



Deposited via The University of Leeds.

White Rose Research Online URL for this paper:

<https://eprints.whiterose.ac.uk/id/eprint/100215/>

Version: Accepted Version

Article:

Woodcock, IR, Fraser, L, Norman, P et al. (2016) The prevalence of neuromuscular disease in the paediatric population in Yorkshire, UK; variation by ethnicity and deprivation status. *Developmental Medicine and Child Neurology*, 58 (8). pp. 877-883. ISSN: 0012-1622

<https://doi.org/10.1111/dmcn.13096>

© 2016 Mac Keith Press. Published by Wiley. This is the peer reviewed version of the following article: "Woodcock, I. R., Fraser, L., Norman, P., Pysden, K., Manning, S. and Childs, A.-M. (2016), The prevalence of neuromuscular disease in the paediatric population in Yorkshire, UK; variation by ethnicity and deprivation status. *Developmental Medicine & Child Neurology*" which has been published in final form at <http://dx.doi.org/10.1111/dmcn.13096>. This article may be used for non-commercial purposes in accordance with Wiley Terms and Conditions for Self-Archiving.

Reuse

Items deposited in White Rose Research Online are protected by copyright, with all rights reserved unless indicated otherwise. They may be downloaded and/or printed for private study, or other acts as permitted by national copyright laws. The publisher or other rights holders may allow further reproduction and re-use of the full text version. This is indicated by the licence information on the White Rose Research Online record for the item.

Takedown

If you consider content in White Rose Research Online to be in breach of UK law, please notify us by emailing eprints@whiterose.ac.uk including the URL of the record and the reason for the withdrawal request.

**The prevalence of neuromuscular disease in the paediatric population in Yorkshire, UK;
variation by ethnicity and deprivation status.**

Dr Ian R Woodcock, Specialty Registrar, Department of Paediatric Neurology, Leeds Teaching
Hospitals NHS Trust, Leeds, UK

Dr Lorna Fraser, Anniversary Research Lecturer, Department of Health Sciences, University of York,
UK

Dr Paul Norman, Lecturer, School of Geography, University of Leeds, UK

Dr Karen Pysden, Consultant Paediatric Neurologist Department of Paediatric Neurology, Leeds
Teaching Hospitals NHS Trust, Leeds, UK

Mrs Sue Manning, Neuromuscular Care Advisor, Department of Paediatric Neurology, Leeds
Teaching Hospitals NHS Trust, Leeds, UK

Dr Anne-Marie Childs, Consultant Paediatric Neurologist, Department of Paediatric Neurology, Leeds
Teaching Hospitals NHS Trust, Leeds, UK

Correspondence to Ian Woodcock:

Email: dr.woodcock@gmail.com

Address: Paediatric Neurology, F-Floor, Martin Wing, Leeds General Infirmary, Great George Street,
Leeds LS1 3EX

Telephone: 0113 3923113

Word Count: 3031

Abstract: 196

Tables 1 (+ 1 supplementary)

Figures 3

Abstract

Background: Previous studies suggest a higher prevalence of neurological disease within certain ethnic communities, but have not specifically consider neuromuscular disorders (NMD)

Method: We undertook a retrospective case note review of those < 16 years with a confirmed diagnosis of NMD in a single centre in Yorkshire in 2010, to calculate the prevalence and relationship to ethnicity and deprivation status.

Results: 261 cases were included. The population (0-16 years) in Yorkshire was 707,961. The overall prevalence was 36.9 per 100,000 (95%CI 34.6-39.1). Dystrophin-related muscle disease was the most common condition with a prevalence of 16.9 per 100,000 males (95%CI 14.7-19.1). There was a significant difference between ethnic groups with a total NMD prevalence of 91.2 per 100,000 (95%CI 81.6-100.7) in the South Asian ethnic group compared to 28.7 per 100,000 (95%CI 26.4-30.9) in the White group. Prevalence of non-dystrophin related NMD was four times higher in South Asian than White children. There was a linear relationship between increased prevalence and increased deprivation.

Interpretation: This study confirms higher levels of NMD, particularly recessively inherited NMD within the South Asian population, as well as a link with higher deprivation. This has implications for service provision and resource allocation.

What this study adds

- Prevalence of neuromuscular conditions in the paediatric population in Yorkshire was 36.9 per 100,000
- Prevalence in the paediatric South Asian ethnic group was 91.2 per 100,000.
- In the paediatric South Asian ethnic group, the prevalence of autosomal recessive NMD was four times that of the White paediatric population.
- Confirms an association between higher prevalence of NMD and higher levels of deprivation.

Neuromuscular Diseases (NMD) are an important cause of morbidity and mortality in childhood¹. Recent studies have looked at the economic and social costs of one of the most common NMD encountered in childhood, Duchenne muscular dystrophy (DMD), and estimated the total economic burden of this condition in the UK to be £128,306,000². As a whole, the NMD are estimated to affect 0.1% of the total UK population, with a prevalence of 37 per 100,000 although published data includes both paediatric and adult populations³.

