The Winston Churchill Memorial Trust – Australia

Dr. Shekeeb S Mohammad

2014 WCMT Fellow – Report

Fellowship – UK and USA

Understanding basal ganglia disorders in children

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Signed: Shekeeb S Mohammad

Dated: 01/09/2015
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Introduction

Since the turn of the millennium, there has been significant progress in the diagnosis and management of children with disorders of movement. This has been helped by improved rehabilitation techniques and development of neuromodulation in the form of intrathecal baclofen pumps and deep brain stimulation. These advances have been complemented by massive progress in understanding the genetic basis of these diseases and in diagnosis of other autoimmune and infection related movement disorders. Many of these advances have been made possible by diligent clinical researchers.

I am a paediatric neurologist and a clinical researcher with an interest in the area of paediatric movement disorders. Training in this field is still informally organized around the world and services in Australia and New Zealand have scope of expansion. The Winston Churchill Fellowship gave me the opportunity to visit international centres of excellence in clinical care and research in paediatric movement disorders at Great Ormond Street Hospital and Evelina London Children’s Hospital in London. This enabled me to advance my clinical expertise in this area, develop several collaborations for research and future work and learn about advances in assessment and treatment of children with movement disorders. I hope to translate this experience into the advancement of these services in Australia.

Acknowledgements

I would like to thank the Winston Churchill Memorial Trust for this opportunity to travel and the ability to establish contact with prominent researchers and clinicians in the field with whom I have the opportunity to collaborate once I return to Australia. I would like to thank my mentor and supervisor Prof. Russell
C Dale and also Dr. Manoj P Menezes, for their support and encouragement as referees during the application process and for being readily available for further advice and tips through my fellowship and beyond. I would also like to thank Dr. Manju Kurian (CMGU, ICH and GOSH), Dr. W Kling Chong (GOSH), Dr. Belen Perez Duenas (ICH and Hospital Sant Joan de Deu Barcelona), Dr. Jean-Pierre Lin (CMDS, ELCH), the "Kurian" research group at ICH – Dr. Esther Meyer, Dr. Serena Barral, Dr. Amy McTague, Dr. Joanne Ng, Dr. Apostolos Papandreou, Dr. Barbara Csanyi, Dr. Elisenda Cortès Saladelafont and Dr. Adeline Ngoh and staff at the CMDS, ELCH. All of them made me feel welcome and helped in maximizing my fellowship experience despite their busy schedules and myriad responsibilities. I would also like to thank all the patients and families that I met in clinics in the United Kingdom and from whom I learnt a great deal. Last but not least I would thank my family for supporting me from Australia during my fellowship and all of their support on Skype and Facetime. I pen my report, following Churchill’s advice when he said “However beautiful the strategy, you should occasionally look at the results.”
Executive summary

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CHURCHILL FELLOWSHIP on advanced understanding of basal ganglia disorders in children. During the fellowship I visited Great Ormond Street Hospital (GOSH) in London and worked with the movement disorder service and allied research wing at the Institute of child health (ICH), University College London (UCL). I also attended the neuromodulation and treatment focused movement disorder service at Evelina London Children’s Hospital. I undertook the first systematic study of neuroimaging of basal ganglia disorders in children with the Neuroimaging department at GOSH. I attended the 19th International congress of Parkinson’s disease and movement disorders in San Diego as a delegate and invited speaker.
Programme

9th March - 27th March, 2015

- Movement disorder service (Dr. Manju Kurian, Great Ormond Street Hospital, London).
- Complex Motor Disorder Service (Dr. Jean-Pierre Lin, Evelina London Children’s Hospital).
- Clinical and Molecular genetics unit (Kurian research group, Institute of Child Health, UCL, London).

