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MILD TRAUMATIC BRAIN INJURIES PRESENTING TO SWEDISH HOSPITALS IN 1987–2000

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Objective: **To evaluate the incidence and causes of mild traumatic brain injury in Sweden.**

Design: **Retrospective, population-based incidence cohort study.**

Subjects: **All persons presenting to hospitals in Sweden between 1987 and 2000 with a discharge diagnosis of ICD-9 code 850 and ICD-10 code S0.60.**

Methods: **Data source was the Hospital Discharge Register at the National Board of Health and Welfare (Sweden). Incidence rates are stratified by age, gender, mechanism of injury and length of hospital stay.**

Results: **Men had a mean of 209 mild traumatic brain injuries per 100,000 inhabitants and women averaged 148 per 100,000. Men had more mild traumatic brain injury than women at all ages. There were 2 incidence peaks, in the age strata 16–20 years and those over 65 years. Falls were the most common cause of mild traumatic brain injury overall and occurred commonly under the age of 10 years and over the age of 65 years. Motor vehicle and bicycle injuries were the second and third most common causes of mild traumatic brain injury, and had their peak incidence in those aged 16–35 years.**

Conclusion: **Preventative strategies for mild traumatic brain injury should be age and gender specific.**

Key words: mild traumatic brain injury, epidemiology, incidence, aetiology.

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INTRODUCTION

Mild traumatic brain injury (MTBI), commonly called concussion, is often diagnosed following a blow to the head with or without brief disruption in cortical function. It is a common injury, with reported incidence rates from 100 to 800 per 100,000 that vary by age, gender, the population under evaluation and the cases definition (1). It is also common in those who participate in certain sports, such as American football, ice hockey and taekwondo (1, 2).

In Sweden, strategies to enhance transport safety, including child safety seats and education about bicycle helmets have been introduced (3–6). However, there is no national legislation requiring the use of bicycle helmets, and there is an ageing population that is more prone to injurious falls (7). Even so, a recent report from the Swedish Health Authority has shown that the incidence of MTBI has remained stable over the years 1989–96 (8).

Epidemiological studies of head injury have been undertaken in several other countries (e.g. USA, France, Norway and Taiwan) over the last 20 years (9–12). However, these studies include limited time periods of evaluation, or are limited in their geographic scope. Hence, generalizing these studies to other health districts, or other time periods can be problematic. In addition, only a few population-based studies have examined causes of MTBI (13, 14). There is some evidence that motor-vehicle-related MTBI is less important in Scandinavian countries than in the USA or other European countries (9–11, 15). Understanding opportunities for prevention requires evaluation of the causes of MTBI over an extended timeframe, in a national sample.

Indeed, an absolute prerequisite to the introduction of effective preventative strategies is a regional and national surveillance system. The Swedish healthcare system, with its uniform access to care and its regular collection of healthcare services over several decades provides a strong environment to study the causes of MTBI over time. The aims of this study are to confirm the stable incidence of MTBI over a 14-year time frame as reported by Britton et al. (8), to examine the causes of MTBI in Sweden over the 14-year period 1987–2000 and to examine differences related to age and gender.

METHODS

Data sources

Our data are from the Swedish Hospital Discharge Register (HDR) (16). In the 1960s the National board of Health and Welfare began to collect individual data on patients treated in public hospitals in Sweden. The register was expanded in 1983, with 20 of the 26 county councils reporting all in-patient care to the HDR. IN 1984, reporting was made compulsory throughout the entire country.

Since 1987, the HDR data includes all public, in-patient care in Sweden. Information held by the HDR is delivered once yearly to the Epidemiological Center (EpC) at the National Board of Health and Welfare in Sweden. This includes data from each of the 26 county councils in Sweden. EpC receives a magnetic tape or disk with 1 data file