Many of the severe NMD presenting in childhood are associated with significantly reduced life expectancy, such as spinal muscular atrophy (SMA) type 1 or the congenital myopathies with respiratory impairment. Children with these conditions are unlikely to survive into adulthood. Conversely, some of the most commonly encountered NMD in the adult population do not present in childhood. Thus prevalence studies that focus on the whole population do not give a clear representation of the conditions that are most prominent in childhood.

A study from Newcastle, UK, identified higher levels of certain NMD, particularly DMD, in association with higher levels of social deprivation⁴, with the implication that certain regions of the UK may have a higher prevalence of NMD than others. Another report highlighted variable life expectancy in DMD, in different parts of the UK⁵. As a consequence, the UK government commissioned an All Party Parliamentary Group which published the Walton report in 2009 confirming significant variability in service provision throughout the UK⁶. The report highlighted the need for accurate data regarding the prevalence and nature of NMD in order to determine the level of service provision required in each region.

Yorkshire contains 10% of the population of England. The population is diverse and multicultural and contains the third largest population of ethnic minorities in the UK⁷. However, this diversity is not uniform across the region. In Bradford 20.3 % of the population is of South Asian origin, mainly from Pakistan, whereas in Hull, a similar sized city, 98% of the population is White British⁸. There are districts with high levels of social deprivation as well as more affluent areas.

Clinicians working in the region have noted an apparently higher level of NMD among certain ethnic groups⁹. This study aims to calculate the prevalence of neuromuscular disease in the former Yorkshire Health Authority region by ethnicity and deprivation status to help to inform the planning of appropriate neuromuscular services.

Methods

Participants

All patients with an established diagnosis of NMD, living in the former Yorkshire Health Authority region are managed by the Regional Paediatric Neuromuscular service based in Leeds. There is a paediatric neurology network encompassing clinicians and therapists across the region with established guidelines and pathways, ensuring that children with suspected NMD are all referred to the regional service.

The period prevalence of NMD for the year 2010 was the main outcome. Therefore, in order not to miss patients who may not have attended a clinic appointment in this period, all cases seen by the service, between 1st January 2009 and the 31st December 2011 were identified. Multiple data sources were used to increase patient ascertainment: databases held by neuromuscular therapists, the regional neuromuscular care advisor, the paediatric neurology department and the Yorkshire paediatric neuromuscular service database.

Inclusion Criteria:

- Aged < 16 years on 31st December 2010
- Under the care of the regional NM service in 2010
- A diagnosis of NMD confirmed genetically, histologically or in the cases of CMT on neurophysiological testing

Exclusion Criteria:

- patients discharged from the regional service after a single assessment or a single follow-up appointment
- patients without a clear diagnosis of a neuromuscular condition
- patients with muscle weakness secondary to systemic disease e.g. vitamin D deficiency

The clinical and demographic data were collected from the clinical case notes of each patient as detailed below.

Diagnostic groups

Eligible patients were divided into diagnostic 'groups'.

1. **Charcot Marie-Tooth type 1**
2. **Charcot Marie-Tooth type 2**
3. **Charcot Marie-Tooth type 4**
4. **Congenital Muscular Dystrophy**
5. **Congenital Myasthenia**
6. **Congenital Myopathy**
7. **Congenital Myotonic Dystrophy**
8. **Dystrophin Related Muscle Disease**
9. **Facio Scapulo Humeral Dystrophy**
10. **Ion-Channel Disorder**
11. **Limb Girdle Muscular Dystrophy**
12. **Myasthenia Gravis**
13. **Myopathy Unspecified**
14. **NMD Plus (mitochondrial cytopathy or metabolic disease causing myopathy)**
15. **Spinal Muscular Atrophy**

A diagnosis of non-specific myopathy was made in the presence of definite myopathic features on histological analysis, but no specific diagnostic abnormalities on electron microscopy or immunohistochemistry. All these cases were reviewed by the nationally commissioned diagnostic service at the Dubowitz Centre, Great Ormond Street Hospital who undertook further histological analysis and genetic testing but were still unable to confirm a particular diagnosis.

Due to very small numbers in some diagnostic groups, patients were categorised into dystrophin-related NMD (DMD and Becker Muscular dystrophy) and non-dystrophin related NMD (all other diagnoses) for the calculations of prevalence by ethnic group and deprivation category.

