Microbiology Services: preparedness and response London 2012 Olympic and Paralympic Games

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1. Microbiology Services (MS) Division – preparedness

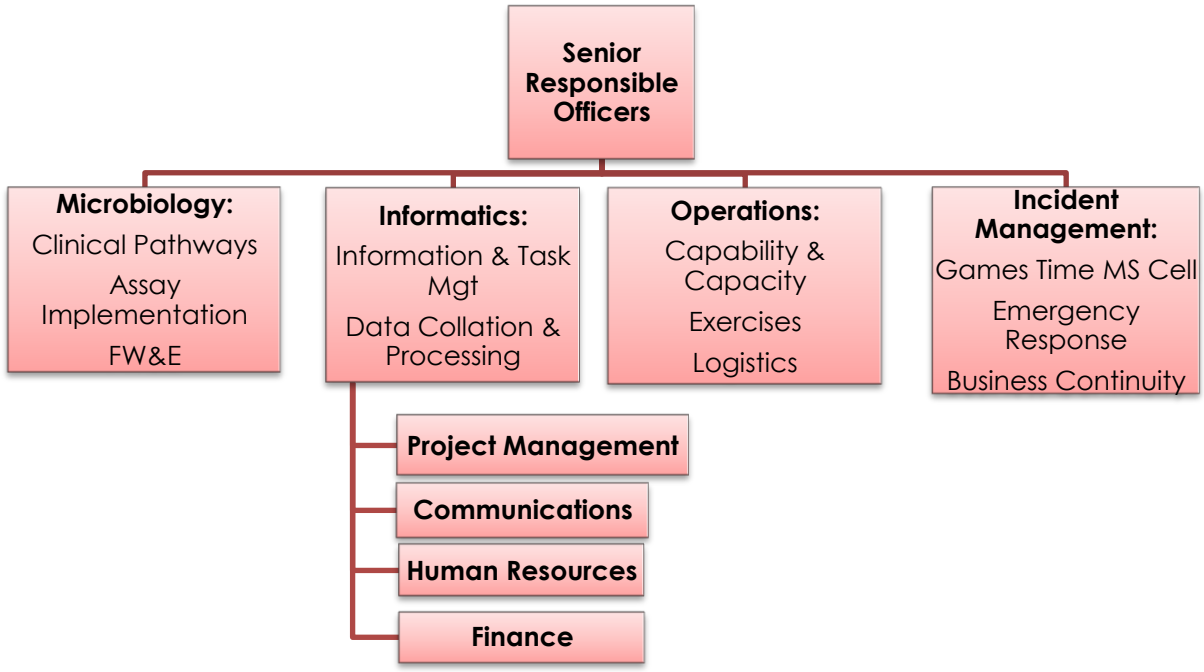
1.1 Coordination of activities within Microbiology Services (MS) Division

A coordinated programme of activities was initiated in December 2010. The MS Games Planning Group was convened under the leadership of the Senior Responsible Officers and work streams were initiated in the following key areas (Figure 1).

- Microbiology - clinical and laboratory diagnosis (clinical pathways, assay implementation)
- Food, water and environmental (FW&E) microbiology
- Informatics (information and task management, data collation and processing)
- Operations (capability and capacity, exercises and logistics)
- Incident management (Games time MS cell, emergency response, business continuity).

The work streams were led by senior staff from around the Division and underpinned by project management, communications, human resources and finance activities.

Figure 1 – MS Olympic Planning Group work streams



The MS Olympic Planning Group held project meetings every 6 weeks until July 2011, and monthly thereafter until the start of the Games time working period at the beginning of July 2012. All planning assumptions and preparations were communicated to all staff via the HPA Games Newsletter and via staff web-casts in December 2011 and March 2012.

1.2 Planning assumptions

The Olympic and Paralympic Games were regarded as an 'event' rather than an emergency situation. The MS planning assumptions were based on the requirement to respond to a major outbreak of infectious disease associated with the event through a generic coordinated response whilst maintaining other essential services. Such a pattern of working was termed the "enhanced business as usual" model.

An outbreak could have an explosive impact on many different parts of the country's health infrastructure, including acute care provision, diagnostic testing, reporting, intervention and surveillance; this was a valuable lesson learnt from the influenza pandemic in early 2009.

Enhanced clinical, public health and environmental microbiology laboratory capability and capacity would be required to meet increased demands during the Games period, as well as the maintenance of a rapidly scalable capability for response to outbreaks of infectious diseases. A lower threshold for response to potential public health incidents requires the provision of rapid, accurate diagnoses and expert advice 24 hours a day, as well as the provision of surge capacity. Workforce planning was therefore essential to ensure staffing resilience. Workforce planning was undertaken in all frontline microbiology laboratories to ensure coordinated staff holiday arrangements, and adequate staff cover for evening and weekend periods through on-call and altered patterns of staff working.

A risk management approach involved assessing the likely communicable disease threats on the basis of historical reports from mass gatherings. The key disease syndromes that were identified as most likely to affect people attending the London 2012 Games were gastrointestinal (norovirus, salmonella and *E. coli*); respiratory (influenza and legionella); waterborne diseases (leptospirosis, cryptosporidium and infections occurring as a result of an infected water supply); and rash (e.g. measles). As a result these disease syndromes were identified for enhanced surveillance with a requirement for frontline microbiology support and, in the case of gastrointestinal pathogens, molecular diagnostic assay development.

