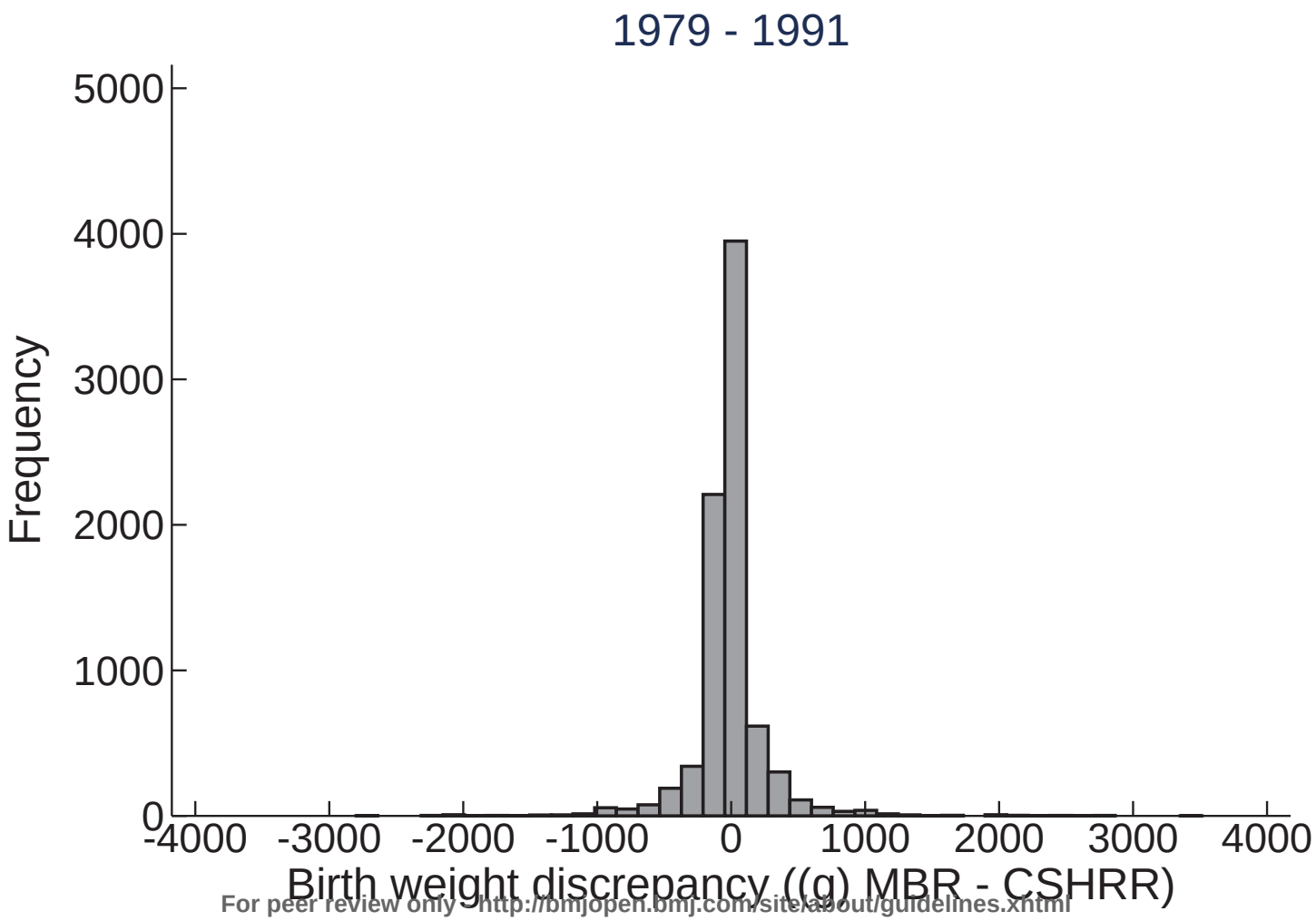


Table S 1: Comparison of BW from the CSHRR and the MBR stratified by gestational age and birth year groups according to MBR procedural changes (the two latter periods (1979-1991 and 1991) were combined).