11th May - 5th June, 2015

- Movement disorder service (Dr. Manju Kurian, Great Ormond Street Hospital, London).
- Complex Motor Disorder Service (Dr. Jean-Pierre Lin, Evelina London Children’s Hospital).
- Clinical and Molecular genetics unit (Kurian research group, Institute of Child Health, UCL, London).
- Dr. John Livingston, Leeds General Infirmary
- Neuro-metabolic clinic (Dr. Evangeline Wassmer, Birmingham Children’s Hospital).

14th June - 18th June, 2015

- 19th International congress of Parkinson’s disease and movement disorders, San Diego, USA
Objectives of the fellowship:

1. To better define the causes of movement disorders in children with basal ganglia lesions on Magnetic Resonance Imaging (MRI).
2. To observe the organisation and service delivery of multidisciplinary paediatric movement disorder services in two referral centres in the UK.
3. To learn patient selection, pre-operative workup and management of paediatric patients with movement disorders who undergo Deep Brain Stimulation
4. Attend the 19th International congress of Parkinson’s disease and movement disorders in San Diego
# Timetable during stay in London

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<th>Day</th>
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<td>Monday</td>
<td>Otto Wolff lectures at ICH</td>
<td>Movement Disorder Clinic - GOSH</td>
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<td>Tuesday</td>
<td>Data compilation and MRI export</td>
<td>MRI project rating</td>
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<td>Wednesday</td>
<td>Research Group Meeting – ICH</td>
<td>MRI project rating</td>
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<td>GOSH Neuroradiology meeting</td>
<td>GOSH Neurology</td>
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<td>Thursday</td>
<td>New DBS referral clinic – ELCH</td>
<td>Movement Disorder Clinic – ELCH</td>
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<tr>
<td>Friday</td>
<td>Data compilation</td>
<td>Queen Square Basal ganglia club meeting</td>
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A study of basal ganglia lesions on MRI in children

**Background:** The “basal ganglia” are parts of the brain that lie deep under the normal thinking parts (grey matter) and cabling parts (white matter) [Figure 1]. We know from decades of research that they are responsible for how the body moves in a well-tuned manner but the mechanisms of their working are still poorly described. Any disorder that affects these parts of the brain can lead to a problem of movement – called a “movement disorder” that may be of various types [Table 1]. In children, this can happen due a number of reasons that includes

1. Infections
2. Problems with how the body and brain use energy – called metabolic disorders
3. Genetic disorders that may
   a. result in some of these metabolic problems
   b. lead to premature degeneration of the basal ganglia or
   c. cause them to function poorly
4. Injury at the time of birth, before birth or later in life resulting in Cerebral Palsy and
5. Sometimes due to autoimmune disorders where the body attacks itself.

When doctors find changes in the basal ganglia on MRI in children, it is important to recognise and differentiate the cause that may be from one of the many categories listed above for the following reasons:

   a. Some infectious, metabolic and autoimmune disorders that cause changes in the basal ganglia in children may be treatable and hence reversible.
b. In longstanding but (currently) untreatable conditions, such as genetic disorders, diagnosis often provides closure to families and helps in genetic counselling. MRI pattern recognition can help narrow down a list of genes that need to be tested.

c. Diagnostic categorisation can help in giving a better prognostic idea to families and also helps avoid unnecessary repeat MRI and other investigations.

Figure 1. An axial (horizontal cross section) view of the brain on MRI demonstrating some components of the basal ganglia (Caudate, putamen, globus pallidus). © Shekeeb S Mohammad
### Table 1. Description of various movement disorders seen in children

