

Bed-wetting and Its Association With Developmental Milestones in Early Childhood

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Objective: To evaluate the relationship between bed-wetting and various developmental milestones in a large and representative sample of young children.

Design: A randomized 3-level stratified survey design.

Setting: Data were collected by questionnaires, and interviews were scheduled at home with the mother.

Participants: A representative sample of children born from 1997 to 1998 in Quebec. A complete set of data on bed-wetting was obtained for 1666 children at the ages of 29, 41, and 53 months.

Main Outcome Measures: Percentage of children who bed-wet and developmental factors associated with bed-wetting.

Results: Approximately 10% of the children were bed-wetting at the age of 53 months. Bed-wetting cessation

occurred for most children studied between the ages of 29 and 41 months. Motor skills were achieved by fewer boys who bed-wet compared with boys who did not (had sat up without support for 10 minutes at 5 months, $P = .05$; and had started crawling at 5 months, $P < .01$). More girls who bed-wet were prematurely born and had hyperactivity and inattention ($P < .01$ for all) compared with those who did not. Language milestones were achieved by fewer children who bed-wet compared with those who did not (boys: $P = .04$; girls: $P = .02$). No between-group difference was found for physical growth and sleep variables.

Conclusions: These findings show an association between bed-wetting and developmental milestones in early childhood. This study supports that bed-wetting could be indicative of a possible delay in the development of the central nervous system and could act as a noticeable indicator for parents and pediatricians.

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NOCTURNAL ENURESIS IS defined as an involuntary voiding of urine into the bed in children older than 5 years in the absence of other signs of organic disease or by the direct effect of a substance.^{1,2} Enuresis is one of the most frequent sleep problems in childhood, along with frequent nocturnal awakenings. At the age of 5 years, 15% to 25% of children wet their bed.³ There is an annual spontaneous remission rate of 15%,⁴ so that the prevalence of enuresis decreases steadily as children become older.⁵⁻⁷ In most studies⁸⁻¹¹ of school-aged children, boys were twice as likely as girls to wet their bed. For those younger than 5 years, the term bed-wetting is generally used to describe the inability to control urination at night. To our knowledge, no population-based study has investigated the evolution of bed-wetting cessation of boys and girls in a prospective fashion, and its association with multiple milestones of development.

Nocturnal bladder control is a key developmental milestone.¹² A conscious

sensation of bladder fullness generally appears after the first birthday. This physiological landmark allows the development of voluntary control of voiding that begins around the age of 2 years.¹³ By the age of 4 years, most children have acquired full daytime and nighttime urinary control.¹⁴ A 3-system model¹⁵ has been recently proposed to explain enuresis, which has wide clinical appeal. It identifies 3 processes that alone or in combination can engender various forms of nocturnal enuresis: (1) lack of arginine vasopressin release during sleep (which

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would normally decrease urine production), (2) overactivity of the bladder (uninhibited bladder contractions) or low functional bladder capacity (eg, volume of urine voided after the child has postponed urination for as long as possible), and (3) inability of the child to wake up in response to sensations of a full bladder.¹⁶ The idea that enuresis is related to

an immaturity of the central nervous system is supported by the finding that premature and/or low-birth-weight children were bed-wetting more often than normal-birth-weight children.^{5,8,17,18} Several clinical observations have suggested an association between bed-wetting and developmental delays in motricity,^{19,20} language,^{6,21-24} physical growth,²¹ and skeletal maturation.^{25,26}

The co-occurrence of nocturnal enuresis and behavioral difficulties, especially hyperactive and inattentive behaviors, has been documented.^{5,7,21,27-34} However, recent studies with representative study samples show that most children with enuresis do not have behavior problems. This is summarized by Longstaffe and coworkers.³⁵

To our knowledge, the present study is the first one that investigated the association between primary bed-wetting (having never experienced a lengthy period of being dry), sex, and hyperactivity and inattention among preschoolers. The evolution of natural bed-wetting cessation of boys and girls in early childhood was first traced. Then, the main aim of this study was to compare different profiles of bed-wetting cessation on a range of developmental milestones, including physical growth, motor and language skills, and behavioral variables.