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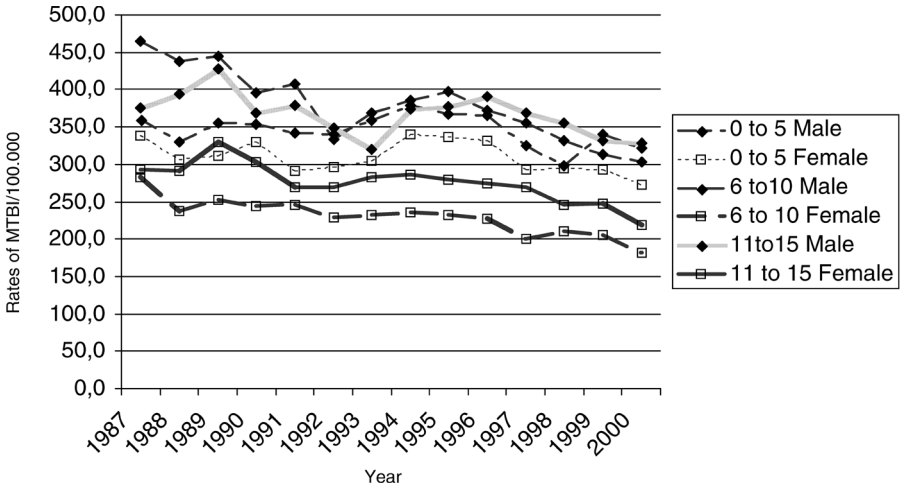

Fig. 1A. Rates of mild traumatic brain injury (MTBI) per 100,000 by age and gender, 1987–2000 (age groups 0–5 years, 6–10 years, and 11–15 years)

from each county. Every discharge during that 1 year interval corresponds to a unique record in the data file.

There are 4 different types of information collected in the HDR, including data on the patient, data on the hospital, administrative data and medical data. Patient data includes a personal identification number (PIN), gender, age and place of residence. Administrative data includes date of admission and discharge and length of stay. Medical data includes discharge diagnosis, coded as International Classification of Disease, Revisions 9 and 10 (ICD-9 or ICD-10 N-codes), cause of injury, coded as an injury E-code, and information on surgery, medical treatment and mortality. In general, the HDR data set is complete, for both the hospital discharge codes and the injury codes.

Case definition

Data on MTBI from 1987 through 1996 is based on ICD-9, and data from 1997 to 2000 is based on ICD-10. One county continued to report using the ICD-9 coding system until 1997, then changed to ICD-10 in 1998. We used the ICD-9 code 850 and the ICD-10 code S06.0 to define MTBI in this study. Importantly, if an individual was admitted more than once during the year, only the first episode of head injury was counted and hospital readmissions were excluded. To be counted as MTBI in this study, a patient had to present to a public hospital for care, be admitted, and have their injury coded as an MTBI using the above codes. Data on outpatients who did not present to a hospital for evaluation was not available during the study period. Patients who were hospitalized and discharged on the same calendar date were counted as staying 0 days, whereas those who were admitted on 1 calendar date and discharged on the next were recorded as 1 day.

Statistical analysis

The population of Sweden was 8.8 million in 2001, and ranged from 8.4 TO 8.8 million during the 14-year study interval. Injury rates are reported as incidence rates per 100,000 inhabitants, and we include age and gender stratified rates. We use means and standard deviations, medians and inter-quartile ranges to describe the annual rates of MTBI. We present length of stay in hospital for MTBI stratified by age groups.

RESULTS

There were 214,149 individuals with a diagnosed MTBI over the 14-year interval. The mean number of individuals injured per annum was 15,296, with a minimum of 14,154 in 1991 and a maximum of 16,951 in 1995. The mean incidence of MTBI per 100,000 persons was 175 over the 14-year interval, with a minimum of 163 in 1991 and a maximum of 191 in 1995. Men had a higher rate of MTBI compared with women (Figs 1A–1C). The mean incidence for women across all age groups was 143 per 100,000 and the corresponding mean for men was 209. This difference in gender rates was consistent across all years of the study (Table I). MTBI occurred more in those under 25 years of age, with a second peak over 65 years of age. Men, aged 6–20 years, had the highest rates of MTBI overall, and female rates