1.3 Diagnostic response

Novel real-time PCR-based assays were developed and evaluated to address specific diagnostic gaps and improve the time for detection of infectious aetiology. A set of gastrointestinal (GI) multiplex PCR assays was developed to facilitate rapid diagnosis of GI infections of public health significance, with particular application to the Olympic Games period. These were intended to be used only where rapid diagnosis would influence public health activity, such as in outbreaks or in patients with links to Olympic events or venues. The targets for the assay included parasitic, bacterial, viral and internal control targets (Table 1).

For rapid detection in environmental samples a similar range of real-time PCR assays was available in the HPA Food, Water and Environmental microbiology laboratories. Viral PCRs (influenza A H1N1 2009; other influenza A; influenza B; RSV; adenovirus; parainfluenza virus; rhinovirus; human metapneumovirus) were also available during Games time together with normal routine microbiological services. The application of molecular tests was intended to reduce the time required to achieve definitive diagnosis, thus enhancing the capability to provide an early intervention. In addition, a gap analysis of microbiological capability unrelated to the Games identified a need to develop and implement a rapid molecular assay for the diagnosis of leptospirosis, which was considered a theoretical risk to participants and staff in the freshwater sporting events.

1.4 Clinical response

Clinical diagnostic algorithms were produced for various syndromic presentations of diseases with public health significance; these were developed in consultation with epidemiological colleagues, laboratory scientists and clinicians. The scope of the algorithms was determined by consideration of likely clinical presentations of affected athletes and spectators following mass gathering exposure, and the potential for unvaccinated visitors contracting communicable disease. Likely common scenarios included clusters of 'rash illness', isolated suspected meningococcal disease, respiratory tract infections, undiagnosed serious illness, water-related infections and diarrhoea and vomiting outbreaks. These were published on the HPA website to help clinicians and microbiologists.

1.5 Training and exercises

The MS Division participated in a variety of national and local exercises that were organised by LOCOG from autumn 2011 onwards, in order to provide assurance of high level command and control arrangements, cross governmental communication, and the ability to respond to

simultaneous incidents of escalating severity. A series of training days were developed for staff in all roles related to the Games, and in particular for the MSDD role. Staff at regional and specialist laboratories were trained in the use of the new multiplex assays, including validating them on local platforms.

In addition, the MS Division organised two internal exercises to test decision making and technical resilience. Frontline HPA clinical as well as HPA FW&E microbiology laboratories participated in real time laboratory exercises using public health scenarios and simulated samples containing live organisms. This allowed assessment of responses to public health scenarios, quality of microbiological output, turnaround time, public health advice provision, referral to reference laboratories and communication with the Olympic reporting structure and surveillance systems, well in advance of Games time. Scenarios used were those considered to be possible threats during the Games, such as a new influenza subtype, Panton-Valentine leukocidin *Staphylococcus aureus* outbreak, gastrointestinal infection outbreaks (e.g. VTEC and salmonella) and imported diseases in visitors. The ability to deploy specialised sampling kits for clinical, food and water testing was also tested, providing valuable lessons in logistics. Such scenario based exercises led to improvements in the reporting systems, and better understanding of risk assessment and communication requirements during the Games.

A second exercise developed by MS Specialist Registrars in liaison with the HPA Emergency Response Division was designed to test laboratory operations, logistics and surge arrangements. It simulated an incident involving multiple laboratories, and involved the distribution of real samples. The full MS Games time communication and reporting structure was tested.

