Classification of MRI in cerebral palsy: findings from an Australian study and review

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The issues

* Important for aetiological research to use more homogeneous neuropathological subgroups instead of clinically defined groups
* Particular interest in CP with unclear aetiology, e.g. term WMI

However:

* No universal agreement on classification or definitions
* Interpretation of MRIs subjective

Aims

* To classify brain MRI patterns in a population cohort of children with CP from Victoria (Australia)
* To compare Victorian data with classifications, definitions, and distributions of patterns reported from other population cohorts
* To identify areas where more specific classification guidelines are required

Victorian study

* Children identified from Victorian CP Register (VCPR)
  * Born in Victoria between 1999 and 2006
  * No known postneonatal cause for CP
* MRI scans accessed from the two state tertiary paediatric hospitals and from other institutions where possible
* Scans reviewed by one of two paediatric radiologists (CD / MD) blind to clinical information and previous reports
* Most recent, good quality scan classified, irrespective of age
* Problems with classification were discussed and resolved
* Additional information collected for each pattern

Victorian classification system

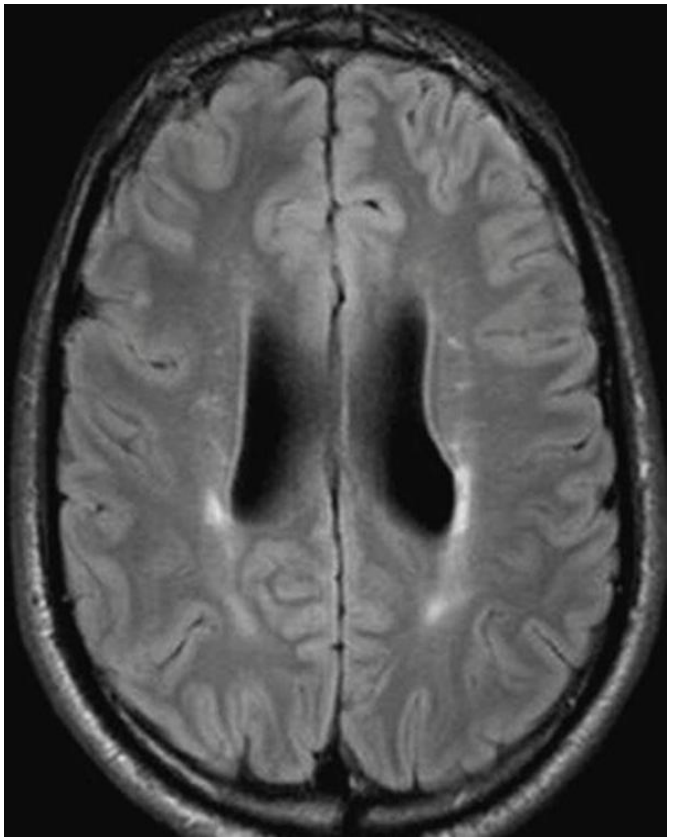
* Adapted from pilot study (2000-1 births) classification*
* Took into account classification used by European CP Study and broad groups reported from previous systematic reviews of imaging findings in CP
* Included a category for normal MRI findings, and one for abnormalities unable to be classified into one of four main patterns: WMI, GMI, FVI and malformations

*Robinson M, Peake L, Ditchfield M, Reid S, Lanigan A, Reddihough D. Magnetic resonance imaging findings in a population-based cohort of children with cerebral palsy. *Dev Med Child Neurol* 2009; **51**: 39-45.

White matter injuries (WMI)

A predominant finding of:

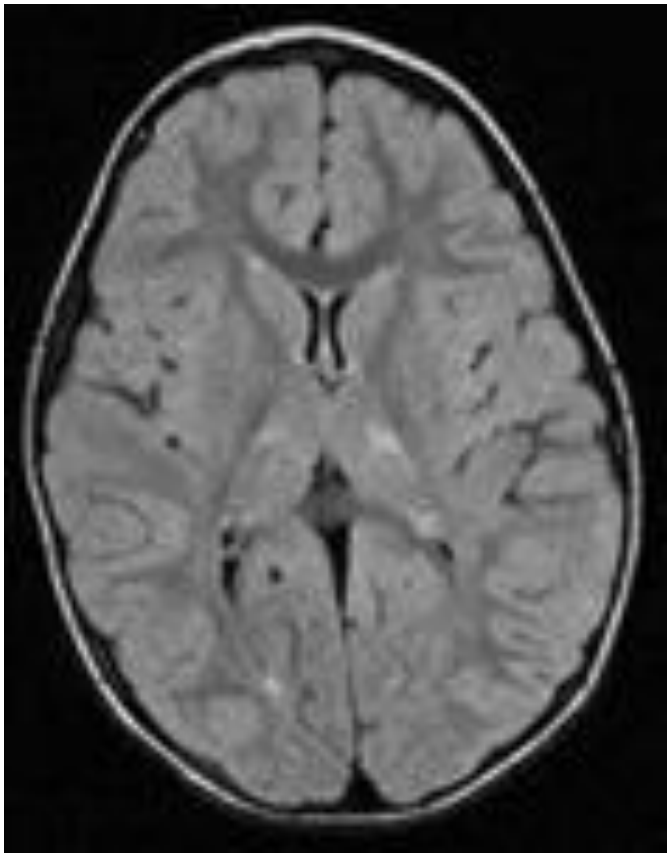
* Signal abnormality and/or volume loss in the periventricular and/or deep white matter
* Ventricular dilatation, scalloping of the ventricles, and cysts may be present
* Grey matter abnormality may also be seen in severe cases