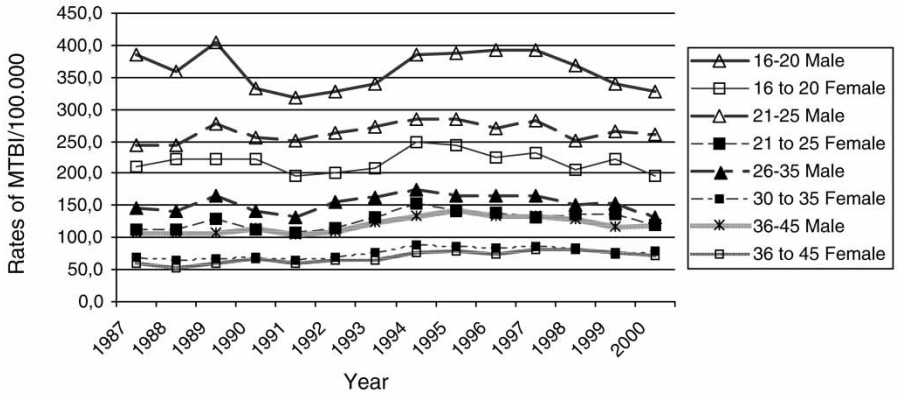

Fig. 1B. Rates of mild traumatic brain injury (MTBI) per 100,000 by age and gender, 1987–2000 (age groups 16–20 years, 21–25 years, 26–35 years and 36–45 years).

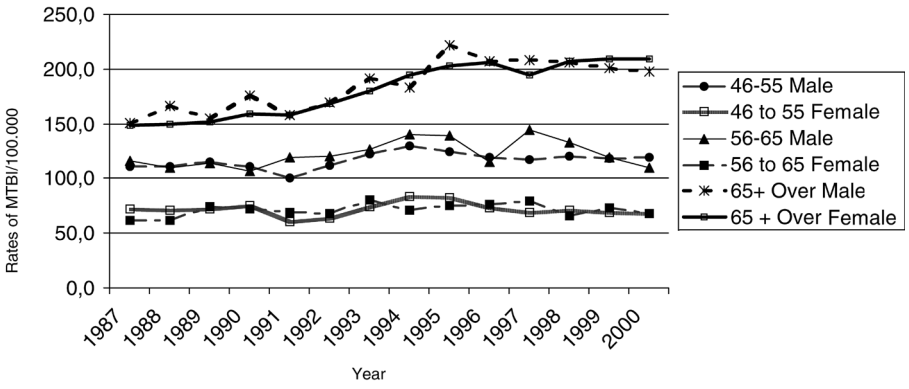

Fig. 1C. Rates of mild traumatic brain injury (MTBI) per 100,000 by age and gender, 1987–2000 (age groups are 46–55 years, 56–65 years and 65 years and over).

Table I. *Annual rates of mild traumatic brain injury per 100,000 by gender*

Year	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
Men	208	204	217	203	196	198	210	224	228	219	217	205	200	192
Women	138	133	141	142	132	136	145	228	157	152	146	145	143	135

were highest in the 16–20 year stratum. The difference in rates between genders becomes less pronounced with age. While it is apparent that the 16–20-year-old group is at the highest risk of MTBI for both men and women, there was a second peak in those over 65 years of age. Beyond the age of 65 years, MTBI rates were 185 and 181 per 100,000 for men and women, respectively. Individuals over the age of 65 years had a progressive increase in MTBI rates from 1987 to 2000, while MTBI rates declined in those younger than 65 years.

Causes of mild traumatic brain injury

The majority of MTBI in Sweden over the study period resulted from falls and not transport accidents (Figs 2A–2C and Table II). Men and women showed similar patterns of injury, with falls common in both the earliest (under 5 years of age) and latest stages (over 65 years of age) of life (Figs 3A and B). Transport-related injuries had their peak incidence in the 25–45-year-old strata. In total, falls were responsible for the largest number of injuries, and were the cause of injury in 50–60% of the total MTBI. This finding is consistent over time. Traffic collisions caused approximately 25% of the total number of MTBI in the population. Violence leading to MTBI accounted for less than 10% of cases. This was true whether the violence was directed towards oneself or towards others.

Transport-related MTBI were only slightly more common as a result of motorized vehicle (cars and motorcycles) compared with non-motorized vehicles (bicycles) crashes. Motorcycle crashes represent a small cause of MTBI across the study period.