<table>
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<tr>
<th>Type of movement disorder</th>
<th>Description</th>
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<tr>
<td>Athetosis</td>
<td>Slow, writhing, limb movements.</td>
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<tr>
<td>Ballism</td>
<td>Flailing limb movements.</td>
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<tr>
<td>Bradykinesia/Akinesia</td>
<td>Slowness or inability to initiate movement (similar to parkinsonism in adults).</td>
</tr>
<tr>
<td>Chorea</td>
<td>Spontaneous, semi-purposeful random movements of the limbs, body, face and tongue</td>
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<tr>
<td>Dystonia</td>
<td>Sustained, patterned, twisting movements of the body, neck or limbs, often provoked or worsened by specific tasks.</td>
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<tr>
<td>Myoclonus</td>
<td>Lightning like jerks due to sudden muscle contraction. (Such as experienced in normal individuals when falling asleep).</td>
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<tr>
<td>Perseveration</td>
<td>Inappropriate maintenance of a posture or repeated movements after the stimulus provoking the movement has stopped.</td>
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<tr>
<td>Stereotypy</td>
<td>Movements that are often provoked by excitement and are distractible. They occur in the same pattern over and over again.</td>
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<tr>
<td>Tremor</td>
<td>Rhythmic or oscillatory movements.</td>
</tr>
<tr>
<td>Tics</td>
<td>Intermittent, jerky movements that are often preceded by an urge to perform the movement.</td>
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Adapted from e-supplement in Mohammad et al. ¹
Planning of the MRI study: I planned a study to systematically analyse the pattern of MRI changes in children with involvement of the basal ganglia to enable doctors to narrow down their diagnostic lists when they see such scans in the future. I required a large set of MRI scans with such changes from children who were already diagnosed. This was one of the major reasons for choosing Great Ormond Street Hospital (GOSH) in London for my Churchill fellowship along with other important factors

a. Expertise in neuro-radiology available at GOSH

b. Easy access to a variety of well characterised patients with a range of conditions

c. Complementing my other objectives with availability of a clinical service for children with movement disorders

The main components of preparation for my study were:

a. Ethics approval both locally and in London to access MRI scans and use them for rating after removing patients’ identifying information.

b. Development of a valid rating system to score MRI scans in collaboration with Dr. W Kling Chong, the collaborating neuroradiologist in GOSH.

c. Collection of eligible scans prior to my departure in Sydney.

d. Contacting various specialists and interrogating databases in London during my first 2 weeks there to collect other scans.

Final database: I compiled MRI scans of ~230 children with diseases representing almost all currently recognised genetic, metabolic, infectious, autoimmune and injury related/toxic conditions known to cause basal ganglia changes on MRI. These were all rated in 16 sessions spanning 6 weeks in London resulting in a rich database that is now the subject of statistical analysis. I plan to
validate our rating by allocating random samples of these scans to other neuro-radiologists in Sydney and London and then compile my final results for dissemination at the respective hospitals and also for publication in a peer-reviewed scientific journal.

**Day visits for MRI compilation:** I made day visits to Birmingham children’s Hospital and Leeds General Infirmary to collect information about some candidates of my MRI study. These were facilitated by my supervisor Prof.Russell Dale in Sydney and Dr.Manju Kurian in GOSH and resulted in valuable additions to my database. Dr.Evangeline Wassmer in Birmingham and Dr.John Livingston in Leeds were very welcoming and lent full support to my study in addition to some valuable tips that helped me improve the study methods. I was lucky to visit Birmingham on one of Dr.Wassmer’s neuro-metabolic clinic days where I saw several patients with movement disorders and was able to observe the similarities and differences in her team’s approach to managing these patients in comparison with us in Sydney and the centres in London.
Multidisciplinary paediatric movement disorder services in the UK

The other main reason for choosing London for my fellowship was the opportunity to attend two well-established movement disorder clinics at GOSH and Evelina London Children's hospital (ELCH). These clinics are both quaternary services where paediatricians and other paediatric neurologists from the UK and elsewhere refer patients for very specialized opinion. Consequently their annual turnover of >300 patients each provided me with the opportunity to sample a cross section of their respective patient loads during my fellowship.

GOSH

GOSH was founded in the mid-19th century as the first hospital for children in England. It has grown from a 10-bed facility to one of the world’s leading children’s hospitals. It functions as a quaternary hospital in that it does not have an emergency department and admits patients only based on referrals, mostly by paediatricians or paediatric sub-specialists. This is different to the referral structure of children’s hospitals in Australia and New Zealand.