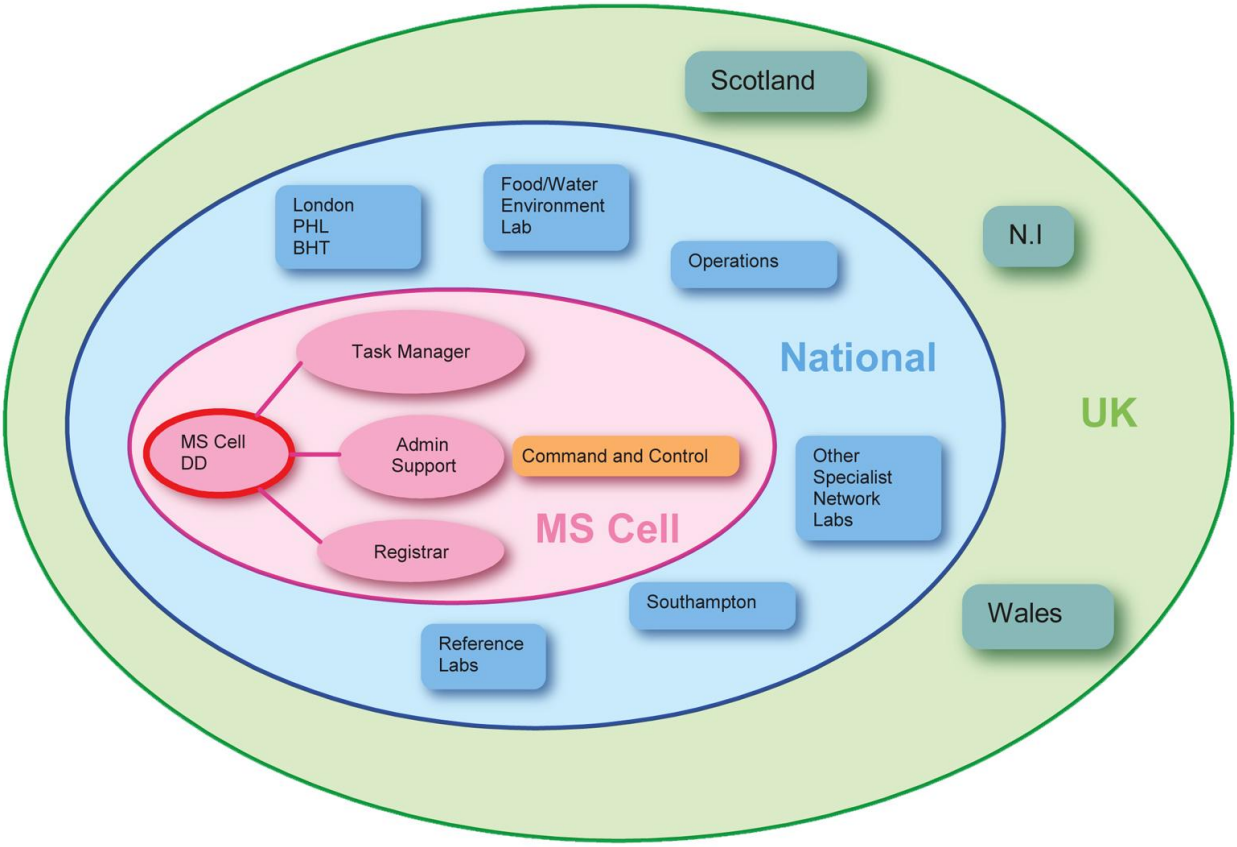
2. Microbiology Services – service delivery

The activities of the HPA Microbiology Services Division (MSD) during the Games were coordinated from a central Microbiology Services (MS) Cell based in Colindale and led by a Consultant Microbiologist as the Microbiology Services Duty Director (MSDD). The HPA MSD network of laboratories provided laboratory testing and clinical/public health support during the Games. HPA Colindale provided a reference service and primary specialist testing for a range of infectious diseases. The HPA FW&E Microbiology laboratories provided support for public health investigations around Games venues with testing to provide assurance on quality of food and water. Specialist diagnostic services were available for rare and imported pathogens at HPA Porton and Colindale.

2.1 The command and control model

Being the overall focal point for the MS Division, the MSDD adopted a 'command and control' role that involved oversight of any Olympic-related activity in both specialist and reference laboratories. Each MSDD was on duty for a week at a time and provided 24-hour, 7-day cover. They were supported by a Specialist Registrar, a Scientist Grade Task Manager and administrative staff. The main functions of the MS Cell were to coordinate a National Microbiology response on a day-to-day basis; to provide Clinical Microbiology advice to the SITREP team; and to oversee the investigation and risk assessments for evolving incidents through close liaison with Reference and Specialist laboratories. For a schematic representation of the "command and control" model, see Figure 2.

Figure 2: Command and Control Model of Service Delivery



2.2 Diagnostic Service

The novel rapid multiplex molecular assay developed for the diagnosis of the common agents associated with infectious diarrhoea was clinically validated and rolled out to two frontline laboratories : the London Public Health Laboratory (Barts Health Trust) and the Southampton HPA Laboratory. Surge capacity was provided by Cambridge and Manchester Public Health Laboratories (Figure 3). The assay had a turn around time of up to 24 hours, with same day testing and reporting being possible depending on timely transport of the sample to the laboratory. A network of FW&E laboratories provided testing of food and water samples (Figure 3). A new leptospirosis molecular assay was also available during the Games. In addition, a multiplex viral PCR used for routine diagnostics (influenza A H1N1 2009; other influenza A; influenza B; RSV; adenovirus; parainfluenza virus; rhinovirus; human metapneumovirus) was available during Games time together with routine microbiological services. Enhanced turnaround times, electronic data reporting and swift communication lines to the HPUs were organized. An H3N2 virus risk assessment was put in place responding to international reports of a possible threat.

Figure 3: Frontline and Specialist Network Laboratories

Figure 4: Network of Food, Water and Environment Laboratories

2.3 Clinical Service

Details of all MSD Services were available in a comprehensive *Guide for Client*s. The purpose of this guide was to provide easy access to key information on Games-related sample collection, transport, testing and reporting, as well as other issues related to laboratory surveillance, expert advice and communication. Clinical diagnostic algorithms that were produced for various symptomatic presentations of public health significance were included in the Client Guide.