Length of stay

Data on the length of hospital stay for MTBI shows that 73% of patients were sent home on the same calendar date, or stayed in hospital for 2 days or less (Table III). This pattern is similar for all age groups, with the exception of those aged over 65 years, where only 49% stayed 2 days or less, and more than 30% stayed

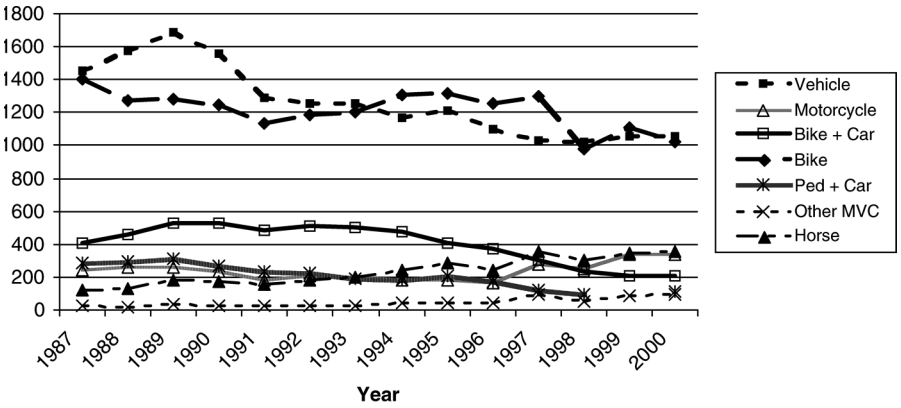

Fig. 2A. Number of persons with mild traumatic brain injury (MTBI) as caused by type of transport. Vehicle refers to motorized vehicle such as car, truck or van. Bike + Car refers to collisions between bicycles and motorized vehicles Ped + Car refers to collisions involving pedestrians and motorized vehicles. Other MVC refers to other motorized vehicles, such as farm equipment, boats, snowmobiles, etc.

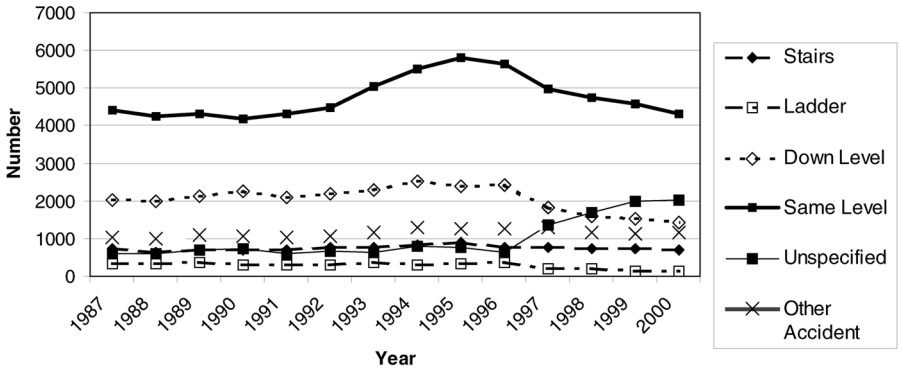

Fig. 2B. Number of persons with mild traumatic brain injury (MTBI) as caused by different types of falls. Down Level refers to falls from one level to another. Same level refers to falls occurring along a constant level. Unspecified refers to falls where level could not be determined. Other accident refers to items such as stumbling and striking head on walls, doorframes, etc.

Table II. *Common causes of mild traumatic brain injury (MTBI) as a proportion of total MTBI across the years 1987–2000*

Year	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	Mean
Falls	55.8	54.7	53.8	55.4	56.6	57.8	59	59.2	55.6	59.7	57.1	58	58.9	59.1	57.2
Vehicles	26.3	27.3	27	26.1	23.7	23.5	21.8	20	19.9	18.9	19.5	17	19	19.6	22.1
Violence	5.1	5.4	5.5	5.5	6.3	6.1	6.6	6.9	6.4	6.5	5.8	4.8	4.7	4.9	5.6
Other	12.8	12.6	13.7	13	13.4	12.6	12.6	13.9	18.1	14.9	17.6	20.2	17.4	16.4	14.9