Ethnicity

Ethnicity data was retrieved from the clinical notes. The 16 census ethnic groups⁸ were merged into 3 super-groups to avoid very small numbers in some groups:

White (comprising persons who are: White: British; White: Irish; White: Other White),

South Asian (comprising persons originating from the Indian Sub-Continent who are: Asian or Asian British: Indian; Asian or Asian British: Pakistani; Asian or Asian British: Bangladeshi; Asian or Asian British: other Asian),

Other (comprising persons from all other ethnicities who are: Black or Black British: Black Caribbean; Black or Black British: Black African; Black or Black British: Other Black Mixed: White and Black Caribbean; Mixed: White and Black African; Mixed: White and Asian; Mixed: Other Mixed; Chinese and Other Ethnic group).

Consanguinity

Consanguinity data were retrieved from the clinical notes. Parents were defined as being consanguineous if they were first cousins i.e. shared 1 set of grandparents.

Deprivation

An Index of Multiple Deprivation (IMD)¹⁰ category was assigned to each individual based upon their Lower Super Output Area (LSOA) of residence. An LSOA is a census geographical area built up of Output Areas. There are 34,753 LSOAs (2011 Census) in England with a population of 1000–3000 per LSOA¹¹. The IMD is a composite measure at LSOA level informed by deprivation indicators across various domains including income, employment, education and skills, and environment. The IMD categories are an ordinal measure based on area specific scores split into five categories for the whole of England (20% of the LSOAs in each category) with category 1 being the highest deprivation and category 5 the lowest.

Population Data

Population data by ethnicity were obtained from the 2011 UK Census and population by deprivation category was calculated using the IMD 2010 aligned to 2011 LSOAs¹¹.

Statistical Analysis

Prevalence per 100,000 of population was calculated for each NMD group using the formula: prevalence = (number of cases/population at risk) x 100,000.

95% Confidence Intervals (CI) for all calculation where $n > 10$ were calculated using the formula: prevalence $\pm 1.96 \times \sqrt{(\text{prevalence} \times 1 - \text{prevalence} / \text{population})}$ ¹². 95% confidence intervals for calculations where $n \leq 10$ were calculated from the binomial distribution¹².

The population at risk was the total population aged under 16 years for our geographical region. The prevalence of dystrophin-related NMD was also calculated using the male population as the denominator to allow comparison with other studies (provided within the text).

Differences between groups were assessed by chi-squared or Fisher's exact test.

All statistical analyses were undertaken using STATA version 13.

Ethical Approval

NHS ethical approval was not required as this study was considered to be a service evaluation study. However, University of Leeds ethical approval was granted in June 2013 (Ref: HSLTLM/12/018)

Results

Of the initial 485 patients found by amalgamating the databases, 261 patients met the inclusion criteria (Figure 1). The population of children less than sixteen years old covered by the Leeds neuromuscular service was 707,961 with the male population 361,007⁸.

Table 1 shows the demographic data for the NMD patients. 69% of the patients were male, with 34.9% of the patients coming from the South Asian population. Dystrophin related muscle disease was the commonest diagnoses (n=61).

The overall prevalence of neuromuscular conditions in the paediatric population was 36.9 per 100,000 (95%CI: 34.6-39.1). Dystrophin-related NMD was the most prevalent condition, 16.9 per 100,000 (95%CI: 14.7-19.1) of the male population. Charcot-Marie-Tooth type 1 (4.4 per 100,000(95%CI: 3.6-5.2)) and congenital myopathies (4.1 per 100,000 (95%CI: 3.3-4.9)) had the next highest prevalence (supplementary Table 1).

The prevalence of NMD varied by ethnic group with the prevalence of NMD within the White population of Yorkshire at 28.7 per 100,000 (95%CI: 26.4-30.9)) but the prevalence of NMD in the South Asian ethnic group was significantly higher at 91.2 per 100,000 (95% CI: 81.6-100.7)(chi² 95.3, p<0.001)(Figure 2). The prevalence in Yorkshire of NMD in 'Other' ethnicities was 17.2 per 100,000 (95%CI: 11.1-23.2). The difference in prevalence by ethnicity was driven by a significantly higher prevalence of non-dystrophin related NMD in the South Asian population (83.2 per 100,000 (95%CI: 65.3-101.0)) compared to the White population (19.6 per 100,000 (95%CI: 15.9-23.2))(chi² 125.9, p<0.001) . There was no significant difference in the prevalence of the dystrophin-related NMD between the ethnic groups (fishers exact p=0.67).

Overall 28.7% (n=75) of the patients had consanguineous parents with 10.7% (n=28) of the patients with an unknown consanguineous status. 6.6% (n=4) of those with dystrophin-related NMD had consanguineous parents compared to 35.5% of those with other NMD diagnoses (Fisher's exact p<0.0001)(data not shown).

The overall prevalence of NMD shows a linear association with deprivation category; the highest prevalence is in category 1 (most deprived) of 46.9 per 100,000 (95%CI: 42.3-51.8) and the lowest prevalence in the least deprived category 5 of 25.5 per 100,000 (95%CI: 20.7-30.3)(chi² 12.0, p=0.02)

(Figure3). This pattern is also evident in the non-dystrophin related NMD group (chi2 18.0, p=0.001) but there is no significant difference in prevalence between the deprivation categories in the dystrophin-related NMD group (chi2 4.0, p=0.41).