2.4 Communication

Together with Health Protection Services Colindale (HPS-C), MSD contributed to the Colindale Operations Centre. The MSDD participated in a 0915hrs daily business meeting at Colindale and provided a daily verbal report to the regular 1215hrs Colindale meeting prior to the daily HPA-wide 1230hrs teleconference. The Ms Cell worked closely with the HPS team at Colindale and contributed to the Colindale SitRep that was despatched daily for inclusion into the HPA wide SitRep. The MS Cell received input from established permanent laboratory reporting systems, which was used to produce exceedance scores that highlighted unusual disease activity. The MS Cell also received tabulated daily results of respiratory and GI PCR results via a system called 'datamart'. Each laboratory within the HPA contributed a 'daily return' or 'exceptional reporting'.

MS Cell ran a daily 1600hrs teleconference chaired by the MSDD that included representation from the Specialist network laboratories undertaking frontline testing; the FW&E and Reference laboratories; Operations personnel; and the Devolved Administrations. Key information was shared at these meetings and a daily briefing was sent by email to the whole of MSD. This pattern was repeated during weekends.

2.5 Provision of a Coordinated Food Water and Environmental (FW&E) Microbiology Service

Provision of FW&E Microbiology Laboratory services for London 2012 was undertaken as part of the HPA Microbiology Service (MS) Division's overall response. For FW&E preparation the following areas were identified as important: advice and training; sampling support; transport and logistics; rapid testing and reporting; information management; and scale up for incidents. All of these areas of activity required some pre-Games activity through changes in practice, writing of procedures and support documents, simulation, exercise and communication.

Activities affected all five FW&E Microbiology Laboratories. Most were around London, and to a lesser extent Porton: approximately 10% of the workload of the London Laboratory was devoted to Olympic activities between April and September 2012. Most of the activities were associated with monitoring (particularly water) to assist Joint Local Authorities of Regulatory Services (JLARS) in the verification of outlets to allow them to be commissioned. Results from these laboratory tests informed public health interventions including relaying water pipe runs, assurance of cleaning for drinking water fountains and evidence for public information on suitability of sources for human consumption. Water, food and environmental monitoring was also carried out to assist Local Authorities (LAs) as part of inspections of marinas, hotels, training camps and ships used by competitors and Olympic staff. Samples from swimming pools, spa pools, water systems, food services, and mobile food vendors along the torch, cycling and running routes were also tested. Monitoring was also carried out to assess the quality of seawater at Weymouth, and to assess the water quality of water features on the Olympic Park. Support was provided to Local Authorities dealing with hygiene problems associated with food manufacturers in the Olympics food chain (sandwiches, meat pies and sliced meat products). Advice was also given to Outbreak

Control Teams dealing with norovirus outbreaks amongst athletes, and in one instance results of sampling for microbiological analysis were used to assess food hygiene in a hotel. Advice and sampling support was also given following the detection of *Legionella pneumophila* in the water system of a ship providing accommodation to Olympic Park staff and volunteers. No cases of Legionnaires' disease were identified but there was a Press enquiry about "an outbreak".

2.6 Analysis of Microbiology Services Output during Games time

There were no major outbreaks during Games time, as is evident from the numbers of samples tested in the Specialist and Network Laboratories. Microbiologists and Scientists were, however, involved in a number of incidents involving Public Health Microbiology (Table 4; Figure 5) and FW&E Microbiology (Table 5; Figure 6). Figure 5 illustrates the clinical and microbiological input into the different infectious disease syndromes. The volume of work (on the Y axis) is weighted by the number of episodes/incidents that required either clinical or microbiological input. For example in the week 2-8 July, there were episodes or incidents where 12 individuals / specimens were reported/laboratory tested for GI infections. Gastro-intestinal infections accounted for the majority of input from clinical and scientific staff. Rashes related to cases and contacts of chicken pox and one case of Parvovirus B infection. The "other" infections included cases of viral meningitis and one case each of mumps and malaria. Figure 6 describes the volume of testing undertaken by the FW&E laboratories either related to clinical incidents or independently as a measure of safety and quality.

Figure: 5 Schematic representation of the Clinical and Microbiology input into specific clinical syndromes during Games time