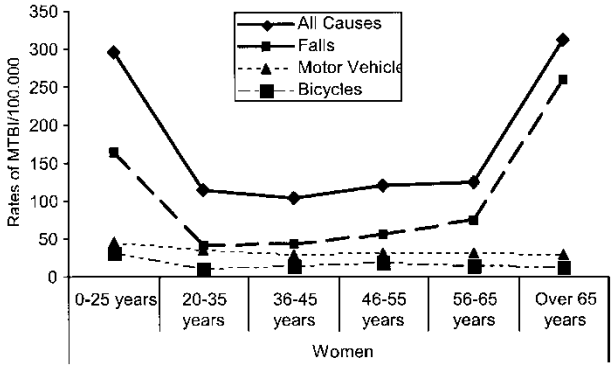

Fig. 3A. Rates per 100,000 women for common causes of MTBI by age in years

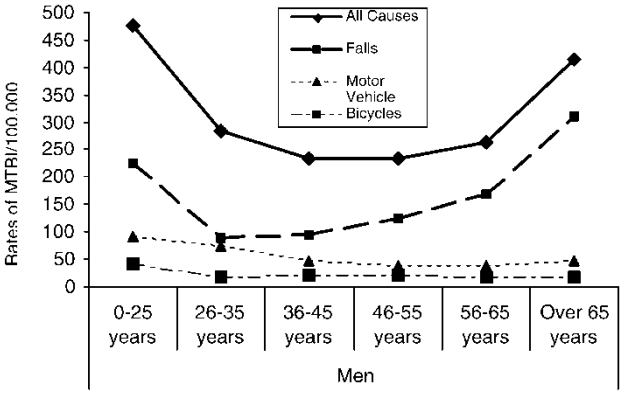

Fig. 3B. Rates per 100,000 men for common causes of mild traumatic brain injury (MTBI) by age in years.

Table III. *Length of hospital stay after mild traumatic brain injury (percentage) by age and gender*

Length of stay (days)	0–25 Men	0–25 Women	26–35 Men	26–35 Women	36–45 Men	36–45 Women	46–55 Men	46–55 Women	56–65 Men	56–65 Women	>65 Men	>65 Women
0	16.7	14.1	21.1	17.3	16.5	13.3	13.9	11.1	10.0	8.1	6.2	5.9
1	60.3	66.7	39.2	47.3	37.4	45.5	36.3	42.9	34.3	38.7	28.5	26.5
2	10.3	9.7	13.6	14.0	14.4	14.8	14.5	15.5	13.9	15.9	13.8	13.1
3	3.7	3.0	6.2	5.4	7.0	7.2	7.3	7.1	8.1	8.6	8.4	9.5
4	2.0	1.7	4.1	3.3	4.4	4.0	4.9	4.6	5.3	5.2	6.7	6.4
5–9	3.8	2.8	7.8	6.5	9.7	7.9	11.2	9.7	14.1	12.6	18.1	19.3
10 or more	3.6	1.0	6.3	4.1	8.3	5.2	9.9	7.8	12.2	9.2	16.4	17.2
50 or more	0.5	0.3	1.7	1.1	2.1	1.6	2.0	1.5	2.1	1.6	1.9	2.1

longer than 5 days. Across age groups, men tended to have longer stays in hospital.

DISCUSSION

The ability to study MTBI injuries over an extended period in a uniform healthcare system is invaluable. The total annual number of MTBI in Sweden has remained relatively constant, as suggested by Britton et al. (8) in a similar study. Our rates are slightly different to those of Britton et al. (8) because we excluded hospital re-admissions and examined smaller age strata.

Over the 14-year study period, the rate of MTBI peaked in 1995–96 and then began to decline. However, this is also coincident with the introduction of the ICD-10 coding, and may represent a coding-related decrease. It is also possible that admission policy changes had some effect on these rates. Policies that encouraged the use of computed tomography (CT) scan and then discharge of patients with normal results could decrease hospital admissions (17). However, Nygren et al.[1] studied readmissions after MTBI in Sweden, and their results suggest that a policy of routine CT scanning and discharge has not been widely applied in Sweden, as less than 20% of their MTBI cases had a CT scan. Indeed, the report by Britton et al. (8) indicates that there is insufficient data to permit the development of a clear policy for routine admission, or routine CT scanning and discharge. At the current time in most jurisdictions in Sweden, patients with MTBI are observed for several hours in the emergency department or are admitted to hospital.

