

A Capacity Planning Toolkit for Radiopharmacy Services in the UK

UK Radiopharmacy Group

Background

In order to manage the workload in the Radiopharmacy, it is important to establish the capacity of the unit. It is also a GMP requirement, with the MHRA's Guidance for Specials Manufacturers recommending that no more than 70-80% of the total staffing resource be allocated to production duties (1). As such, a Radiopharmacy's capacity plan is likely to be reviewed as part of any GMP inspection or audit process (2).

Capacity planning is required to ensure that:

- Response/lead times remain within agreed time limits
- Quality and safety standards are not compromised
- Excessive overtime is not worked or excessive pressure placed on staff
- Error and defective product rates do not increase as a result of workload.

Radiopharmacy manufacturing/preparation workload is not evenly spread throughout the day as the majority of the aseptic preparation takes place in the morning, although additional sessions may be necessary. A minimum number of people will be required to prepare one or several products as per GMP, therefore estimation of capacity is more challenging, as it cannot be achieved by simply calculating the staff time required to prepare the number of doses requested.

The Radiopharmacy service, involves more than simply product supply. Although smaller Nuclear Medicine departments may out-source the Radiopharmacy service, most larger departments require a unit on site to provide a clinical and scientific Radiopharmacy service to underpin Nuclear Medicine.

General functions include (3):

1. Manufacture/preparation and supply of radiopharmaceuticals
2. Dispensing of individual patient doses
3. Quality control of radiopharmaceuticals
4. Quality Assurance and Quality Management Systems
5. Research and Development
6. Education and training
7. Clinical pharmaceutical service to Nuclear Medicine

Capacity planning has traditionally involved an estimation of staff time required to carry out all the functions required. However, other factors do influence capacity and these should also be considered when formulating a capacity plan.

Introduction

The supply of radiopharmaceuticals is primarily a specialised aseptic preparation service that also has to take into account operator protection due to the radioactive nature of the precursors and products. It differs from other pharmacy aseptic services in that new molecular entities are prepared rather than simply changing the physical

characteristics of an existing compound, such as the change by dissolution of a freeze-dried material into a liquid phase. Quality Control of manufactured radiopharmaceuticals is therefore an essential part of the process. The physical location of the Radiopharmacy must be considered in planning Nuclear Medicine services due to the radioactive and short-lived nature of the products which can affect the delivery of clinical Nuclear Medicine.

Pharmacists, clinical scientists, radiochemists, radiographers, pharmacy technicians, clinical technologists and assistant technical staff may all be included in Radiopharmacy staffing models. Their training, experience and qualifications may be vastly different, and this should be taken into account when making decisions as to what roles they will be expected to fulfil (4). However, because of the short supply of staff from many of these groups, there may be occasions where some of them undertake duties not necessarily appropriate for their band and position. For example, senior scientific staff are often part of the routine daily processes, and equally, other staff may well have to cover some aspects of the roles undertaken by the Radiopharmacy manager. Careful consideration must be made as to whether this is appropriate, including a risk assessment if necessary. It is clear from a GMP point of view that there must be a clear delineation between production/ preparation, quality control and release of products. The MHRA Guidance for Specials Manufacturers requires there to be a second person in the clean room so that the operator performing aseptic preparation does not have to remove their hands from the Grade A area (1). As a result of this, radiopharmacies that do not perform aseptic manipulations in an isolator, must have more than one person involved in the process. How this is addressed is outside the remit of this document. However, the National Occupational Standards and the Healthcare Science career framework for Radiopharmacy (5) give guidance about the types of functions and levels of responsibility which can be expected of staff, depending on their grade, experience, training, education and qualifications.

When developing a capacity plan for Radiopharmacy, the complexity of some of the preparations must be taken into account. For example, some activities such as radiolabelling antibodies may take up to a day to perform. Radiopharmacy staff may also be involved in running clinics and providing advice to patients and customers. Radiopharmacy is one of the most highly specialized and regulated areas in the NHS and other capacity planning models used for pharmacy aseptic services may not be appropriate (2).