METHODS

This research is part of a large epidemiological study entitled Quebec Longitudinal Study of Child Development (1998-2002) conducted by the Quebec Institute of Statistics.^{36,37} The children were recruited from the Quebec Master Birth Registry of the Ministry of Health and Social Services. A randomized 3-level stratified survey design was used to have a representative sample of children born from 1997 to 1998 in Quebec. The 3 levels were as follows: (1) geographical regions of Quebec, (2) each region subdivided into areas representative of the number of births in the region, and (3) number of children selected per area proportional to the number of births and the sex ratio of the area. The families living in the northern part of Quebec, the Inuit territories, and the First Nations reserves were excluded from the study for technical reasons.

Of the 2940 children who were first selected, 265 were excluded; thus, 2675 children were invited to participate. Of these subjects, 452 families refused to participate. Therefore, a total of 2223 children born from 1997 to 1998 and aged approximately 5 months were included in this longitudinal study. At the second round, 2045 children aged approximately 17 months were studied. Finally, and this is the purpose of this article, 1997 families accepted to be reinterviewed when the children were aged 29 months (near 29 months old), 1950 children were studied again at the age of 41 months (approximately 41 months old), and 1944 children were studied for the fifth time at the age of 53 months (near 53 months old). To address the main goal of the study (bed-wetting), a complete set of data was obtained on all 3 occasions for 1666 children, and represented 83.4% of the cohort. Furthermore, a survival analysis illustrated the natural bed-wetting cessation of 933 boys and 923 girls (1856 children). The increase in sample size for the survival analysis was explained by the fact that subjects were included even if one data point was missing.

SAMPLE DESCRIPTION

Most children (85.7%) had a Canadian nonimmigrant mother, and 14.3% were first-generation immigrants. Most of the sample

is white (89.7%). Other ethnic groups, such as black Africans, Native Amerindians, Arabs, and Asians, represented 2.5%, 0.4%, 2.3%, and 1.1% of the sample, respectively. Most mothers spoke French as a first language (77.1%); 8.9% spoke English, and 14.0% had another first language.

OUTCOME MEASURES

Data were collected by a questionnaire and an interview conducted in English or French. First, the Self-administered Questionnaire for the Mother, which took about 20 minutes to complete, provided information on the child's bed-wetting status. This question yielded categorical data: (1) never, (2) sometimes, (3) often, and (4) always wet his or her bed or diaper at night. The Self-administered Questionnaire for the Mother also gave information on sleep patterns.

Second, the Interviewer Completed Computerized Questionnaire, a face-to-face structured interview with the mother, provided information on her age, her working status, and her immigrant status when the child was aged 29 months. The Interviewer Completed Computerized Questionnaire also included questions on the sex of the child, birth weight, prematurity status, number of siblings, type of family, and index of poverty. Birth weight was classified into 2 levels: low (<2.5 kg) and normal (≥ 2.5 kg). Prematurity was classified into 2 categories: premature (<37 weeks' gestation) and nonpremature (≥ 37 weeks' gestation). Finally, the Interviewer Completed Computerized Questionnaire provided information on the child's motor skills at the age of 5 months, language evolution at the age of 17 months, growth development at the age of 53 months, and behavioral variables (hyperactivity and inattention as rated by the mother) at the age of 53 months.

The ethics review committee of the Hôpital du Sacré-Coeur de Montréal approved the study. It was centrally managed at the Quebec Institute of Statistics, which was responsible for data collection. Before participating in the study, all families had received detailed information by mail on the aims and procedures of the research program and had signed a consent form.

STATISTICAL ANALYSES

Statistical analyses were conducted using a commercially available software program (SPSS for Windows, version 10; SPSS Inc, Chicago, Ill). To ensure the reliability of the measures over time and to limit biases of estimate, each subject was given a longitudinal weight corresponding to the number of subjects he or she represented in the population. The weight was corrected to take into account the overall nonresponse and the subjects who dropped out of the study. Bed-wetting status was separated into 2 categories for each age. One category represented children who "never/sometimes" wet their bed or diaper at night (non-bed-wetting group), and the second category was composed of children who "often/always" wet their bed or diaper at night (bed-wetting group).