Grey matter injuries (GMI)

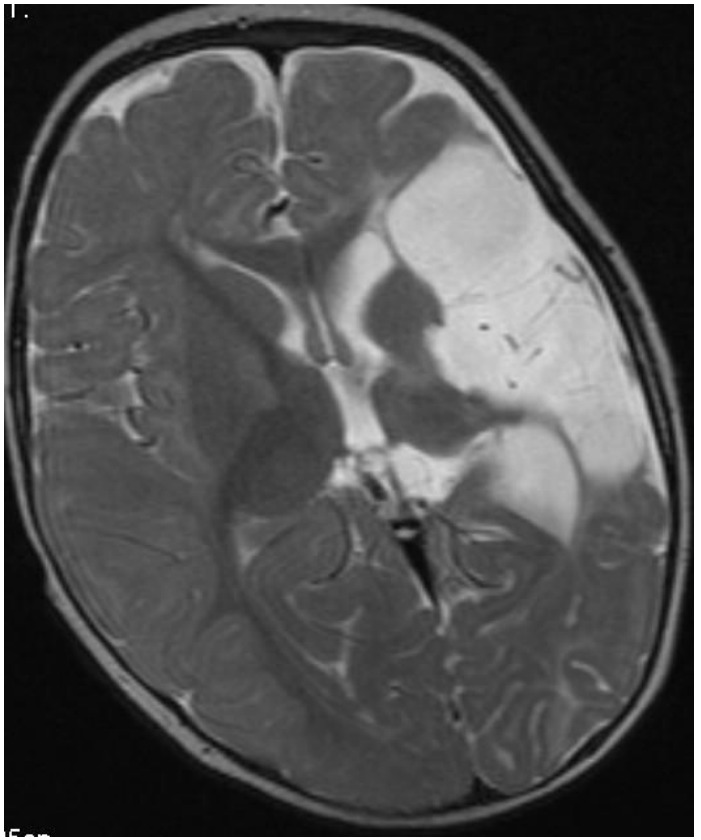
A predominant finding of:

* Signal abnormality and/or volume loss predominantly involving the cortical-subcortical grey matter, deep grey matter, or both
* White matter may also be involved



Focal vascular insults (FVI)

* Signal abnormality, volume loss, or porencephaly in an established vascular territory
* Includes venous sinus thrombosis and isolated haemorrhagic lesions
* Does not include IVH / periventricular venous infarction (WMI)
* Majority were unilateral MCA infarcts