GOSH Movement disorder service:

The movement disorder service at GOSH is structured in three major groups

a. Clinical movement disorder clinics run by Dr. Manju Kurian with a focus on advanced diagnostics and pharmacological treatment.

b. Neurodisability clinics: Rehabilitative aspects of treatment of movement disorders which are run by specialists in neurodisability. This service works closely with occupational and physiotherapists and is similar to rehabilitation services in Australia but with special expertise in neurological rehabilitation.
c. Research based diagnostics in genetic and metabolic movement disorders and cutting edge research in developing gene therapy for some of these disorders. This is run by Dr. Manju Kurian with her expert group of post-doctoral and doctoral scientists at the Clinical and molecular genetics unit within the Institute of Child Health (ICH), affiliated with University college London (UCL). ICH and GOSH together form the largest concentration of children's health research in Europe.

**Dr. Manju Kurian:** Dr Kurian is an academic paediatric neurologist who has worked at Great Ormond Street Hospital since March 2011. She is also affiliated to the Neurosciences Unit at ICH, UCL where she heads a highly skilled research group. Her research group hosted me during my days at GOSH. Their areas of research include molecular genetic investigation of:

1. Early onset epileptic encephalopathy
2. Neurodegeneration with brain iron accumulation
3. Early onset and other genetic movement disorders
4. Dopamine transporter deficiency syndrome (first described by Dr. Kurian): functional characterization and therapeutic approaches.

Dr. Kurian is an academician par-excellence with worldwide recognition in her field of work. She was immediately very welcoming from the planning stages of my fellowship and proved to be an excellent mentor. She assisted immensely in planning my MRI project, recruiting patients from the UK in a very short period of time and also linking me up with important contributors Dr. Evageline Wassmer from Birmingham and Dr. Susan Hayflick from Portland, USA who added to my MRI study cohort.
**Clinical model:** Dr Kurian’s movement disorder clinics were held weekly, comprising of 8-10 patients in each clinic. Almost all of the patients I met in these clinics had already been seen by paediatric neurologists who had referred them for specialized opinion to GOSH. They included patients belonging to one of the categories mentioned above and other movement disorders. They were referred for diagnostic and treatment purposes. I was able to observe and learn from practical management strategies for patients with various neurometabolic and genetic disorders, particularly for neurotransmitter disorders. The clinics also gave me a clearer perspective into the role of current diagnostic approach for families who have children with rare genetic disorders. Invariably, all families were relieved to have closure if their children had been recently diagnosed and been given a name for their disease, often after waiting for years. In addition to diagnostic closure, these genetic discoveries have already led to initiation of research into understanding how they result in disease and how the diagnostic information may be used to tailor therapy and develop gene therapy. Most patients with suspected genetic movement disorders are now tested by gene panels, which can test for dozens of genes at once in contrast to single gene tests till a few years ago. If testing for recognised genes is negative, patients are often enrolled in research based next generation sequencing for the coding part of our DNA – called whole exome sequencing. I was able to learn the process of patient selection for such testing and the selection of genes for panels tailored for children with movement disorders.

**Exposure to basic science research:** Dr.Kurian’s research group is engaged in diagnostic gene discovery for many rare neurometabolic disorders and genetic movement disorders. They have already been a part of many such discoveries\(^2,^5\).
During my fellowship, it was a unique experience for a pure clinical researcher like me to spend time and work with many basic neuroscience researchers in the group. The research group had a weekly combined “lab meeting” with every member discussing updates to their work and canvassing for possible solutions to any questions that may have arisen. This contributed immensely to my understanding of intricate aspects of the disorders that I see in my patients and also led to several research collaborations. In addition, these weekly meetings were vital in timing my progress and keeping me on track by setting and revising my strategy and targets for the various objectives of my fellowship.