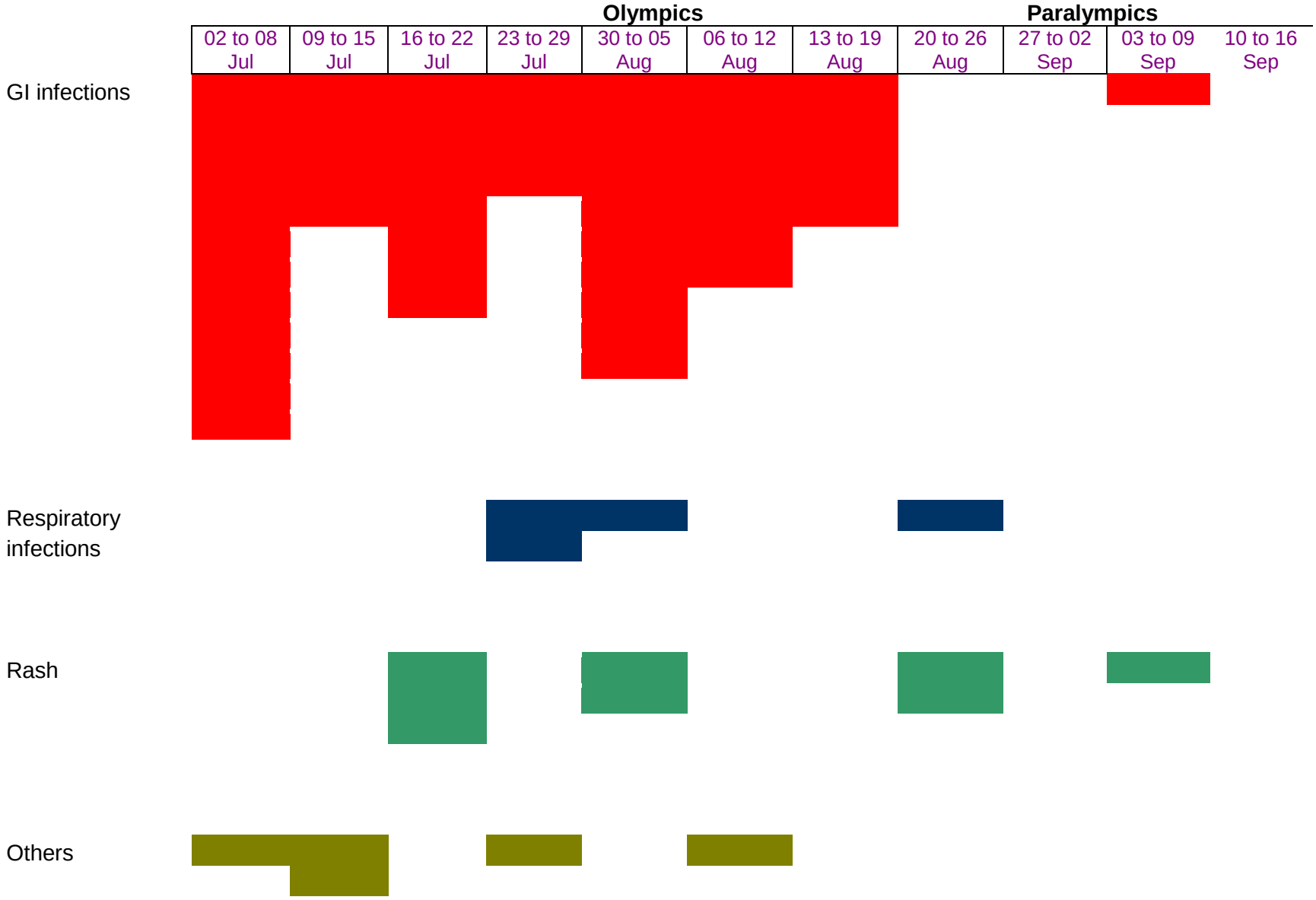
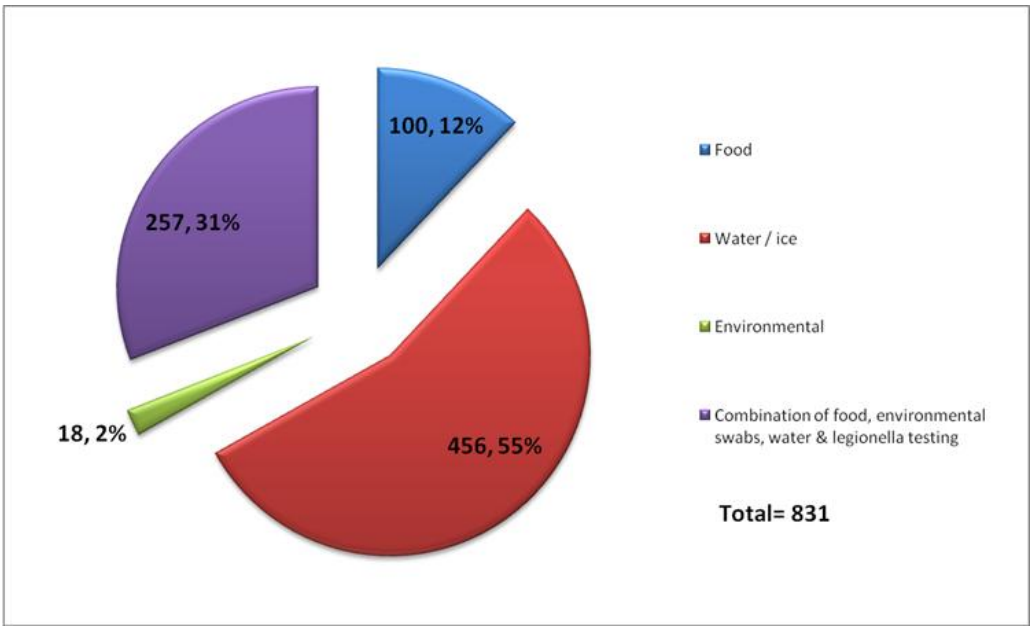


Figure: 6 Schematic of volume and spread of testing conducted by FW&E

Values reflect number, percentage of n=831



2.7 Were our planning processes adequate to meet Games time needs?

Microbiology Services did not face any significant challenges that specifically tested either capacity or capability. The response structure and the processes were found to be fit for purpose and suitable for future emergency and incident response capability. This was tested during large inter- and intra-division exercises. Overall the "enhanced business as usual " model worked well, as MSD also dealt with large non-Olympic related events in the run up to the Games and maintained a response capability for several ongoing level 3 incidents during Games time.