Malformations

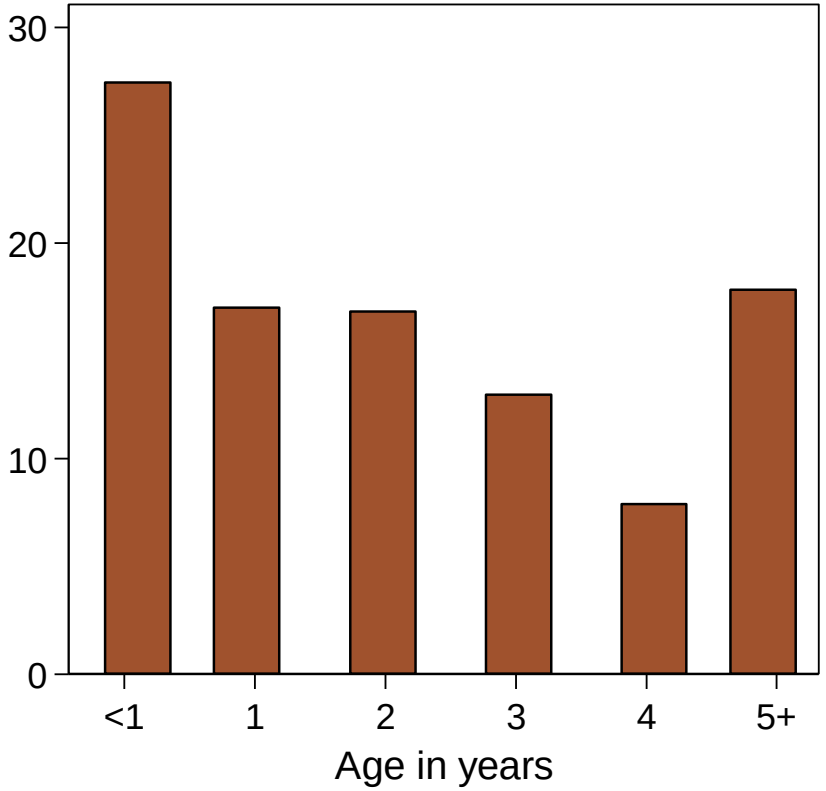
* Abnormal formation of the brain, including cortical dysplasia, polymicrogyria, lissencephaly, pachygyria, heterotopia, schizencephaly, polymicrogyria, cerebellar hypoplasia or dysgenesis, holoprosencephaly, hydranencephaly, congenital hydrocephalus, and agenesis of the corpus callosum
* Also includes the sequelae of intrauterine infection which may manifest as dystrophic, predominantly periventricular, calcifications, with or without focal white matter destruction, microcephaly, and cerebellar hypoplasia

Victorian MRI cohort

* MRI classification possible for 593/884 (67%) eligible children
* MRI less likely to be available for:
  * Earlier birth years
  * Gestational age <32w
  * GMFCS levels I & II
  * Spastic diplegia

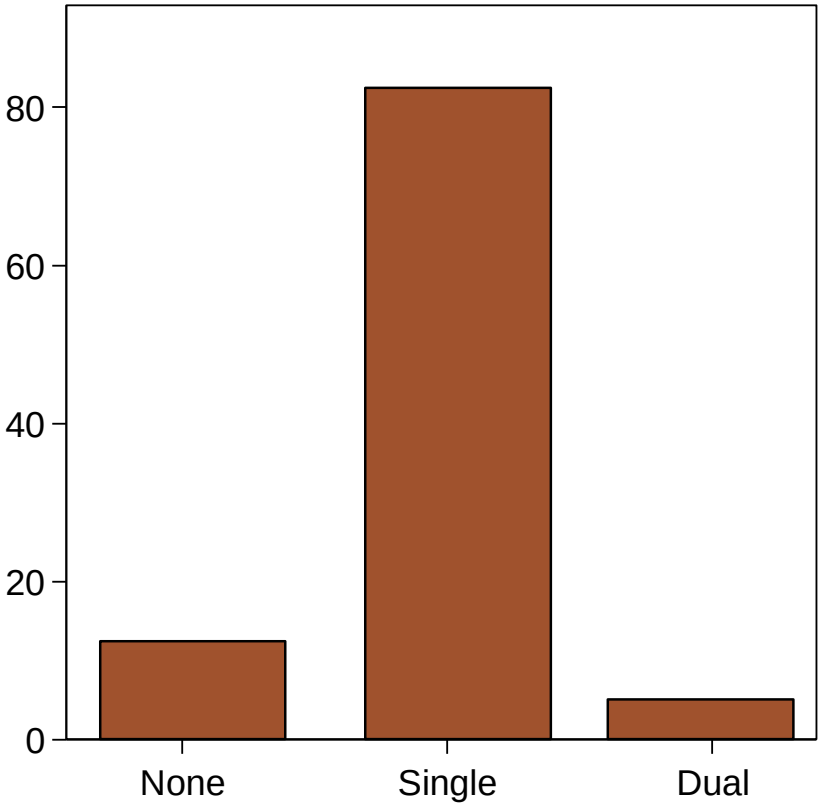
Age at most recent scan

* 38 (6%) had their most recent imaging within the first 28 days of life
* 163 (27%) children were < 1 year