To illustrate the natural bed-wetting cessation of boys and girls, a survival analysis was performed by using Stata, version 8 (Stata Corp, College Station, Tex). χ^2 Tests were used to compare different bed-wetting cessation groups with categorical variables (eg, child sex, birth weight, prematurity status, motor development, language evolution, and behavioral problems; mother's age, working status, and immigrant status; number of siblings; and type of family). When the χ^2 value for a particular contingency table was significant, we performed a partitioning of the *df* values into different independent subtables for (*k* - 1) comparisons.³⁸ Between-group comparisons for continuous variables were performed by analyses of variance and post hoc tests with Tukey A. No analyses were done on ethnic

groups because there were not enough subjects in each group. For all tests conducted, the significance level was $P = .05$.

RESULTS

EVOLUTION OF BED-WETTING

The evolution of children who were bed-wetting and those who were not is displayed in the **Figure**. At the age of 29 months, 62.4% of children wet their bed or diaper at night. Of these children, only 22.7% continued to bed-wet at the age of 41 months, while most (77.3%) stopped bed-wetting. Among the children who bed-wet at the ages of 29 and 41 months, half (50.8%) were still bed-wetting at the age of 53 months. At the age of 29 months, 37.6% of children were not bed-wetting. Of these children, 95.4% remained in this category, while only 4.6% started to wet their bed the next year (age, 41 months). Among the children who did not bed-wet at the ages of 29 and 41 months, 98.8% were still not bed-wetting, whereas only 1.2% started to bed-wet, at the age of 53 months. The overall prevalence of bed-wetting at the age of 53 months is 9.7% (161/1666). Most of these children (120/161) were bed-wetting for the entire duration of the study (from the age of 29 months), whereas 41 (2.5%) had resumed bed-wetting after having achieved previous bladder control. As depicted in the Figure, 4 groups of young children who stopped bed-wetting at different ages were created: (A) the bed-wetting group counted 120 children who were still bed-wetting at the age of 53 months, (B) the late non-bed-wetting group included 116 children who had stopped bed-wetting at the age of 53 months, (C) the intermediate non-bed-wetting group comprised 779 children who ceased bed-wetting from the age of 41 months, and (D) the early non-bed-wetting group represented 590 children who stopped bed-wetting from at least the age of 29 months.

DEMOGRAPHIC VARIABLES AND SLEEP PATTERNS

Table 1 shows that most demographic factors, such as mother's age, mother's working status, number of siblings, type of family, and index of poverty, were similar for each group. However, children in the early non-bed-wetting group had, in a greater proportion, a mother who was an immigrant compared with those in the intermediate non-bed-wetting group ($P < .01$). Sex differences were observed between the early and intermediate non-bed-wetting groups ($P < .01$), and even more if the early, intermediate, and late non-bed-wetting groups are pooled and compared with the still bed-wetting group ($P < .01$). To illustrate, 68.9% of boys and 59.5% of girls were bed-wetting at the age of 29 months. At the age of 41 months, 20.5% of boys and 13.9% of girls had not ceased bed-wetting ($P < .001$). Finally, 9.6% of boys and 5.4% of girls were still bed-wetting at the age of 53 months ($P < .001$). Therefore, the boy-girl ratio for bed-wetting at the age of 53 months was nearly 2:1.