In general our systems were not strained and capacity was not breached. There were contingency measures in place to cope with 24 hour testing availability and enhanced testing over and above the daily workload. Additional laboratory equipment and consumables were held in stock and backup laboratories were prepared to receive specimens if front line laboratory capacity was breached. Clinical validation testing of the GI multiplex PCR continued throughout Games time, and contributed to additional workload rather than actual testing.

In terms of the diversity of organisms that were detected in human and FW&E samples, there were no surprises. As expected GI pathogens were the predominant organisms isolated from human specimens. However MSD was involved in several incidents (ref EBS report) where our Clinical and Public Health input and risk assessment was utilized. The FW&E laboratories also dealt with the expected range of organisms – predominantly coliform and other gut associated bacteria, *Legionella* species, *Listeria monocytogenes* and *S. aureus.*

3. Lessons learnt

Overall the process of delivery of Microbiology Services went very smoothly. However it must be acknowledged that none of the systems put in place were challenged, as there were no major outbreaks/incidents to contend with. In particular, the following areas worked particularly successfully:

- Planning process and inter- and intra-agency working
- National co-ordination
- Communication with other parts of HPA

What did not go so well:

- IT and communications infrastructure suffered a few hitches (but were re-set promptly).
- There were issues with the wording of some of the MS daily briefing reports – this was rectified by seeking clarity
- Full validation of the GI multiplex PCR was not available before the Games – issues remain about sourcing and distributing control material. Delays in planning of the GI multiplex PCR led to delays in full service implementation at Games time and specialist laboratories were involved in completing clinical validation over and above their daily work load.
- A national shortage of medical virology expertise was evident in work force planning, particularly for the frontline London laboratory. This had little impact, as overall the service was not challenged; but was recognized as a major risk.

What are we doing to improve these for future events

Future improvements will involve:

- Improved planning for design and implementation of new assays
- Improved training for end-users (HPU and NHS) in the use and interpretation of new tests
- Improved connectivity and communication through enhanced data capture systems and IT infrastructure
- Improved work force planning for specialist medical expertise
- Improved logistics infrastructure relating to transport of material and the involvement of private partners in Microbiology.

Other challenges were related to LOCOG awarding the Olympic venues Polyclinic microbiology services to a private laboratory. This led to confusion regarding responsibility for sample processing where there was a clear public health implication.

3.1 From a corporate perspective

3.1.1 Human Resources (HR) and Communications

The HR engagement with the entire Olympic Programme for the MS Division would benefit from re-examination and an improved working relationship for future events. Workforce planning for a complex and diverse staff cadre requires an understanding of work patterns within different staff groups. This needs a more flexible approach to remuneration and leave arrangements for a planned event working to an "enhanced business as usual" model.

3.1.2 Relationship with the Food Standards Agency (FSA)

Interactions with FSA staff were cordial, but did not reflect reality on the ground. Full and frank engagement would strengthen this important relationship.

3.1.3 Bioterrorist threat preparation

Most of the time during the Games preparation the "need to know" culture managed to exclude many of the professional microbiologists who did need to have an overview of what was underway. This arrangement needs to be re-visited.

3.1.4 Operational coordination of task and file management

The project management for implementation of tasks was delayed and implementation and testing should have occurred earlier.

3.1.5 Exercises

MSD found the various planned exercises very useful during the lead up to the Games. These highlighted gaps in MSD planning that were addressed, and this improved the overall state of readiness during the games period. The HPA wide exercises also raised issues about professional communications between different parts of the HPA and also the frailty of electronic and IT links across the HPA. The HPA needs a more robust electronic communications system for the future.

3.1.6 Training opportunities for, and contribution made by, postgraduate medical trainees

The preparation and delivery for the Olympic and Paralympic Games were excellent opportunities for trainees to hone their skills in the public health aspects of mass gatherings. Several HPA microbiology/virology trainees were involved in all aspects of preparedness and delivery. In addition, trainees from the NHS were seconded to the MSD to gain experience of working during mass gatherings. MSD acknowledges their contribution.

3.1.7 Legacy

Work on both documentation and capitalisation of legacies of the Games should have visible microbiology input. Key legacies for the Agency include:

- Improved microbiological detection systems: the principles of rapid molecular testing can now be applied to a range of organisms and infectious disease syndromes to deal with current public health issues (*Bordetella pertussis*) and orphan diagnostics such as leptospirosis

- Microbiologists across the agency gained valuable insight into the risk assessment and well-controlled quality assurance of new tests that need to be applied to all new diagnostics
- There was coherent support by MS for other parts of the Agency and for external partners. There was also improved intra-divisional working. This will serve to strengthen intra and inter-Agency working in the future. This should promote early engagement and consultation with MSD in strategic planning and decision-making.
- MSD is now recognized within and outside the Agency as a pre-eminent training facility for all cadres of trainees (medical and scientific) in public health microbiology and virology including those pertaining to mass gatherings. This was strengthened by HPS colleagues who shared their experience and expertise with our trainees.