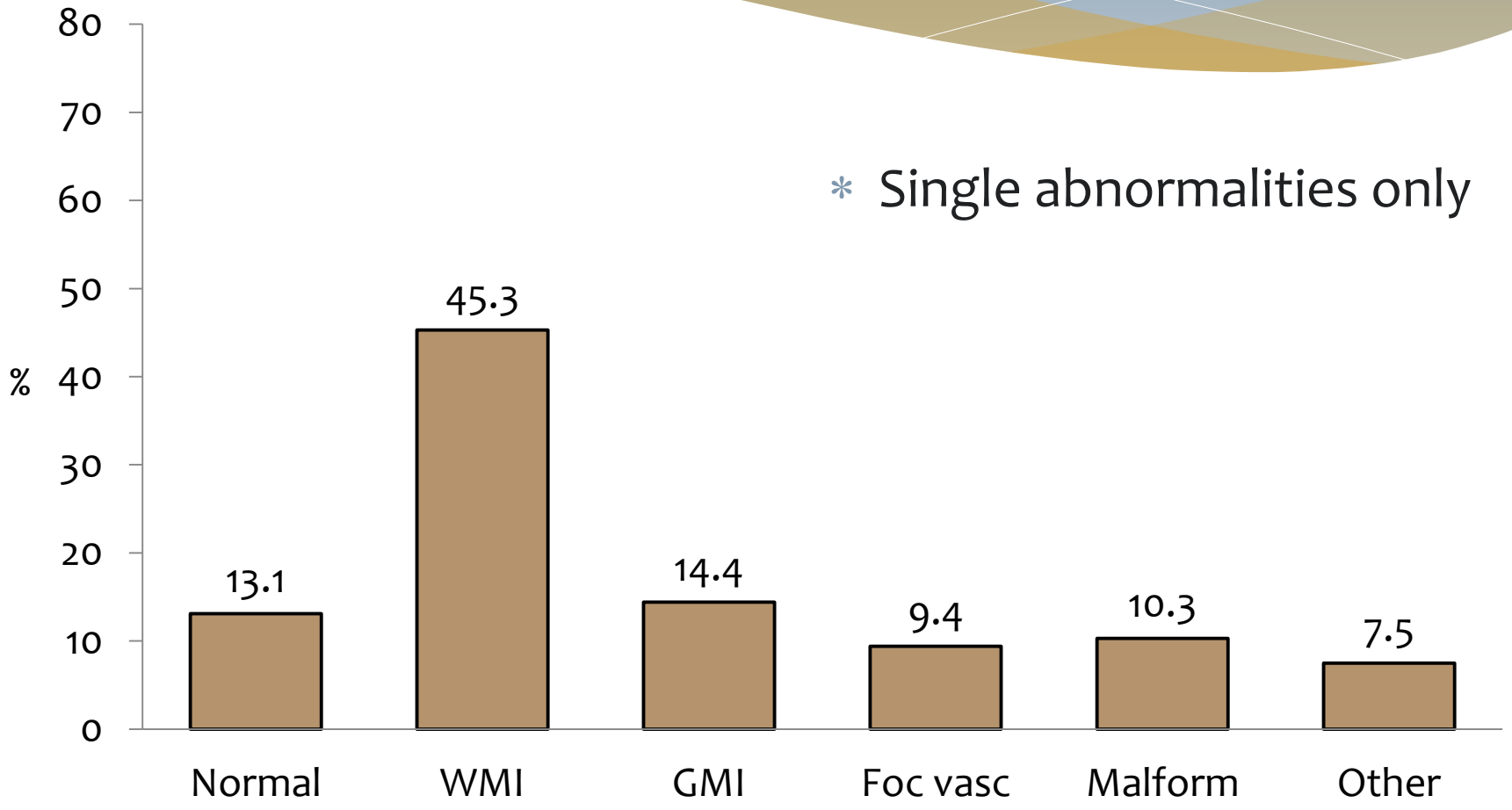


Number of abnormal findings

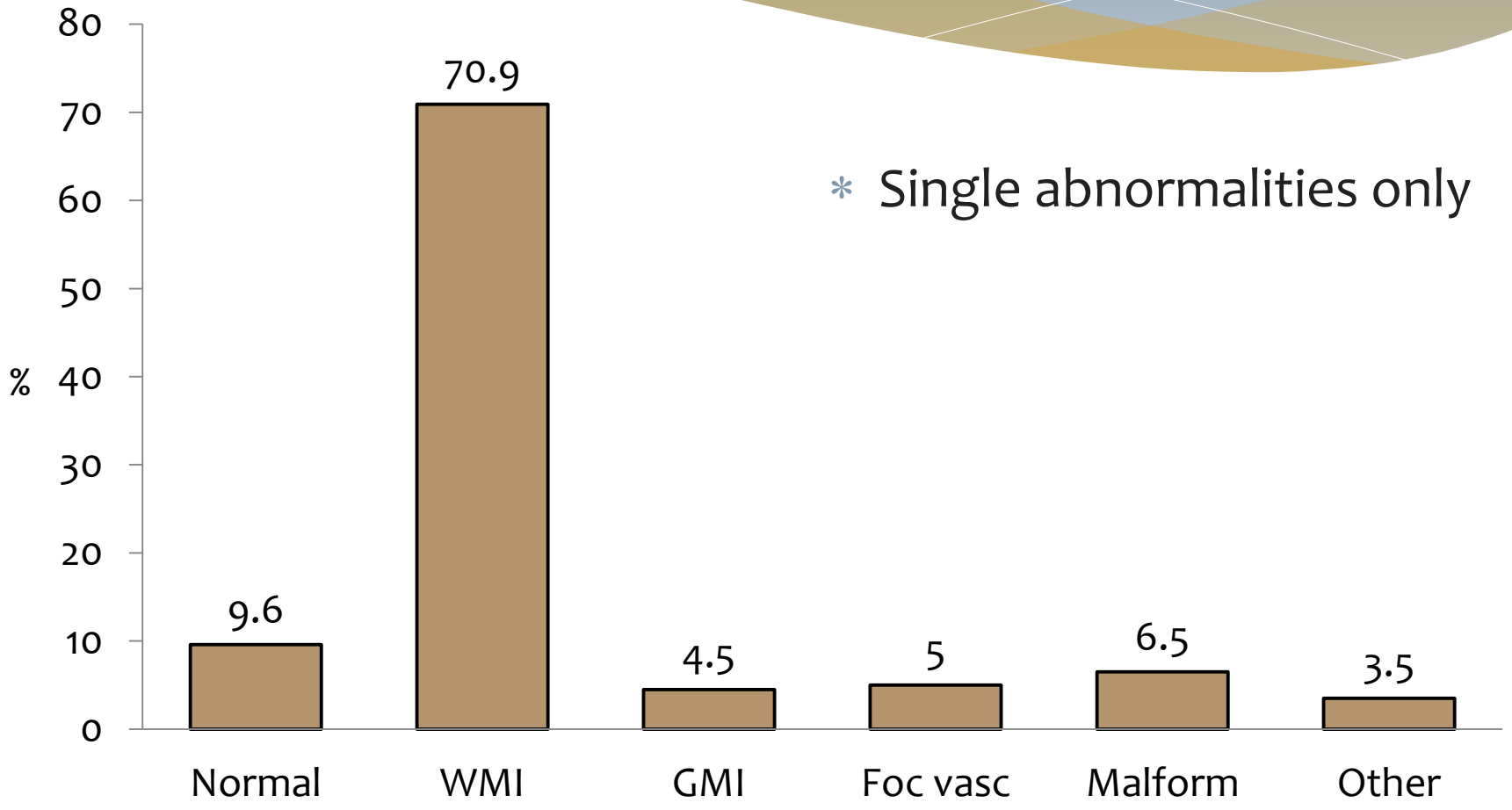
* 82.5% of assessed scans showed a single pattern of abnormality
* 12.5% showed no observable abnormality
* 5% had dual abnormalities (excluded)



