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1 **Brief communication:**

2 **Time of birth and additional support need at school age: national cohort study of 865 409 children**

3

4 Running title: Time of birth and additional support need

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17 **Introduction**

18 Multiple studies have identified birth outside regular working hours as an independent risk factor for  
19 neonatal death.<sup>1,2</sup> An increased incidence of birth asphyxia has been implicated as the most likely causal  
20 mechanism.<sup>1</sup> Although birth asphyxia can cause adverse neurodevelopmental and educational outcomes  
21 among survivors, long term implications of birth outside regular working hours are unknown. In a large  
22 national cohort of singleton births in Scotland, we studied whether birth during the evening/night or  
23 weekend was independently associated with additional support need (ASN) at school age.

24

25 **Methods**

26 We used the community health index (CHI) unique identifier to link individual-level birth and death  
27 records from the General Register Office for Scotland to maternity data from the Scottish Morbidity  
28 Record-02 for all singleton births in Scotland (1988-2009). These records were then linked to national  
29 school census data from regular and special public schools (ScotXEd; 2006-2013) for all children aged 4-  
30 18 years. We excluded births via elective caesarean section, which typically occur during regular hours  
31 and carry a relatively low risk of birth asphyxia, and births with unknown gestational age or with  
32 gestational age <24 or ≥43 weeks.

33

34 In keeping with earlier work,<sup>1</sup> the exposure was birth outside regular working hours (9am-5pm), further  
35 divided into evenings/nights (any day 5pm-9am) and weekend days (9am-5pm on Saturdays and  
36 Sundays; also including 1 and 2 January, Good Friday, 25 and 26 December, and national bank holidays).  
37 The primary outcome was recording of any type of ASN at any time point, as assessed annually by the  
38 child's school. ASN was categorised as follows: physical impairment; motor impairment; sensory  
39 impairment; learning disability; learning difficulty; language/speech impairment; mental health  
40 impairment; autism spectrum disorder.

41  
42 We used logistic regression to explore the association of out-of-hours birth (separately for term and  
43 preterm births) with ASN, adjusting for: maternal age; area deprivation quintile (assessed by Scottish  
44 Index of Multiple Deprivation); parity; previous spontaneous abortions; previous therapeutic abortions;  
45 previous caesarean sections; hospital admission for pre-eclampsia during the index pregnancy; labour  
46 induction; mode of presentation; mode of delivery; gestational age; birth weight centile; sex; annual  
47 hospital throughput; and year (continuous; to account for underlying temporal trends) and month  
48 (categorical; to account for seasonality) of birth.

49

## 50 **Results**

51 Population characteristics are available in eTables 1-2. Among children born at term (n=816 693), birth  
52 during a weekend day or during the evening/night was not associated with ASN at school age: odds ratio  
53 (OR) 1.01 (95% confidence interval (CI): 0.98-1.03), and OR 1.00 (95%CI: 0.98-1.01), respectively, or with  
54 any ASN subtype (Table 1). Findings were similar for children born preterm (n=48 716): OR 1.01 (95%CI:  
55 0.92-1.10) for weekends, and OR 0.98 (95%CI: 0.93-1.04) for evenings/nights.

56

## 57 **Discussion**

58 Birth outside regular working hours was not associated with ASN or any subtype of ASN at school age in  
59 this large national cohort of singleton births in Scotland.

60 Whereas the association between out-of-hours birth and neonatal outcomes has been extensively  
61 investigated,<sup>1,2</sup> very few studies assessed long-term outcomes.<sup>3,4</sup> A recent Japanese case-control study  
62 identified out-of-hours birth as a risk factor for cerebral palsy, but only among children born via  
63 emergency caesarean section.<sup>3</sup> No association between out-of-hours admission and  
64 neurodevelopmental outcomes at 2-3 years was found among children born extremely preterm in a

65 multicentre Australian study.<sup>4</sup> Our study adds importantly to this small body of existing literature by  
66 assessing a very large national cohort with long-term follow-up (i.e. up to 18 years) and uniform  
67 assessment of exposure and outcome. Limitations of our approach include the retrospective assessment  
68 of data not primarily collected to address this research question, lack of information on outcomes  
69 among children not attending school, and among those attending private schools (approximately 4% of  
70 school-age children in Scotland).