The incidence and epidemiology of MTBI has been extensively reviewed elsewhere in this supplement (1). As confirmed by our study, men are more likely to suffer MTBI than women, at all ages. In addition, our data shows that falls are the most common cause of MTBI in Sweden. Other population-based studies from the USA, France and Australia show that motor-vehicle crashes are a more common cause of MTBI in those jurisdictions (9, 13, 18–20). However, a Norwegian study also showed falls as a more common cause of MTBI than motor vehicle collisions. These findings could reflect the greater importance of automobile transport to some societies compared with the Scandinavian countries, or a greater emphasis on automobile safety in the Scandinavian countries. Indeed Sweden has had seatbelt regulations for front seat passengers since 1975 and for rear seat passengers since 1986.

In the literature, there is limited population-based data on the causes of MTBI in children (1). This study shows that falls are an important issue in childhood MTBI. Further studies investigating strategies to reduce falls in children are needed.

There are differences in hospital stays for MTBI, related to age. The elderly used more hospital days than younger individuals. Our data do not allow us to judge whether elderly patients have more complications with MTBI, or whether they have other comorbidities that contribute to longer hospital stays.

While the data quality of the HDR is thought to be high, we did not perform an independent chart review of the MTBI to validate coding of concussions (ICD codes) or the causes of the injury (E-codes). Also, a change in MTBI coding during the study period from ICD-9 to ICD-10 could have influenced our results. We recognize that the ICD-9 code 850 may have misclassified some cases as MTBI and missed other cases of MTBI. The validity of ICD-9 850 in the HDR was checked in the study by Nygren et al.[1], who reviewed 406 patient with MTBI charts from several counties in Sweden. About 75% of the charts had sufficient information on loss of consciousness and post-traumatic amnesia to support a diagnosis of MTBI. Approximately 25% of the charts had insufficient information to confirm or refute the diagnosis. Also, 7% of charts contained information that suggested MTBI was not the correct diagnosis. Furthermore, in 1996 a quality assurance exercise with the HDR disclosed that the number of stays with missing PINs was only 0.95%. The main reason for admission was missing in only 1.46% of the hospital stays, and 3 of 26 counties accounted for most of the missing data in this check. The frequency of missing E-codes was evaluated in 1987 and 1996 and found to be 3.05% and 3.75%, respectively. One county accounted for the majority of the missing E-codes.

Despite its limitations of diagnostic validity, our study examines a 14-year period in the entire Swedish population, and does suggest several avenues for further investigation. Different preventive strategies might be required for different age groups with greater attention to fall prevention in the very young and very old, vs strategies to limit transport-related MTBI in those aged 16–45 years. Since bicycle-related injuries are a very common cause of MTBI in Sweden, focused attention on bicycle safety, including helmet laws, should be a priority. With an ageing Swedish society (7) greater numbers of elderly persons with MTBI are expected. There have been high quality studies of interventions to reduce falls in the elderly (21).

This study highlights that transport-related injuries and violence make up a smaller proportion of causes of MTBI injury in Sweden than in other countries such as Scotland (22) or the USA (9). This has important implications for comparisons of prognosis after MTBI injury across societies. While our study did not specifically address prognosis, it is likely that that prognosis varies by mechanism of injury (23). International comparisons of prognosis after MTBI are important and need to consider differences in the prevailing national causes of MTBI.

CONCLUSION

The mean number of MTBI across the 14-year span in Sweden was 209/100,000 for men and 148/100,000 for women. At all ages, men were more likely to suffer an MTBI than women. The highest rate of MTBI occurred in those 16–20 years of age in

[1] Nygren C, Bellocco R, af Geijerstam J-L, Borg J, Adami J. Delayed, intracranial complications after concussion: a population-based nested case-control study in Sweden. Unpublished work, submitted 2003.

both genders, although there was a second peak beyond the age of 65 years. The most common cause of MTBI was falls, being more than 55% of the total. Motor vehicles and bicycle collisions were the second and third most common causes. Falls were more common in those under the age of 5 years and over the age of 65 years, whereas individuals aged 16–25 years were most likely to suffer MTBI as the result of motor-vehicle collisions. Different preventive strategies might be necessary for different age groups.

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