Table 2 shows between-group comparison sleep patterns at the age of 53 months. No between-group differ-

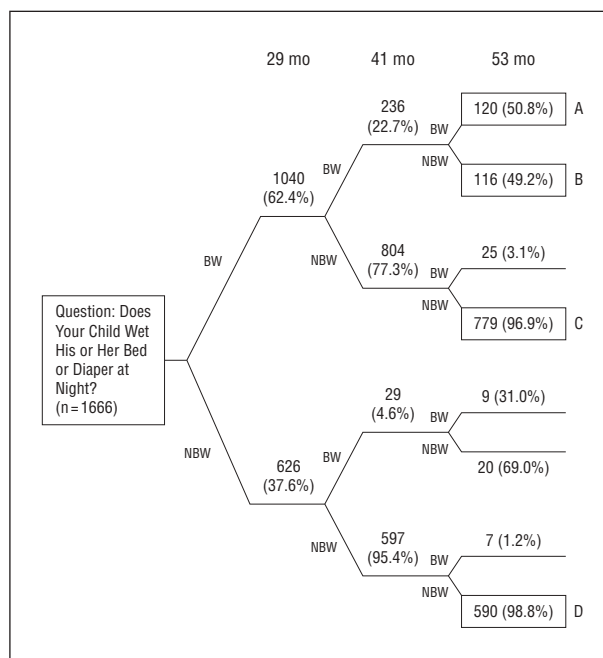


Figure. Evolution of children who were bed-wetting (BW) and not bed-wetting. The percentages represent the probabilities of the distribution of children for each path. A, Those still BW at 53 months. B, Late non-BW (NBW) group. C, Intermediate NBW group. D, Early NBW group.

ence was found for sleep duration, time spent awake at night, number of awakenings at night, percentage of children with a sleep latency of longer than 30 minutes, daytime nap duration, or percentage of children who snored.

DEVELOPMENTAL MILESTONES

Table 3 shows between-group differences for birth characteristics, physical growth, behavioral characteristics, language, and motor skills. Motor milestones, such as having already sat up without support for 10 minutes at the age of 5 months, were attained by significantly fewer still bed-wetting boys at the age of 53 months compared with the 3 non-bed-wetting groups combined ($P = .05$). Moreover, significantly fewer late non-bed-wetting boys had already started crawling at the age of 5 months compared with early and intermediate non-bed-wetting boys ($P < .01$). In addition, language milestones, such as being able to speak 2 words (without counting mom and dad) at the age of 17 months, were reached by significantly fewer late non-bed-wetting boys compared with early and intermediate non-bed-wetting boys ($P = .04$). No between-group difference was found for boys for birth characteristics, behavioral problems, and physical growth at the age of 53 months.

For girls, more still bed-wetting at the age of 53 months were prematurely born compared with all non-bed-wetting groups combined ($P < .01$). No between-group difference was found for low birth weight and motor skills. However, girls in the late non-bed-wetting group pronounced a familiar word (eg, ball) in a lower proportion compared with those in the early and intermediate non-bed-wetting groups combined ($P = .02$). Many more late non-bed-wetting girls were perceived as hyperactive by their mother compared

Table 1. Demographic Factors Associated With Each Group*

Factor	Group				P Value
	Early NBW (n = 590)	Intermediate NBW (n = 779)	Late NBW (n = 116)	Still BW (n = 120)	
Child sex					
Male	43.7	51.7	53.4	68.3	†‡
Female	56.3	48.3	46.6	31.7	
Maternal data					
Aged ≥35 y	28.3	27.2	25.9	25.8	.92
Working full-time	51.0	55.2	48.3	54.7	.22
Immigrant	17.9	11.0	12.9	15.8	†
Family data					
0 Siblings	33.7	32.6	29.3	30.8	.79
Intact family	78.4	78.6	87.9	80.0	.12
Index of poverty§	0.6 (0.1)	0.5 (0.1)	0.6 (0.1)	0.5 (0.1)	.39

Abbreviations: BW, bed-wetting; NBW, non-bed-wetting.

*Data are given as percentage of each group unless otherwise indicated.

†Significant ($P < .01$) difference between early and intermediate NBW groups.

‡Significant ($P < .01$) difference between early, intermediate, and late NBW groups combined and children who were still BW.

§Data are given as mean (SEM). This continuous variable was assessed with an analysis of variance.