		Birth weight (*grams)*				
		CSHRR		MBR		
	N	Mean	SD	Mean	SD	P
1973-1978						
Preterm (before 37 weeks)	101	2 308	537	2 020	552	0.0002
Early term (37 0/7 through 38 6/7 weeks)	255	3 008	538	2 733	552	0.0001
Term (39 0/7 through 40 6/7 weeks)	1 240	3 427	466	3 131	469	0.0001
Late term (41 0/7 through 41 6/7 weeks)	345	3 606	462	3 307	446	0.0001
Postterm (42 0/7 weeks and beyond)	165	3 562	445	3 306	457	0.0001
Missing	13 701	3 317	554	3 031	557	0.0001
1979-1991						
Preterm (before 37 weeks)	1 609	2 283	592	2 284	585	0.97
Early term (37 0/7 through 38 6/7 weeks)	4 498	3 055	492	3 052	474	0.8
Term (39 0/7 through 40 6/7 weeks)	16 961	3 416	468	3 413	451	0.64
Late term (41 0/7 through 41 6/7 weeks)	5 447	3 581	472	3 579	460	0.88
Postterm (42 0/7 weeks and beyond)	2 361	3 679	491	3 682	476	0.8
Missing	851	3 303	579	3 298	549	0.84

STROBE Statement—checklist of items that should be included in reports of observational studies

	Item No	Recommendation	Page number
Title and abstract	1	(*a*) Indicate the study's design with a commonly used term in the title or the abstract	4
		(*b*) Provide in the abstract an informative and balanced summary of what was done and what was found	4
Introduction			
Background/rationale	2	Explain the scientific background and rationale for the investigation being reported	5
Objectives	3	State specific objectives, including any prespecified hypotheses	5
Methods			
Study design	4	Present key elements of study design early in the paper	6-7
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection	6-7
Participants	6	(*a*) *Cohort study*—Give the eligibility criteria, and the sources and methods of selection of participants. Describe methods of follow-up *Case-control study*—Give the eligibility criteria, and the sources and methods of case ascertainment and control selection. Give the rationale for the choice of cases and controls *Cross-sectional study*—Give the eligibility criteria, and the sources and methods of selection of participants	6-7
		(*b*) *Cohort study*—For matched studies, give matching criteria and number of exposed and unexposed *Case-control study*—For matched studies, give matching criteria and the number of controls per case	N/A
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable	6-8
Data sources/ measurement	8*	For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group	6-8
Bias	9	Describe any efforts to address potential sources of bias	N/A
Study size	10	Explain how the study size was arrived at	9
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why	8
Statistical methods	12	(*a*) Describe all statistical methods, including those used to control for confounding	8
		(*b*) Describe any methods used to examine subgroups and interactions	8
		(*c*) Explain how missing data were addressed	8-9
		(*d*) *Cohort study*—If applicable, explain how loss to follow-up was addressed *Case-control study*—If applicable, explain how matching of cases and controls was addressed *Cross-sectional study*—If applicable, describe analytical methods taking account of sampling strategy	N/A
		(*e*) Describe any sensitivity analyses	8

Continued on next page

Results			
Participants	13*	(a) Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed	9
		(b) Give reasons for non-participation at each stage	9
		(c) Consider use of a flow diagram	9
Descriptive data	14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders	9-11
		(b) Indicate number of participants with missing data for each variable of interest	9-11
		(c) *Cohort study*—Summarise follow-up time (eg, average and total amount)	N/A
Outcome data	15*	*Cohort study*—Report numbers of outcome events or summary measures over time	9-11
		Case-control study—Report numbers in each exposure category, or summary measures of exposure	N/A
		Cross-sectional study—Report numbers of outcome events or summary measures	N/A
Main results	16	(*a*) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included	9-11
		(*b*) Report category boundaries when continuous variables were categorized	9-11
		(*c*) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period	N/A
Other analyses	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses	9-11
Discussion			
Key results	18	Summarise key results with reference to study objectives	12
Limitations	19	Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias	12-15
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence	12-15
Generalisability	21	Discuss the generalisability (external validity) of the study results	12-15
Other information			
Funding	22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based	16

*Give information separately for cases and controls in case-control studies and, if applicable, for exposed and unexposed groups in cohort and cross-sectional studies.

Note: An Explanation and Elaboration article discusses each checklist item and gives methodological background and published examples of transparent reporting. The STROBE checklist is best used in conjunction with this article (freely available on the Web sites of PLoS Medicine at http://www.plosmedicine.org/, Annals of Internal Medicine at http://www.annals.org/, and Epidemiology at http://www.epidem.com/). Information on the STROBE Initiative is available at www.strobe-statement.org.