Discussion

This study has demonstrated a significantly higher prevalence of NMD in South Asian children in Yorkshire. The prevalence was 3 times higher than White children for all NMD and 4 times higher when considering non-dystrophin related muscle disease, much of which is inherited in an autosomal recessive manner. This is consistent with other published studies, identifying a higher prevalence of progressive neurodegenerative disease¹³, congenital anomalies¹⁴ and other life-limiting conditions¹⁵ in children of South Asian origin in the UK.

There is evidence that consanguinity is associated with higher rates of NMD in other countries. A population study in North East Brazil concluded high rates of endogamy within certain ethnic groups increased the prevalence of NMD. The estimated prevalence of 80 per 100,000 is similar to that found in the South Asian children of Yorkshire, although the Brazilian study looked at the total population¹⁶.

Previous genetic studies within the South Asian Muslim population show that 63% of parents are cousins and that the Pakistani community in West Yorkshire marry within sub-communities known as Biraderi and originate from a small number of ancestral groups^{17,18}. High rates of parental consanguinity have been identified in South Asian Pakistani families¹³ and documented in 28.7% of families (all South Asian) of this study population. It is likely to be a major risk factor in the increased frequency of certain NMD within this ethnic group. The exact prevalence of consanguinity in the population of Yorkshire is not known so prevalence of neuromuscular conditions based upon consanguinity could not be calculated.

There are other social and cultural factors that may account for a higher prevalence of NMD within the South Asian community. There is a high birth rate in this community¹⁹, with greater numbers of children per family and short spacing between pregnancies. This results in reduced time for diagnosis and appropriate counselling of recurrence risk in the case of genetic disorders. Cultural views regarding antenatal screening and low rates of termination also contribute to a higher incidence of congenital and genetic disease^{20,14}. There may also be genetic variability that increases the prevalence of specific NMD in the South Asian population.

The overall prevalence of NMD in this study (36.9 per 100,000) is similar to that reported in Bologna in 1992 of 42 per 100,000 in 1-19 yr olds²¹, but much lower than the reported prevalence of 63 per 100,000 in under 16 year olds in Western Sweden²². Sweden has well-established, integrated health care systems for children with motor disorders, which would ensure high levels of data ascertainment in their population. The inclusion criteria were somewhat different in the Swedish study; acquired disorders such as poliomyelitis and acute inflammatory demyelinating polyneuropathy were included, as were children with clinical evidence of neuromuscular disease with electrophysiological but not necessarily histological confirmation, which would increase the overall prevalence. The authors suggest that genetic differences between different populations and accurate data collection accounted for their high prevalence in comparison to other studies.

Other studies of the prevalence of NMD tend to relate to the whole population. Although the prevalence of NMD in Yorkshire children appears to be similar to the 37 per 100,000 found in a population study in the North East of England³, the inclusion criteria for the two studies were very different, both in age and disease characteristics and so the studies cannot really be compared.

The prevalence of specific NMD at different ages varies depending on the disease course, the resources available to manage complications and the age of the population being studied. The mean age of survival in DMD has dramatically improved in recent years with young men now surviving into their 30s where they have access to optimal respiratory, nutritional and postural support²³. However, where services are less developed⁵, boys may die from complications before transitioning to adult services resulting in variable survival rates in different areas. This underlies the considerable variation in reported prevalence of DMD in different studies. The prevalence was 8.46 per 100,000 of the total male population in the North East study³, whereas the prevalence in under 16 years olds in the Swedish study was 16.8 (CI 11.4- 23.8) per 100,000²² and 28 per 100,000 in under 19 years old males in the Bologna study²¹. The pooled prevalence of dystrophin related NMD calculated from a systematic review of 31 international prevalence studies, with varying case definitions, was 4.78 per 100,000 (CI 1.94-11.81), although only 3 of these studies related to paediatric populations²⁴. The prevalence figures for dystrophin related NMD in this study of 16.9 (CI 14.7-19.1) per 100,000 in the < 16 year old male population of Yorkshire are therefore consistent with those reported in the Swedish childhood population, although do include a few boys with a diagnosis of Becker MD.

The prevalence of Spinal Muscular Atrophy (SMA) in this study of 3.8 (3.1-4.5) per 100,000 is comparable to that reported in the Swedish study of 2.8 (CI 1.3-5.1) per 100,000²² but lower than that found in Italy of 6.5 per 100,000²¹. No confidence limits are reported for the Italian study so it is difficult to draw comparisons. The published UK data from the North East gives a prevalence of SMA

in the whole population of 1.87 per 100,000³. The increased prevalence seen in childhood studies is expected, given the life-limiting nature of some forms of SMA.