Table 2. Sleep Characteristics Associated With Each Group at the Age of 53 Months*

Characteristic	Group				P Value
	Early NBW (n = 590)	Intermediate NBW (n = 779)	Late NBW (n = 116)	Still BW (n = 120)	
Sleep duration at night, h + min†	10 + 27 (2.5)	10 + 24 (2.1)	10 + 25 (4.8)	10 + 15 (6.4)	.28
Nap duration, min†	54.0 (2.2)	51.6 (3.1)	49.5 (6.6)	40.7 (6.7)	.08
Waking time at night, min†	5.3 (0.6)	6.9 (0.9)	6.6 (1.2)	7.9 (1.4)	.41
Those with >3 awakenings‡	6.7	7.9	6.5	6.8	.81
Those with a sleep latency of >30 min‡	14.1	16.4	23.0	15.8	.12
Those who snored often or always‡	7.3	6.5	8.0	10.1	.54

Abbreviations: See Table 1.

*Data are given as mean (SEM) unless otherwise indicated. All differences between groups were not significant.

†These continuous variables were assessed with an analysis of variance.

‡Data are given as percentage of each group.

with early and intermediate non-bed-wetting girls combined ($P < .01$). Moreover, many more girls who were still bed-wetting at the age of 53 months were rated as inattentive compared with all non-bed-wetting groups combined ($P < .01$). No between-group difference was found for physical growth at the age of 53 months.

COMMENT

EVOLUTION OF BED-WETTING CESSATION

Only 10% of the children were bed-wetting at the age of 53 months. This prevalence is lower than that reported by 2 population-based studies,^{6,7} which found that 20% to 33% of children were bed-wetting at the age of 5 years. One explanation for this discrepancy might be the criterion used for bed-wetting. Our definition of bed-wetting (often or always), compared with at least once a month or once in the prior year in those studies, was chosen to follow up on children who were at high risk of having enuresis at the age of 5 years. This large and representative study confirms that girls achieved nocturnal

bladder control earlier than boys, as reported in other studies.^{6,24} For most children in the present study, bed-wetting cessation occurred between the ages of 29 and 41 months (between 2 measure points), as also noted by Kawauchi et al.²⁴ The probability tree shows that when a child ceased bed-wetting, the child had excellent chances of staying a non-bed-wetter the next year. Few children lose their ability to control urination during the night if they are non-bed-wetting in early childhood.

SLEEPING PATTERNS

The present findings show that children still bed-wetting at the age of 53 months have similar sleep patterns as non-bed-wetting children. This is in agreement with the findings of a polysomnographic study on a few children with enuresis.³⁹ Two studies^{40,41} have suggested that it is rather the neuronal process converting sleep to a complete awakening that might be abnormal among children who have enuresis. More polysomnographic studies are needed to better understand the role of sleep and arousal mechanisms in bed-wetting.

Table 3. Data for Boys and Girls on Birth Characteristics and Developmental Milestones*

Variable	Boys					Girls				
	Early NBW (n = 258)	Intermediate NBW (n = 403)	Late NBW (n = 62)	BW (n = 82)	P Value	Early NBW (n = 332)	Intermediate NBW (n = 376)	Late NBW (n = 54)	BW (n = 38)	P Value
Birth characteristic										
Low weight <2.5 kg	5.8	4.2	4.8	6.1	.79	4.5	3.5	0.0	2.6	.41
Prematurity <37 wk	8.5	5.7	4.8	7.3	.49	6.3	3.2	5.6	18.4	†
Motor development at 5 mo										
Had sat up for 10 min	2.7	4.5	7.9	0.0	†	1.8	2.4	3.7	2.6	.83
Had already crawled	23.9	19.1	6.5	12.2	‡	16.1	14.9	18.5	17.9	.88
Language evolution at 17 mo										
Speaking 2 words (not counting "mom" and "dad")	86.4	83.9	72.6	78.0	‡	91.3	90.9	87.0	82.1	.24
Pronounced familiar word (eg, "ball")	74.4	72.2	61.3	69.1	.21	83.1	84.0	69.8	71.1	‡
Behavioral variables at 53 mo										
Often hyperactive	19.3	20.8	19.7	23.2	.89	12.0	13.8	25.9	12.8	‡
Often inattentive	3.9	6.0	5.0	3.7	.62	1.2	3.5	7.5	12.8	†‡
Physical growth at 53 mo§										
Height, cm	10.39 (0.3)	104.4 (0.2)	103.1 (0.5)	104.8 (0.6)	NS	103.1 (0.3)	103.0 (0.2)	103.2 (0.6)	102.9 (0.6)	.98
Weight, kg	17.5 (0.2)	17.6 (0.1)	17.0 (0.3)	17.7 (0.4)	NS	16.9 (0.1)	16.7 (0.1)	16.7 (0.3)	17.2 (0.3)	.65