71 Although birth asphyxia likely contributed to the increased risk of neonatal death among out-of-hours  
72 births observed in earlier studies,<sup>1</sup> neither low Apgar scores nor ASN occurred more frequently among  
73 survivors born out-of-hours in our cohort (eTables). Despite these reassuring long-term findings among  
74 survivors, the increased risk of adverse neonatal outcomes outside regular working hours seen in  
75 previous studies,<sup>1,2</sup> although not uniformly so,<sup>5</sup> remains concerning. Whereas reduced presence and  
76 seniority of staff, higher workload, staff fatigue, and hospital throughput have been implicated as  
77 potential mediators, observational studies have produced mixed evidence on whether such factors are  
78 indeed responsible.<sup>2</sup> More robust studies involving detailed linkages of perinatal data to rotas, presence,  
79 and seniority of attending obstetric and neonatal staff and other organisational aspects are clearly  
80 needed. Recent studies in adult intensive care have in addition elegantly demonstrated how variation in  
81 staffing may be investigated using randomised controlled trials to further investigate this.<sup>6</sup>

82 **Additional information**

83

84 **Conflict of interest**

85 The authors have no conflict of interest to disclose

86

87 **Ethics approval and consent to participate**

88 The study was approved by the Privacy Advisory Committee of the National Health Service Scotland

89 Public Benefit and Privacy Panel for Health and Social Care.

90

91 **Availability of data and materials**

92 Data access requests need to be directed at National Health Service Scotland

93

94 **Funding**

95 Supported by the Chief Scientist Office for Scotland (grant number CZH/4/1082).

96

97 **Author Contributions**

98 Dr Been conceptualized and designed the study, acquired funding, performed analyses, interpreted the

99 findings, and wrote the initial draft manuscript. Profs Smith, Cooper, and Pell designed the study,

100 interpreted the findings, and reviewed and revised the manuscript. Prof Mackay conceptualized and

101 designed the study, acquired funding, performed analyses, interpreted the findings, and reviewed and

102 revised the manuscript.

103

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**Table 1. Association of timing of birth with additional support need at school age**

	Children born at term (n=809 684)		Children born preterm (n=48 038)	
	OR (95%CI) <sup>a</sup>	P value	OR (95%CI) <sup>a</sup>	P value
<b>Any ASN</b>				
Weekend day 9am-5pm	1.01 (0.98-1.03)	0.657	1.01 (0.92-1.10)	0.841
Any day 5pm-9am	1.00 (0.98-1.01)	0.714	0.98 (0.93-1.04)	0.585
<b>Physical health impairment</b>				
Weekend day 9am-5pm	1.01 (0.94-1.08)	0.836	0.92 (0.74-1.13)	0.412
Any day 5pm-9am	1.00 (0.96-1.05)	0.885	1.04 (0.92-1.18)	0.527
<b>Motor impairment</b>				
Weekend day 9am-5pm	0.97 (0.88-1.07)	0.709	0.92 (0.75-1.14)	0.451
Any day 5pm-9am	0.99 (0.94-1.05)	0.740	0.99 (0.87-1.12)	0.816
<b>Sensory impairment</b>				
Weekend day 9am-5pm	1.04 (0.97-1.11)	0.287	0.96 (0.79-1.16)	0.653
Any day 5pm-9am	1.01 (0.97-1.05)	0.598	1.02 (0.91-1.14)	0.720
<b>Learning disability<sup>b</sup></b>				
Weekend day 9am-5pm	1.02 (0.96-1.07)	0.531	1.10 (0.95-1.28)	0.188
Any day 5pm-9am	0.99 (0.96-1.03)	0.740	0.97 (0.88-1.06)	0.457
<b>Learning difficulty</b>				
Weekend day 9am-5pm	1.00 (0.96-1.03)	0.806	1.02 (0.90-1.15)	0.769
Any day 5pm-9am	0.99 (0.97-1.01)	0.466	1.00 (0.93-1.08)	0.911
<b>Language/speech impairment</b>				



Weekend day 9am-5pm	1.02 (0.95-1.09)	0.534	0.93 (0.76-1.14)	0.479
Any day 5pm-9am	1.02 (0.98-1.06)	0.435	0.95 (0.84-1.08)	0.443
<b>Mental health impairment</b>				
Weekend day 9am-5pm	1.01 (0.95-1.08)	0.768	1.07 (0.88-1.31)	0.506
Any day 5pm-9am	1.01 (0.97-1.05)	0.650	1.00 (0.88-1.13)	0.983
<b>Autism spectrum disorder</b>				
Weekend day 9am-5pm	1.01 (0.94-1.09)	0.700	1.00 (0.82-1.22)	0.989
Any day 5pm-9am	1.01 (0.96-1.05)	0.814	0.93 (0.83-1.05)	0.272

124

125 <sup>a</sup>reference category: weekdays 9am-5pm. <sup>b</sup>UK term synonymous with the international term ‘intellectual  
126 disability’. ORs derived from logistic regression analysis adjusted for maternal age, Scottish Index of  
127 Multiple Deprivation quintile, parity, previous miscarriages, previous therapeutic abortions, previous  
128 caesarean sections, preeclampsia, labour induction, presentation and mode of delivery, gestational age,  
129 birth weight centile, sex, hospital throughput, year, and month. ASN = additional support need; OR =  
130 odds ratio; CI = confidence interval.