The association between a higher prevalence of NMD and higher levels of deprivation was most marked in the 'non-dystrophin' related disease group. The South Asian population in Yorkshire, where 'non dystrophin' related disease was most commonly seen, tend to live in areas of higher deprivation⁷ but the numbers in our study were too small to analyse deprivation as a confounding variable for ethnicity. However, similar associations with deprivation have been found in other studies of chronic disease in childhood^{15,23}

Caring for a child with a severe NMD places additional financial burdens on a family and reduces the total earning potential². The effects of disease in parents and other family members, both physical impairments and learning difficulties further increase the difficulty of maintaining socioeconomic status. In our study 25% of the cohort had at least one first degree relative with the same condition. Population studies show that both myotonic dystrophy and DMD are more commonly seen in association with high levels of social deprivation^{4,25}. We were unable to confirm a link in our study between DMD and deprivation score. This may be because the numbers are too small or perhaps because social differences become more marked when those over 16 years of age are included in the data set.

This study was carried out in a discrete geographical area with an established clinical network and well-defined referral pathways into a single centre. There is naturally some overlap in referral pathways at the 'borders' of the region, with some children being referred to neighbouring NMD clinics. However, local therapy services are restricted by postcode area and therefore by using multiple data sources, including child therapy databases, we believe we have optimised ascertainment. It is possible that children with milder disease phenotypes who have not presented to primary care or been referred to secondary level services have been missed from our analysis. Given the nature of NMD presenting in childhood, we believe these numbers would be small.

This was a retrospective case notes review. Some data were missing from clinical notes, in particular information regarding consanguinity. This may reflect difficulty in asking families about this issue in a clinic setting or poor documentation, but did restrict analysis of this variable. Even though this was a full population study, the specific conditions being studied are rare and numbers in individual

diagnostic groups were small which limited the power to undertake more detailed analysis. As it is a prevalence study it was only possible to assess association rather than causation.

This study has identified high levels of NMD in the South Asian community within areas of high social deprivation..Language barriers and cultural values may restrict access to services in these communities, resulting in later genetic diagnoses and multiple affected individuals in a family. An accurate estimate of the prevalence of NMD is necessary to determine the resources required to provide high quality medical, therapy and social services that are sensitive to the needs of the local population. A larger population study would allow evaluation of the relationship between ethnicity, consanguinity and deprivation in specific childhood onset NMD.

Table 1: Clinical and Demographic characteristics of the patients with neuromuscular disease

| Characteristic | Cases | | Population of Yorkshire and Humber (0-15 years) |
|-----------------------------------|-----------|------|---|
| | N | % | % |
| Sex | | | |
| Male | 180 | 69.0 | 51.0 |
| Female | 81 | 31.0 | 49.0 |
| Missing | 0 | | |
| Age mean (SD) | 9.0 (4.6) | | |
| Ethnicity | | | |
| White | 161 | 61.7 | 79.3 |
| South Asian | 91 | 34.9 | 14.1 |
| Other | 8 | 3.0 | 6.6 |
| Missing | 1 | 0.4 | |
| Deprivation Category | | | |
| 1 most deprived | 107 | 41.0 | 32.3 |
| 2 | 49 | 18.8 | 18.5 |
| 3 | 38 | 14.5 | 15.5 |
| 4 | 38 | 14.5 | 18.1 |
| 5 least deprived | 28 | 10.7 | 15.6 |
| Missing | 1 | 0.4 | |
| Diagnostic Category | | | |
| Dystrophin Related Muscle Disease | 61 | 23.4 | |
| CMT 1 | 31 | 11.9 | |
| Congenital Myopathy | 29 | 11.1 | |
| SMA | 27 | 10.3 | |
| Congenital Muscular Dystrophy | 21 | 8.0 | |
| NMD Plus | 20 | 7.7 | |
| Myopathy Unspecified | 12 | 4.6 | |
| Congenital Myotonic Dystrophy | 11 | 4.2 | |
| Ion-Channel Disorder | 10 | 3.8 | |
| CMT 4 | 8 | 3.1 | |
| Limb Girdle Muscular Dystrophy | 8 | 3.1 | |
| CMT 2 | 6 | 2.3 | |
| Congenital Myasthenia | 6 | 2.3 | |
| Myasthenia Gravis | 6 | 2.3 | |
| Facio Scapulo Humeral Dystrophy | 5 | 1.9 | |