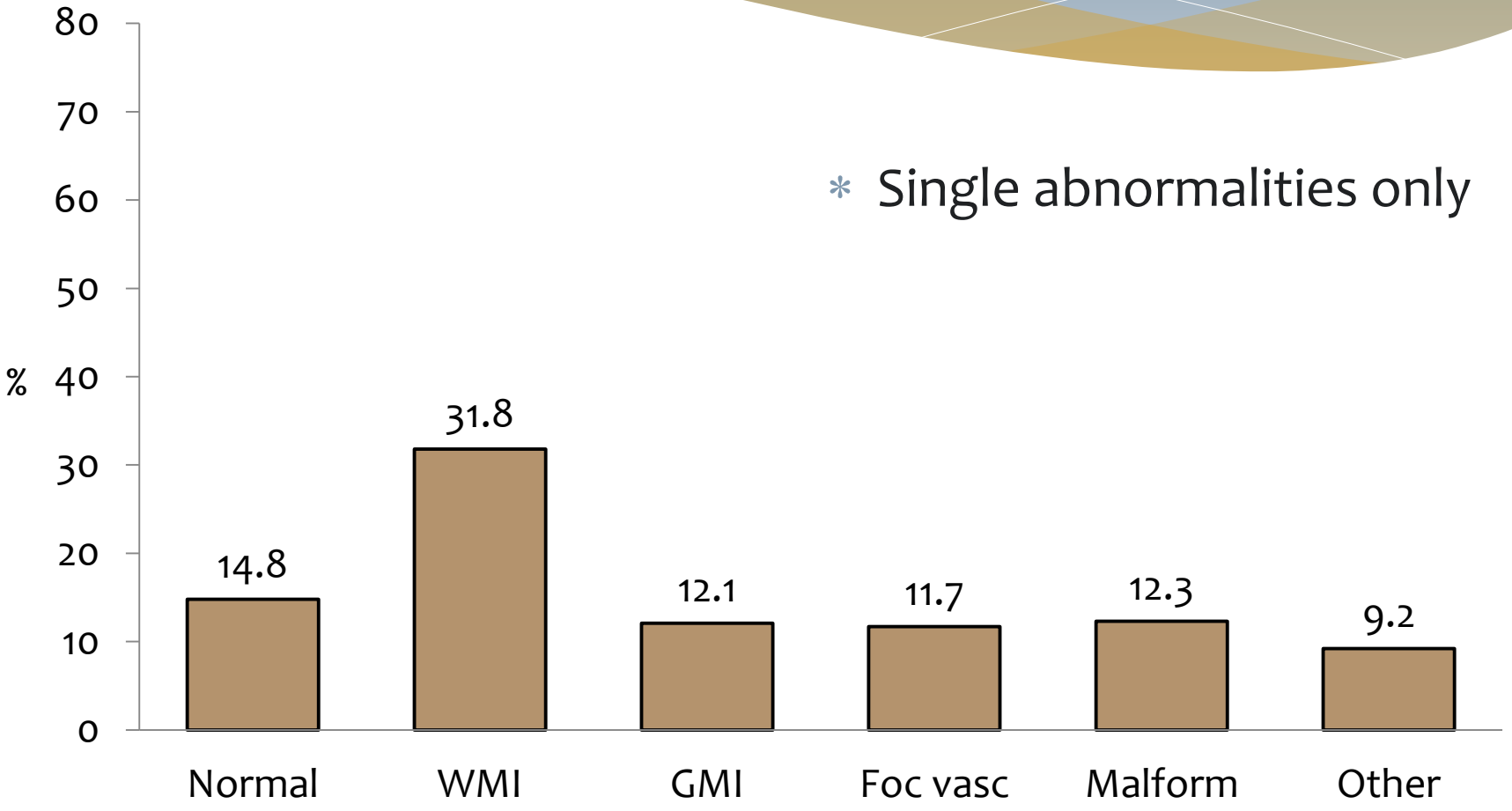
Distribution of MRI patterns



Distribution of MRI patterns following preterm birth



Distribution of MRI patterns following term birth



Methods for the review

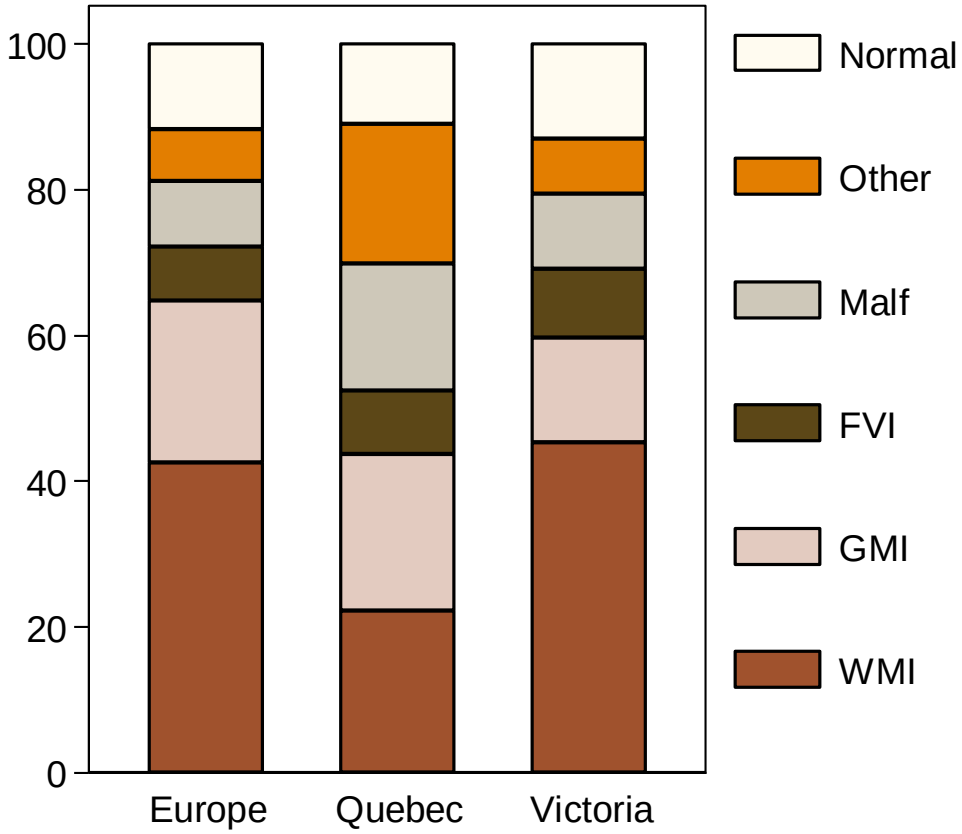
* Following a literature search and selection of comparable studies, the distribution of imaging patterns was examined for each included study for all CP, and for subgroups based on gestational age, CP subtype, and GMFCS level
  * Comparisons for all CP and groups based on gestational age presented here