**Dr. W Kling Chong**

Dr Chong is a consultant paediatric neuroradiologist at GOSH. He is one of few full-time paediatric neuroradiologists in the UK and currently heads the service at GOSH. Dr Chong guided me through compilation of the database for my basal ganglia MRI study and refining my research methodology. I completed rating all the scans for the project during my fellowship with Dr Chong’s generosity in sharing 2 hourly slots from his busy weekly schedule. I also attended weekly neuroradiology meetings run by Dr.Chong or one of his neuroradiology colleagues. In addition to the intended goal of finishing my project, these meetings were invaluable in educating me about many intricate aspects of neuroradiology that I will be able to use in my clinical and research practice and will be able to share with colleagues in Australia.
ELCH

ELCH Complex motor disorders service:

ELCH is situated on the St Thomas' Hospital precinct opposite Westminster and the houses of parliament. It is administratively a part of Guy's and St Thomas' NHS Foundation Trust and provides teaching hospital facilities for London South Bank University and King's College London School of Medicine. I was hosted by Dr. Jean-Pierre Lin at ELCH. Dr. Lin is a paediatric neurologist who is an expert in paediatric movement disorders. He has extensive experience in caring for children with genetic and acquired forms of brain injury, many of whom suffer from movement disorders in addition to other problems. Dr. Lin and his colleagues (Figure 2) have meticulously established a comprehensive service for such children – the Complex motor disorder service (CMDS). The CMDS bridges diagnostic and therapeutic services in movement disorders and neurodisability.

Figure 2. A schematic representation of the Complex motor disorders service at Evelina London Children’s Hospital, which provides comprehensive assessment and management of children with movement disorders, including deep brain
stimulation (DBS) for dystonia in childhood. The service is linked with neurosurgery support via King’s college hospital, London.

**Neuromodulation:**

Intrathecal baclofen: Baclofen is a medication that works on the spinal cord and possibly at some centres including the basal-ganglia to help relax muscles that are abnormally tight. This is pertinent for children who have suffered brain injury, such as those with cerebral palsy, where they have tightness of their limb muscles – a condition called spasticity. To a lesser extent, baclofen can help alleviate dystonia (see Table 1 for description) as well. When taken orally, the sedating effects of baclofen often limit reaching high doses needed to produce muscle relaxation. A technique of delivering baclofen directly to the fluid inside the brain and spinal cord called – Intrathecal baclofen (ITB), has been available for medical use for some time. ITB pumps can deliver very low doses of the medication with the aid of a programmable, implanted pump. The CMDS service at ELCH assesses children who might benefit from an ITB pump and co-ordinates pump implantation by the neurosurgery team and then follows up patients with dose adjustments, pump refills and troubleshooting.

**Deep brain stimulation:** A technique to deliver electrical impulses to precisely targeted structures within the brain was first developed in the late-mid 20th century. Neurosurgeons are now aided by advanced medical imaging to plan this precise targeting – a process known as stereotactic surgery. Over time, clear benefit from targeting parts of the basal ganglia have been noted in Parkinson’s disease and dystonia in children and adults. The NHS in the UK recognizes the utility of this procedure and covers the cost for children who are assessed by experts such as Dr. Lin to be suitable candidates for surgical treatment of
dystonia by DBS. In Australia, only Parkinson's disease is recognised as an indication for DBS for coverage by Medicare. Few children's hospitals in Australia and New Zealand, including my current place of work at the Children's hospital at Westmead, have undertaken this procedure. Our own experience is limited to 5 children with funding arranged on a patient-to-patient basis.

Service model of the CMDS

Similar to the clinic at GOSH, the patients referred to this service are often already being managed by specialists. The CMDS fulfills several roles in addition to day-to-day inpatient and outpatient care:

a. Assessment of suitability of children for neuromodulation in the form of DBS
b. Serial detailed scoring of children's functional abilities by dedicated therapists
c. Passing back vital management tips to referring team of doctors and therapists nearer to the patients' homes
d. Face to face and remote trouble shooting for patients with DBS units and intrathecal baclofen pumps

I attended weekly clinics at ELCH on Thursdays. The morning clinics were focused on patients with movement disorders who had been referred for consideration of DBS. Each patient was reviewed for 60-90 minutes in the presence of an occupational therapist. Detailed videos were taken for each patient with the family's permission observing the child undertake many tasks of play as well as while being examined. The CMDS have a comprehensive video library for each patient in their medical records, which helps in evaluating patients' progress and observing their improvement after any intervention.
Their practice illustrates the use of readily available video technology as a vital tool in today's clinical practice, particularly in movement disorders.