Figure 2 Prevalence of neuromuscular conditions by ethnic group

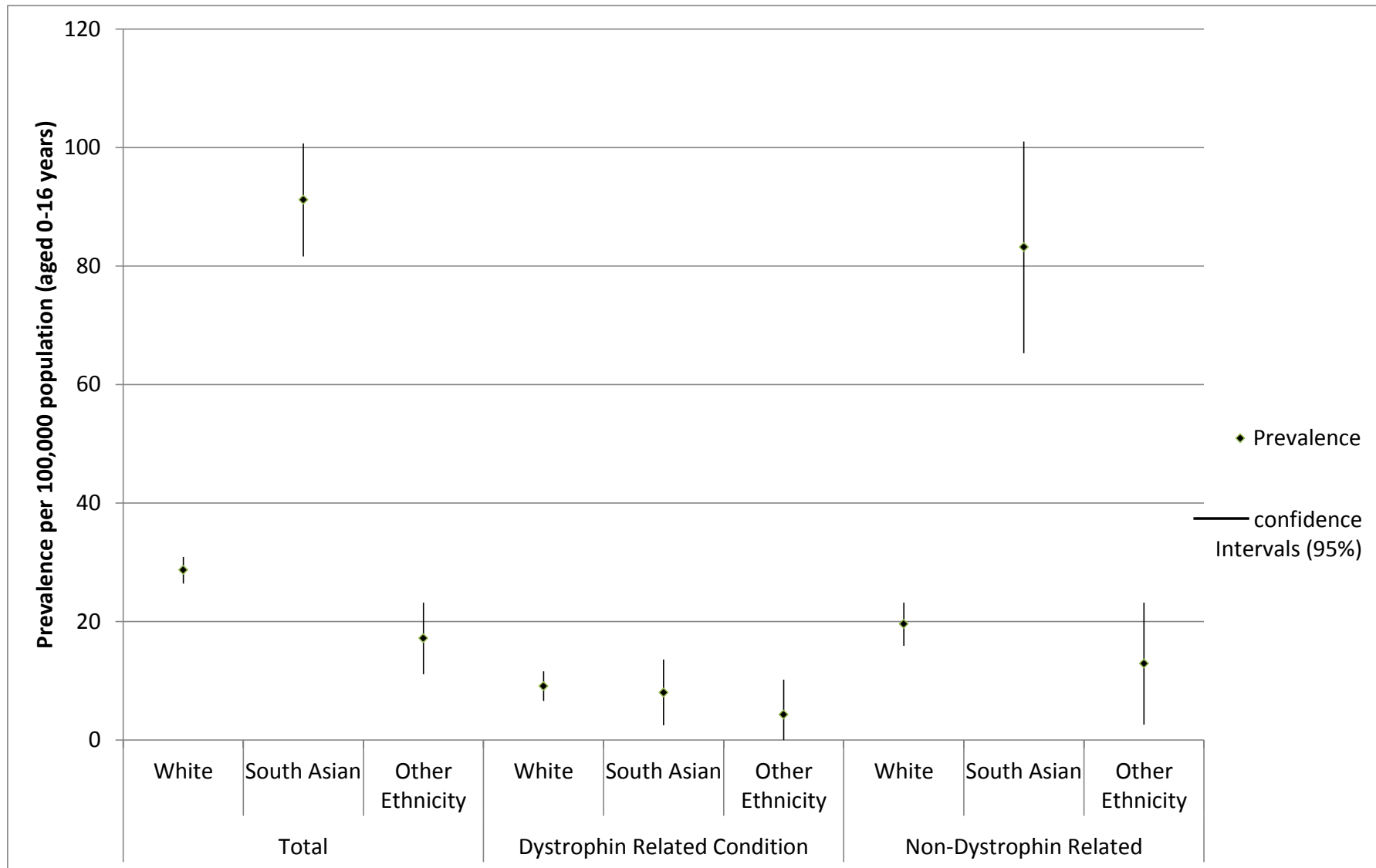
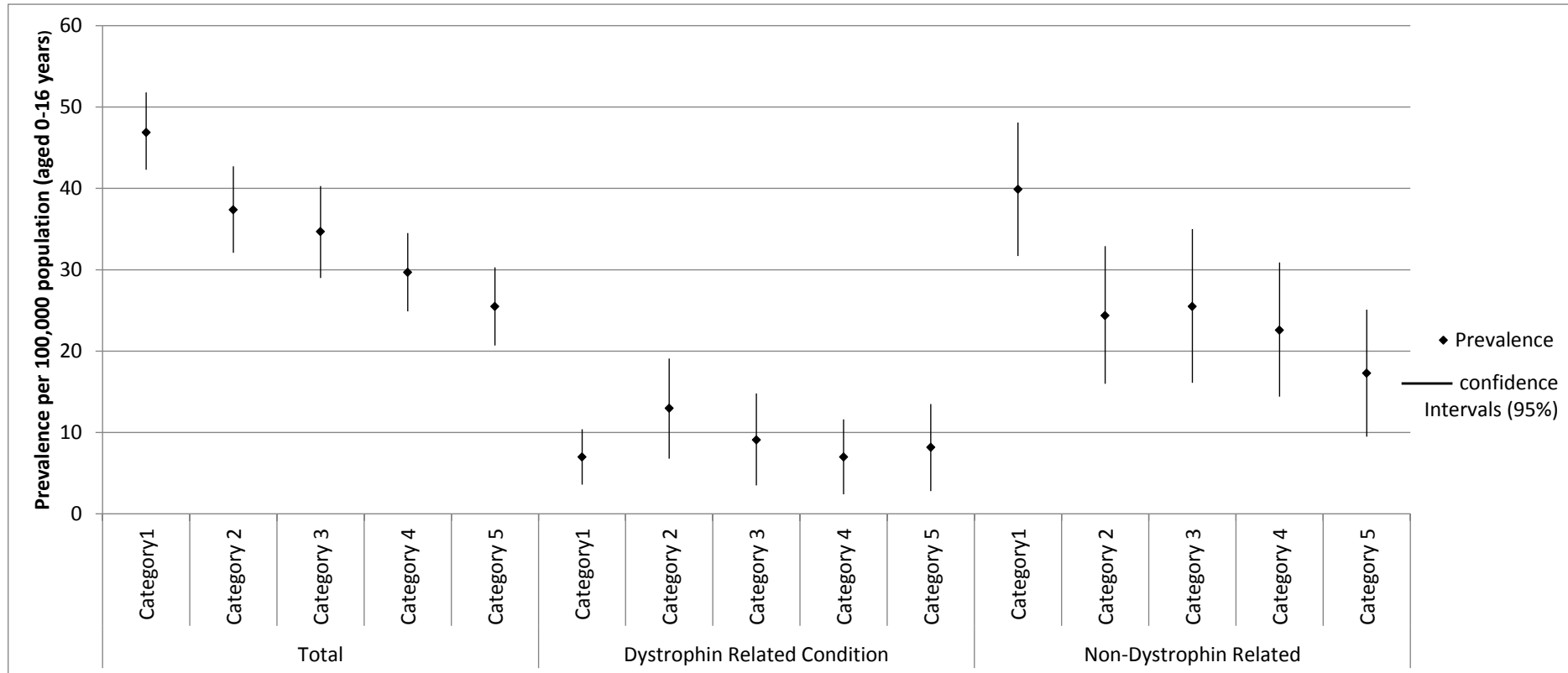