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2. Tables

Table: 1 Targets of the Gastro-intestinal Multiplex PCR

PCR (no. targets)	Organism	Target
Para1 (triplex)	*Entamoeba histolytica*	18S rRNA
	Giardia lamblia	ss rRNA
	Cryptosporidium spp.	18S rRNA
Bac1 (Triplex)	*Salmonella* spp.	ttr
	Campylobacter coli	ceuE
	Verocytotoxigenic *E. coli*	vtx1
Bac2 (Triplex)	*Salmonella* subsp. 1	hilA
	Shigella spp.	ipaH
	Enteroaggregative *E. coli*.	aag
Bac3 (Duplex)	*Campylobacter jejuni*	mapA
	Verocytotoxigenic *E. coli*	vtx2
Vir1 (Triplex)	Norovirus (GI)	vp2
	Norovirus (GII)	polymerase
	Rotavirus	vp6
Vir2 (Triplex)	Adenovirus 40/41	fibre
	Astrovirus	capsid
	Sapovirus	polyprotein
ICb (Monoplex)	Phocine distemper virus	H
ICb (Monoplex)	Gfp *E. coli* (bac mix)	gfp
ICc (Monoplex)	Gfp *E. coli* (para mix)	gfp
9 PCR assays in total (1 parasitic, 3 bacterial, 2 viral & 2 internal controls)		

Table: 2 Results of Games related specimens processed by the Specialist Network of Laboratories

*1 each for genogroup I and II; ** genogroup I

Laboratory/ Specimens	London	Southampton	Cambridge	Manchester	Birmingham	Leeds	Bristol	Newcastle
Faeces	35	7	0	36	0	1	0	0
Pathogens								
Salmonella	12	1						
Norovirus	5	2*		9**				
Entero aggregative *E. coli*	3							
VTEC	1							
G. lamblia	3							
C. jejuni	1					1		
Shigella spp.								
Respiratory	3	0	0	0	0	0	0	0
Pathogens								
Rhinovirus	1							
Serum/Plasma	8	0	0	0	0	0	0	0
Pathogens								
VZV IgG	1							
Others (eg blister Fluid for PCR)	1	0	0	0	0	0	0	0
Pathogens								
VZV	1							
Total	47	7	0	36	0	1	0	0

Table: 3 Results of Games related specimens processed by the Reference Laboratories

Gastro-intestinal Bacteria Reference Unit		
Test performed	**Result**	**Number**
Detection of *Clostridium perfringens* enterotoxin	Negative	4
PCR identification of enterotoxigenic *C. perfringens* isolates	Negative	4
Confirmation of identification	*Salmonella confirmed*	2
Confirmation of identification	*Shigella flexneri confirmed*	1
Confirmation of identification	VTEC confirmed	3
VNTR typing	*E. coli O157* confirmed 2 different profiles	2
Gastro multiplex PCR positive/culture negative	Confirmed negative	1
Serology	Negative for *Salmonella* Typhi	1
Respiratory and Vaccine Preventable Bacteria Reference Unit		
Mycoplasma PCR	Negative	1
Bordetella pertussis PCR	Negative	1
Virus Reference Department		
Parvovirus	Confirmed positive	1

VTEC: Verocytotoxin producing *E. coli;* VNTR: Variable number tandem repeats

Table: 4 Public Health Microbiology input into reported incidents

S. No	**Date**	**Report details**	**Result**	**Link to Olympics**

	02/07/2012	Diarrhoea & vomiting (D&V) in hotel - Olympic team scheduled to stay	2 samples positive for Norovirus GII	Local to Olympic venue (team accommodation)
2	04/07/2012	Olympic team member admitted to an NHS hospital with possible viral meningitis	Viral meningitis confirmed	Team member
3	09/07/2012	Mumps in member of catering staff	Mumps positive	Olympic venue
4	09/07/2012	Schoolchild in SE confirmed with viral meningitis - links to Olympics in the school (2 Olympic volunteers, 1 reserve team member, 1 paralympian)	Viral meningitis confirmed	Indirect link to the Olympics
5	13/07/2012	Food poisoning at a hotel ; involving (athlete, coach and 2 conference delegates)	1xNorovirus GII 4x Norovirus GI positive	Team members
6	19/07/2012	D&V in a hotel - Olympic athletes affected	4 x Norovirus G1 2 x negative	Team member; Olympic accommodation
7	19/07/2012	3 cases of chickenpox among adult crew of floating hotel cruise ship providing services to Olympic Park	Varicella zoster virus (VZV) confirmed	Olympic venue
8	25/07/2012	Malaria in a 13 year old female athlete from abroad (Falciparum malaria)	Malaria confirmed	Team member
9	27/07/2012	Olympic Park food outlet - worker at the till vomiting	Negative for virology and bacteriology	Olympic venue
10	28/07/2012	Team Official in Olympic Park	*Salmonella* Enteriditis	Olympic venue - believed to be acquired abroad (not food handler)
11	28/07/2012	Olympic Park staff with upper respiratory symptoms	virology negative	Olympic venue
12	29/07/2012	Soldier, worked on Olympic Park gate with diarrhoea	*Shigella flexneri*	Olympic venue
13	29/07/2012	Visitor to Olympic Park reported severe vomiting following sandwich consumption	No samples sent	Olympic venue
14	29/07/2012	Olympic park worker with respiratory symptoms	Respiratory screen negative	Olympic venue
15	31/07/2012	Chickenpox in national team official - equestrian site. Exposed team vet (pregnant)	VZV confirmed and contact tracing performed	Team member