The selection process for DBS is based on the type of movement disorder the child had, the underlying cause of the disorder, the age of the child and adequate understanding on the family’s part. Dr. Lin’s service has championed the use of DBS for children with movement disorders and are able to consider the procedure for children >10 kg in weight. My experience attending the clinics was invaluable in learning several key points for children who may benefit from DBS

a. Children with dystonia are particularly likely to benefit from this mode of treatment

b. Children with genetic forms of dystonia, which generally do not lead to progressive brain damage as seen on MRI are likely to demonstrate more easily observable benefits than those with existing or progressive brain injury

c. Some dystonic children with progressive disorders or existing brain injury as may be seen on MRI are still likely to demonstrate benefit from the procedure though this may not be similarly observable using conventional scales that are not tailored for such patients. (The CMDS team includes several members who are actively researching the use of novel monitoring and assessment scales that are tailored to children with disability8, 9).

d. The benefits of DBS are likely to be higher if children have a shorter “Life already lived with dystonia” as demonstrated in previous research by Dr. Lin and colleagues10.
More information about the service can be found here:


If a patient was considered to fit the criteria for consideration of DBS, they were scheduled to come back to ELCH for a 1-2 day visit at a future date for multiple assessments. Except in rare circumstances demanding urgency, the decision making and assessment process for DBS is carefully planned and spread over a period of time which allows families to understand what is involved in the process and get a realistic idea of setting goals to be achieved after surgery.

Afternoon clinics at ELCH were review clinics for patients seen previously and for new patients with other movement disorders who did not require consideration of neuromodulation.
Meetings and Lectures

**Otto Wolff Lectures:** I was able to attend a series of Otto Wolff lectures at ICH. The lectures are named after one of the great GOSH/ICH Clinical Professors of Paediatrics, Otto Wolff, who maintained an active interest in Paediatrics and attended many of the sessions until his death at the age of 90, in April 2010. The Lectures are held in the Kennedy Lecture Theatre in ICH. Some of the talks I attended were:

- **Speaker - Dmitri Kullman** (Renowned neurologist and editor of the leading neurology journal – BRAIN)
  
  Topic: Gene therapy for refractory epilepsy: time for clinical trials?

- **Speaker - Helen Firth:** A Consultant Clinical Geneticist at Cambridge University Hospitals Trust
  
  Topic: The Deciphering Developmental Disorders (DDD) project ([http://www.ddduk.org](http://www.ddduk.org)). This nationwide project to genetically diagnose rare diseases has finished recruitment and is working with 12,000 families to diagnose their child's developmental disorder, demonstrating the feasibility and value of introducing large-scale sequencing diagnostics into health care. The DDD project has so far found a diagnosis for nearly a third of the first 1000 families analysed.

**Neurology tutorials at GOSH:** I attended weekly tutorials/presentations in the Neurology department at GOSH with talks from local and visiting experts covering several cutting-edge topics in paediatric neurology such as neurometabolic disorders, interferonopathies, paediatric stroke and epilepsy. I
was invited to present on a clinic-radiological approach to basal ganglia disorders in children in one of these meetings.

**Basal ganglia club:** The Basal Ganglia Club is an institution at the National Hospital for Neurology and Neurosurgery (NHNN), Queen Square (started 1983). It continues to be an excellent opportunity for both attendees and experts in the field to exchange clinical experience and new research findings. I attended a couple of sessions which provided an excellent learning and networking opportunity.