Figure 3 Prevalence of neuromuscular conditions by deprivation category



#Category 1 = Most Deprived, Category 5= Least Deprived

Supplementary Table 1 Prevalence of Neuromuscular Disease in children < 16 years in the former Yorkshire Health Authority Region

| Diagnosis Category | Number of Patients | Prevalence per 100000 population | 95% CI Lower | 95%Ci Upper |
|-----------------------------------|--------------------|----------------------------------|--------------|-------------|
| Dystrophin Related Muscle Disease | 61 | 8.6 | 7.5 | 9.7 |
| CMT 1 | 31 | 4.4 | 3.6 | 5.2 |
| Congenital Myopathy | 29 | 4.1 | 3.3 | 4.9 |
| SMA | 27 | 3.8 | 3.1 | 4.5 |
| Congenital Muscular Dystrophy | 21 | 3.0 | 2.3 | 3.6 |
| NMD Plus | 20 | 2.8 | 2.2 | 3.5 |
| Myopathy Unspecified | 12 | 1.7 | 1.2 | 2.2 |
| Congenital Myotonic Dystrophy | 11 | 1.6 | 1.1 | 2.0 |
| Ion-Channel Disorder | 10 | 1.4 | 1.0 | 1.9 |
| CMT 4 | 8 | 1.1 | 0.7 | 1.5 |
| Limb Girdle Muscular Dystrophy | 8 | 1.1 | 0.7 | 1.5 |
| CMT 2 | 6 | 0.8 | 0.5 | 1.2 |
| Congenital Myasthenia | 6 | 0.8 | 0.5 | 1.2 |
| Myasthenia Gravis | 6 | 0.8 | 0.5 | 1.2 |
| Facio Scapulo Humeral Dystrophy | 5 | 0.7 | 0.4 | 1.0 |
| | | | | |
| Total | 261 | 36.9 | 34.6 | 39.1 |

Prevalence of dystrophin related muscle disease using male population as denominator = 16.9 (14.7-19.1)