Studies included: all CP

* Europe
  * Bax M, Tydeman C, Flodmark O. Clinical and MRI correlates of cerebral palsy: the European Cerebral Palsy Study. *JAMA* 2006; **296**: 1602-08.
* Quebec
  * Towsley K, Shevell MI, Dagenais L. Population-based study of neuroimaging findings in children with cerebral palsy. *Eur J Paediatr Neurol* 2011; **15**: 29-35.

Comparison of MRI patterns: all CP

* Abnormalities seen in 88% cases in Europe, 89% in Quebec, and 87% of the Victorian cohort
* Overall distribution of MRI patterns in the European study similar to distribution in Victoria



Classification differences: all CP

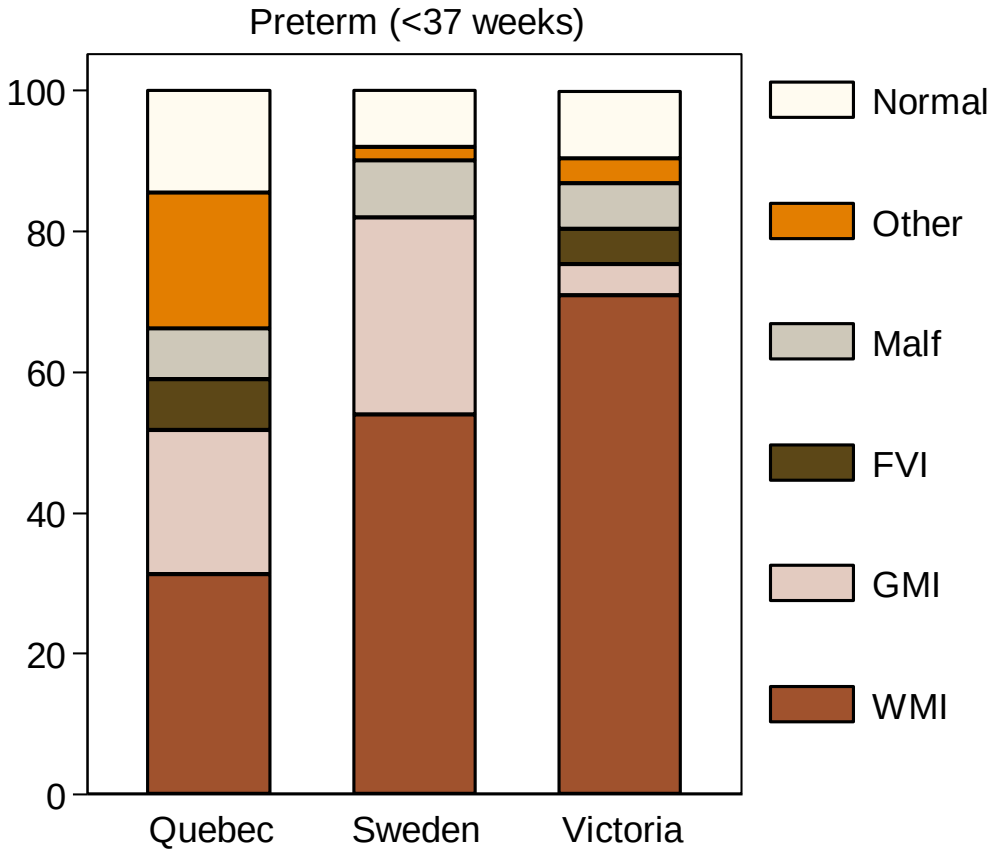
* The proportion of WMI in Victoria (45%) and Europe (43%) was higher than the proportion reported from Quebec (22%).
* The Quebec cohort included relatively more malformations (17.5% vs 9-10%) and scans classified as non-specific/other (19% vs 7%)
* Some of the variation in distributions might be accounted for if cases of IVH and/or periventricular venous infarction were included in the non-specific/other category in Quebec

Studies included: based on g.a.