Abbreviations: See Table 1.

*Data are given as percentage of each group unless otherwise indicated.

†Significant ($P = .05$) difference between early, intermediate, and late NBW groups combined and children who were still BW.

‡Significant ($P = .05$) difference between early and intermediate NBW groups combined and late NBW groups.

§Data are given as mean (SEM). These continuous variables were assessed with an analysis of variance.

DEVELOPMENT MILESTONES

Our results show that mother's age, mother's working status, child's birth order, and index of poverty were not associated with bed-wetting, as noted by another longitudinal study.⁶ The present study reports more mothers who were immigrants in the early non-bed-wetting group compared with the intermediate non-bed-wetting group. This difference could reflect variations in cultural attitudes toward earlier bladder control training.^{9,11}

To our knowledge, no previous study has investigated the effect of sex in the co-occurrence of bed-wetting, motor/speech development, prematurity, and behavioral problems. We found indications for a possible delay in motor development for boys and in language maturation for boys and girls. A study²⁴ with a small sample had also reported that a 5-year-old child who bed-wet had walked 1 month later and that the time at which real words were first spoken had occurred significantly later compared with non-bed-wetters. No between-group difference was found for boys for low birth weight, prematurity, and behavioral variables at the age of 53 months. On the other hand, more bed-wetting girls were prematurely born compared with non-bed-wetting girls, but this was not associated with low birth weight, as previously shown in studies^{5,8,17} that overlooked sex effects. The absence of this association may be explained by the fact that there were few low-birth-weight girls. However, the present study suggests that premature girls have more probabilities to bed-wet for a longer period. Moreover, bed-

wetting girls have increased rates of hyperactivity and inattention compared with non-bed-wetting girls. Previous studies^{5,7,23,31-34} have also found that children with enuresis were more likely to show hyperactivity and inattention compared with control subjects, but the studies did not investigate the sex difference. The high propensity of hyperactivity and inattention in children who bed-wet may be caused by the high proportions of premature girls in this group. This hypothesis has been raised in studies of preterm children,⁴²⁻⁴⁵ who had more behavioral problems than full-term children.

In conclusion, bed-wetting could serve as an easily noticeable indicator for potential delays in some spheres of child development. As a consequence, in addition to seeking treatment for bed-wetting (if desired), parents could evaluate whether to implement some specific strategies or join programs designed to promote progress in certain developmental domains or to simply seek a more regular clinical follow-up to ensure that their child has optimal chances for school success.

LIMITATIONS

This study has a few limitations that are important to mention. First, our data do not permit causal explanation. This longitudinal, prospective, and representative study of Quebec has identified important developmental associations, but not the mechanisms behind those findings. Also, it is generally thought that once children reach a milestone, they maintain it. It would be interesting to look at children who lose milestones. This study has not in-

vestigated genetic factors, the presence of sleep disorders or specific environmental factors, such as family violence or stress, or alcoholism or smoking in the parents. Before making generalizations, it is important to keep in mind that the population studied herein is mostly white and that the population of Quebec might not be representative of other populations. Finally, no objective data were available to validate these parental reports. Fortunately, bed-wetting is a behavior that is easily noticeable by parents. This longitudinal study will follow up on the evolution of children who still wet their bed through the school-aged period.

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