References

- 1 Muscular Dystrophy Campaign. Muscle Disease: the impact Incidence and Prevalence of Neuromuscular Conditions in the UK. 2012.
- 2 Landfeldt E, Lindgren P, Bell CF, Schmitt C, Guglieri M, Straub V, Lochmueller H, Bushby K. The burden of Duchenne muscular dystrophy An international, cross-sectional study. *Neurology* 2014; **83**: 529-36.
- 3 Norwood FLM, Harling C, Chinnery PF, Eagle M, Bushby K, Straub V. Prevalence of genetic muscle disease in Northern England: in-depth analysis of a muscle clinic population. *Brain* 2009; **132**: 3175-86.
- 4 Bushby K, Raybould S, O'Donnell S, Steele JG. Social deprivation in Duchenne muscular dystrophy: population based study. *British Medical Journal* 2001; **323**: 1035-6.
- 5 Hanna M, Muntoni F, Reilly M, Bushby K, Hilton-Jones D, Quinlivan R, Jardine P, Meadowcroft R. Building on the Foundations: The Need for a Specialist Neuromuscular Service Across England. London: Muscular Dystrophy Campaign; 2007.
- 6 ALL Party Parliament Group for Muscular Dystrophy. Access to Specialist Neuroimascular Care: The Walton Report. 2009.
- 7 Race for Opportunity Campaign. Regional Factsheet: Ethnic Minorities in the UK -Yorkshire and the Humber. 2010.
- 8 Office for National Statistics. Population Data. <https://www.nomisweb.co.uk/>
- 9 Childs A-M, Rotime F, Yeung S. Significant variation in the prevalence and spectrum of neuromuscular disease among different ethnic groups: an observational study. *Developmental Medicine and Child Neurology* 2008; **50**: 38.
- 10 Department for Communities and Local Government. English indices of deprivation. <https://www.gov.uk/government/statistics/english-indices-of-deprivation-2010>
- 11 Public Health England. IMD 2010 scores adjusted to align with 2011 LSOAs. <http://www.apho.org.uk/resource/item.aspx?RID=125887>
- 12 Bland M. *An introduction to medical statistics*. Oxford: Oxford University Press; 2006.
- 13 Devereux G, Stellitano L, Verity CM, Nicoll A, Will RG, Rogers P. Variations in neurodegenerative disease across the UK: findings from the national study of progressive intellectual and neurological deterioration (PIND). *Archives of Disease in Childhood* 2004; **89**: 8-12.
- 14 Sheridan E, Wright J, Small N, Corry PC, Oddie S, Whibley C, Petherick ES, Malik T, Pawson N, McKinney PA, Parslow RC. Risk factors for congenital anomaly in a multiethnic birth cohort: an analysis of the Born in Bradford study. *Lancet* 2013; **382**: 1350-9.
- 15 Fraser LK, Miller M, Hain R, Norman P, Aldridge J, McKinney PA, Parslow RC. Rising National Prevalence of Life-Limiting Conditions in Children in England. *Pediatrics* 2012; **129**: E923-E9.
- 16 Santos S, da Silva Pequeno AA, Pessoa A, Galvao CRC, de Medeiros JLA, Mathias W, Kok F. Increased prevalence of inherited neuromuscular disorders due to endogamy in Northeast Brazil: the need of community genetics services. *Journal of community genetics* 2014; **5**: 199-203.
- 17 Born in Bradford. The Born in Bradford (BIB) cohort study: Summary statistics by ethnic group. 2012.
- 18 Jackson AP, McHale DP, Campbell DA, Jafri H, Rashid Y, Mannan J, Karbani G, Corry P, Levene MI, Mueller RF, Markham AF, Lench NJ, Woods CG. Primary autosomal recessive microcephaly (MCPH1) maps to chromosome 8p22-pter. *American Journal of Human Genetics* 1998; **63**: 541-6.
- 19 Norman P, Rees P, Wohland P. The use of a new indirect method to estimate ethnic-group fertility rates for subnational projections for England. *Population Studies-a Journal of Demography* 2014; **68**: 43-64.
- 20 Hewison J, Green JM, Ahmed S, Cuckle HS, Hirst J, Hucknall C, Thornton JG. Attitudes to prenatal testing and termination of pregnancy for fetal abnormality: a comparison of white and Pakistani women in the UK. *Prenatal Diagnosis* 2007; **27**: 419-30.
- 21 Merlini L, Stagni SB, Marri E, Granata C. Epidemiology of neuromuscular disorders in the under-20 population in Bologna Province, Italy. *Neuromuscular disorders : NMD* 1992; **2**: 197-200.

- 22 Darin N, Tulinius M. Neuromuscular disorders in childhood: a descriptive epidemiological study from western Sweden. *Neuromuscular Disorders* 2000; **10**: 1-9.
- 23 Rahi JS, Cumberland PM, Peckham CS, British Childhood V. Improving Detection of Blindness in Childhood: The British Childhood Vision Impairment Study. *Pediatrics* 2010; **126**: E895-E903.
- 24 Mah JK, Korngut L, Dykeman J, Day L, Pringsheim T, Jette N. A systematic review and meta-analysis on the epidemiology of Duchenne and Becker muscular dystrophy. *Neuromuscular Disorders* 2014; **24**: 482-91.
- 25 Laberge L, Veillette S, Mathieu J, Auclair J, Perron M. The correlation of CTG repeat length with material and social deprivation in myotonic dystrophy. *Clinical Genetics* 2007; **71**: 59-66.