		being checked		
16	01/08/2012	D&V cluster at a sailing venue	Total 7 stool samples received 1 positive for Salmonella (*Salmonella* Ramatgan) and 2 positive for Norovirus G1 & GII respectively; 4 negative	Olympic athletes
17	03/08/2012	Suspected chickenpox at Eton Dorney	serology negative but does not exclude Varicella	Olympic athlete
18	04/08/2012	African athlete with atypical pneumonia	Atypical pneumonia, respiratory screen performed- negative	Olympic team member
19	04/08/2012	Olympic village volunteer with fever, sore throat, rash and arthropathy	Parvovirus B19 confirmed	Olympic venue volunteer
20	05/08/2012	GI symptoms in attendee of Eton Dorney	No samples received	Attended Olympic venue
21	06/08/2012	Gastroenteritis in Olympic team support officer staying in Olympic village	No samples received	Olympic venue worker & resident
22	06/08/2012	Viral illness following attendance at Olympic event	No samples received	Attended Olympic venue
23	08/08/2012	GP sample from London Olympic park attendee (diarrhoea for 5 days)	Campylobacter confirmed	Attended Olympic venue
24	09/08/2012	3 journalists with D&V; ate at Olympic park	Only 1 sample received negative	Olympic venue attendee
25	09/08/2012	Gastroenteritis in an Olympic venue attendee	VTEC O157 confirmed	Attended Olympic venue
26	10/08/2012	Worker at Olympic site	E. coli O157 (verotoxin negative)	Olympic venue
27	11/08/2012	Stool sample from policeman with diarrhoea	Negative	Olympic venue
28	11/08/2012	Gastroenteritis in an Olympic venue attendee	VTEC O157 confirmed	Attended Olympic venue
29	13/08/2012	Athlete admitted with diarrhoea	*Campylobacter jejuni*	Olympic athlete

30	14/08/2012	Olympic athlete- history of headache and recurrent fever with previous history of typhoid' and 'recovered and finished treatment'.	Antibody results consistent with past history of Salmonella	Team member
31	16/08/2012	Three visitors to Olympic Park developed temperature and diarrhoea	2 out of 3 samples positive for *Campylobacter jejuni* on PCR, culture negative 3/3	Attended Olympic venue
32	23/08/2012	Olympic athlete with possible chickenpox	Chickenpox confirmed (swab and EDTA sample)	Team member
33	23/08/2012	Suspected pertussis in a child of paratrooper involved in Olympic security	Pertussis negative	Olympic venue
34	04/09/2012	D&V in an Olympic venue worker	Sample negative	Olympic venue

Table 5 Summary of FW&E sampling activity at Games food chains or Olympic venues

Activity	Number of samples	Results & public health outcomes
Water sampling across Olympic Park & venues in London & surrounding area	420 water samples, mainly drinking water outlets	34 (10.7%) were unsatisfactory due to presence of coliform bacteria; 8 (2.5%) due to presence of *E. coli*; 8 (2.5%) due to the presence of *Enterococcus* spp. All failures were responded to immediately with disinfection or re-laying of pipework and were re-sampled to ensure problem resolved.
Bi-weekly seawater monitoring at Weymouth marina	24 waters	Trending of results – no significant increase throughout the Games
Monitoring of a hotel linked with a norovirus outbreak with cases in Olympic athletes	Ice sample, two foods and 11 environmental swabs	One food sample of unsatisfactory and one or borderline microbiological quality.
Legionella sampling of a passenger vessel used to provide accommodation for Olympic venue staff	14 water samples	One sample contaminated with *Legionella pneumophila* serogroup 1
Monitoring of mobile vendors around cycling	30 (food & swabs & water)	All of satisfactory microbiological quality

road race route		
Sampling of competitor accommodation near Eaton Dorney	17 Food, environmental, water and legionella	Two cleaning cloths unsatisfactory for *E. coli* and *Staphylococcus aureus*
Monitoring of torch relay route	26 food, water and environmental	One unsatisfactory potable water (coliform bacteria)
Monitoring of pools and environmental swabs at training camps	11 pools and seven swabs	Two pools with low coliform bacterialevels (present in single samples only)
Sampling of a sliced, cooked meat producer supplying the Olympic food chain due to *Listeria monocytogenes*	59 food and environmental samples	Eight swab samples and seven food samples of unsatisfactory microbiological quality for *L. monocytogenes*
Sampling of a sandwich filling producer in the Olympic park area due to *Listeria monocytogenes*	33 samples of ready-to-eat foods used as sandwich fillings	Three samples of unsatisfactory microbiological quality
Monitoring of suppliers of sandwiches for the Olympics: 3 production factories	111 samples (food, water & environmental swabs)	One swab of cutter with unsatisfactory *E. coli* level
Monitoring of pie and pasty producer supplying the Olympic food chain due to reports of *Listeria monocytogenes* contamination	65 food samples	All of satisfactory microbiological quality