* Quebec
  * Towsley K, Shevell MI, Dagenais L. Population-based study of neuroimaging findings in children with cerebral palsy. *Eur J Paediatr Neurol* 2011; **15**: 29-35.
* Sweden
  * Himmelmann K, Hagberg G, Beckung E, Hagberg B, Uvebrant P. The changing panorama of cerebral palsy in Sweden. IX. Prevalence and origin in the birth-year period 1995 to 1998. *Acta Paediatr* 2005; **94**: 287-94 (37w data)

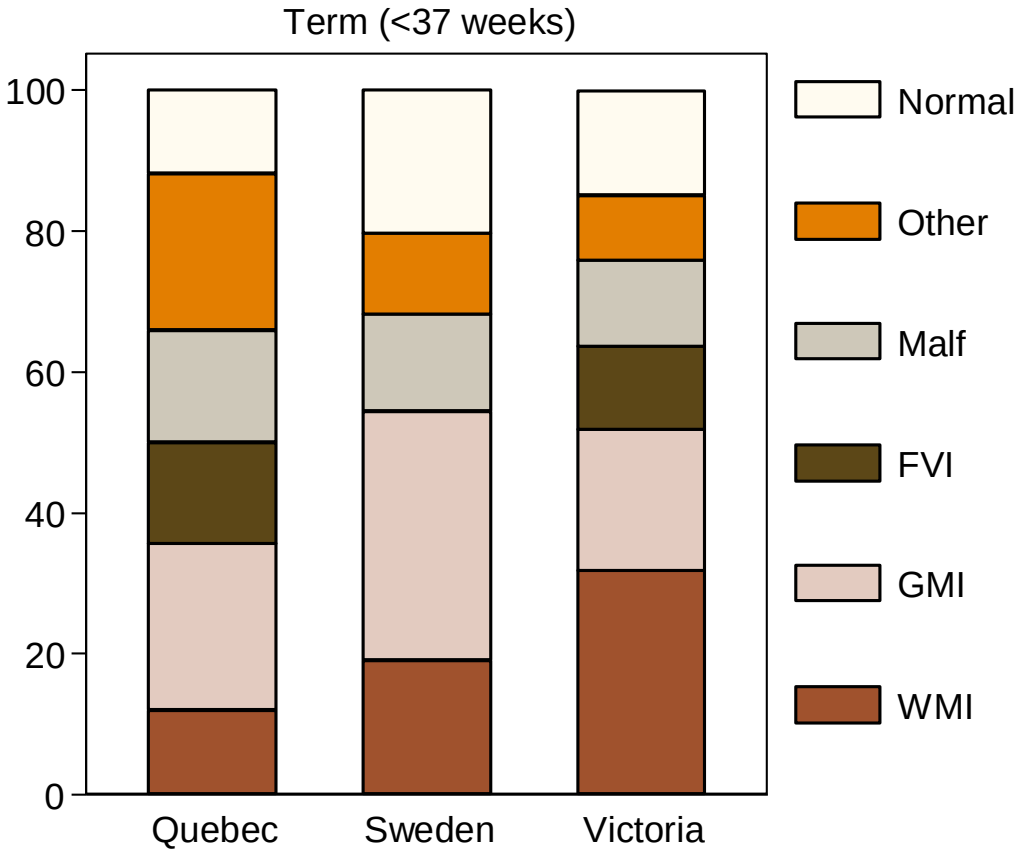
Preterm birth and MRI pattern

* Proportions of WMI different (71% in Victoria vs 54% in Sweden and 31% in Quebec)
* More GMI in Sweden
* More 'other' in Quebec



Term birth and MRI pattern

* Victoria had similar distribution to Sweden (GMI includes FV insults) but more WMI in Victoria
* Quebec more ‘other’; less WMI



Methodological issues for registers

* Imaging modality
  * including CT / cranial ultrasound alters ability to pick up some abnormalities and distribution of patterns, but increases available data
* Blinding to clinical information
  * Clinical information aids in getting classification right but increases risk of classifying according to expectations
* Multiple scans
  * Need to decide whether to assess all scans, most recent, or other. Some patterns change between acute and chronic

Methodological issues for registers

* Age at imaging
  * differentiating white matter gliosis from normal, unmyelinated WM can be difficult before age 3, but GMI can be easier to diagnose acutely
* Dual abnormalities
  * need to decide whether to include or exclude both or decide which is the predominant
* Classifying from reports or scans
  * Interpreting reports from multiple radiologists can be difficult and may not be blinded

Specific classification issues

* The study suggested a need for clarification around
  * classification of the sequelae of intraventricular and intracranial haemorrhage
  * ventriculomegaly / hydrocephalus
  * differentiating grey matter injury in white matter patterns from white matter injury in grey matter patterns
  * focal infarcts not in a specific vascular territory

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