**Queen square video meetings:** The Sobell Department of Motor Neuroscience and Movement Disorders houses one of the world’s most renowned movement disorder service. I was able to attend a couple of the monthly video sessions discussing intriguing movement disorder cases, with interactive discussions and updates on new advances in diagnostics and treatment.

**The Gowers Grand Round at NHNN, Queen Square, London**

The NHNN continues the tradition of weekly grand rounds – famous as the Gowers grand rounds in honor of eminent neurologist - Sir William Richards Gowers. Live patients participate in this interactive session every week, with neurology trainees facing probing questions that are then moderated by experts from the faculty. I attended a couple of these sessions, which I found to be inspiring and educational, on the recommendations of my referees.
The 19th International congress of Parkinson’s disease and Movement Disorders


The international congress of Parkinson's disease and movement disorders is held annually and organized under the auspices of the Movement disorders society ([http://www.movementdisorders.org](http://www.movementdisorders.org)). I had the privilege to be invited to this year's congress in San Diego as a speaker. The topic of my talk was “Sydenham’s chorea and movement disorders in systemic autoimmune disorders”. This topic is linked to my interest in movement disorders and has formed part of my previous research. Sydenham chorea (SC) is a type of movement disorder that can have its onset in children and young adults after throat infection with bacteria called streptococcus. Along with involuntary movements, the affected individuals often have difficulties with emotional and mood control. Most patients can recover with time but have to be closely monitored for heart disease that can occur in many of them. SC carries the name of Thomas Sydenham who described this disorder in London in the early 17th century. Subsequently the understanding of SC was advanced by major works produced by prominent neurologists based in the hospital campus around Queen Square and GOSH where I was based during my fellowship. This included Sir William Richards Gowers, Samuel Alexander Kinnier Wilson and many others including my current research supervisor Professor Russell C Dale. SC is the oldest example of an autoimmune movement disorder where the body’s own protective immune system may attack some parts like the basal ganglia, heart and joints. If this immune response is controlled, then disorders such as SC may
be controlled or treated early. My talk focused on recent advances in the understanding of SC and other such autoimmune movement disorders as well as ways to treat these disorders.

In addition, the conference provided me with an update on latest advances in the fields of understanding, diagnosis and treatment of movement disorders as well as the opportunity to meet world-renowned experts in the field.
Recommendations

1. Service model: Further develop the existing movement disorder service at the children’s hospital at Westmead and build collaborations with other children’s hospitals in Australia and New Zealand in caring for children with movement disorders.

2. Incorporation of existing allied health expertise in occupational therapy, physiotherapy, psychology, psychiatry, neurosurgery and neuro-rehabilitation into a dedicated service for children with movement disorders in Australia.


4. Coordination of genetic testing and research into paediatric movement disorders at a national level and building on international collaborations developed during my fellowship.

5. Setting up a nationwide collaboration for neuromodulation in paediatric movement disorders and participating in an established international DBS registry.

6. Initiate dialogue and work towards facilitating a nationwide funding model for paediatric DBS and research into rare causes of movement disorders.

7. Rationalize the use of MRI in basal ganglia disorders and integrate results from my study of MRI pattern recognition to guide focused diagnostic testing.
Dissemination and implementation

1. I will have the opportunity to apply my improved skill and knowledge in the diagnosis and management of children with movement disorders into my clinical practice as a specialist in movement disorders, and to present the knowledge I have gained at clinical and scientific meetings.

2. I will finish statistical analysis and compilation of results from my MRI study and submit this for publication to a peer-reviewed journal. I aim to make the resulting algorithm available as an open-source electronic tool that can be freely used by clinicians around the world.

3. I plan to collaborate with many of the scientists and researchers I have met through the Churchill Fellowship in order to provide access for local patients to newer genetic tests and genetic research techniques not currently available in Australia.

4. I plan to advocate and work towards the establishment of a centre of clinical and research excellence in paediatric movement disorders in Australia.
References