Capacity plans are inextricably linked to contingency plans, but in the context of this paper, they can be separated by regarding capacity as part of strategic planning (and is thus more long-term) whereas contingency planning can be seen as operational planning, and is thus more short-term. Capacity plans do not take account of succession planning and future service requirements. There is a critical shortage of Radiopharmaceutical Scientists and Technologists in the UK. Allowance must be made for training of new staff and the creation of training posts to support this. Currently when a senior member of staff leaves, many departments may be put in the position of exceeding capacity and may subsequently have difficulties recruiting appropriate registered staff, which is a serious GMP and clinical governance issue.

Use of the Capacity Plan

The capacity plan should be a live document which should be reviewed annually, alongside a monthly review of workload in the Radiopharmacy (2). Compliance with the plan should be assessed regularly, preferably within a management review meeting, and any increase in workload which could impact on the unit's capacity should be discussed. The defined capacity should only be exceeded infrequently, and management approval sought through the use of the planned deviation system.

Unplanned breaches in maximum capacity should be discussed and reviewed as part of the deviation reporting process, and a clearly defined escalation mechanism should be in place (2). Regular breaches of the capacity plan pose a significant risk to product quality. A risk assessment should be undertaken for the unit operating out with its capacity, and an agreed action plan should be in place to mitigate the risk of further capacity breaches (2). Depending on the outcome of the risk assessment, the risk should be documented on the relevant risk register until the risk reduction measures on the agreed action plan have achieved an acceptable level of residual risk to capacity.

The capacity plan should be agreed and signed by the Chief Pharmacist and be accepted by senior hospital management (2).

How to use this Toolkit (Table 1 & Table 2)

This toolkit is not prescriptive - it is to be used as a guide. Its aim is to identify the activities that may take place in the Radiopharmacy and the time required to carry them out. The list is not exhaustive and will vary from one department to another. Any other activities may be added to the list and any activities not undertaken can be removed.

If an extension to existing services, such as an extended working day or new clinical service is being planned, this should be incorporated into the table in order to estimate the effect on the Radiopharmacy's capacity. The information can then be included in any business planning document.

The toolkit is in the form of two tables, Production/Preparation Duties (Table 1) and Quality Assurance Duties (Table 2), with the functions to be carried out listed under main and sub-headings. The tables are also reproduced in a spreadsheet on the UKRG website to enable a live document to be maintained. These headings and sub-headings are a guide, and should be adapted for individual circumstances. Examples of times taken have been included, but again this may vary between departments. In the final column of the table, the user should insert the times taken in their own department in order to arrive at a total number of staff hours required to undertake all activities. The total number of required hours to undertake all activities can then be calculated. A correction is required to take account of leave and absence, which is typically done by dividing the total by 0.85 (4). The corrected number of staff hours is then divided by 37.5 to give the total number of whole time staff equivalents required for your service.

To determine whether the department is in compliance with the MHRA's recommendation of no more than 70-80% of staffing resource being allocated to Production duties, the following calculation should be performed:

$$\text{Staff resource allocated to Production (\%)} = \frac{\text{Total hours in Table 1 (x100\%)}}{\text{Total hours (Table 1 + Table 2)}}$$

The result should be less than 80%. Remember that the estimated times in column 3 are for a guide only and may not reflect actual time taken in any individual department.

Demonstrating compliance with GMP recommendations

By using the spreadsheet version of this tool available on the UKRG website, it is possible to calculate compliance with the recommended proportion of staff performing production duties on a day-by-day basis. This information can be reviewed on a monthly basis to determine how many days in each month your department had the appropriate level of staffing. This can be used for departmental Key Performance Indicators (KPIs) to demonstrate trends in your department's capacity. It also demonstrates the impact that capacity can have on other KPIs, such as availability of products at the required time, or the investigation and closure of deviations.

Capacity may be limited by other factors such as:

- a. Availability of trained drivers to deliver type A packages
- b. Availability of starting materials
- c. The type of radiopharmaceuticals ordered and the time of injection. Both of these may require a higher amount of the radiopharmaceutical to be allocated to that particular patient dose, and may impact on capacity in terms of number of doses supplied as a result
- d. The functionality and state of repair of equipment – unplanned breakdowns will impact on capacity
- e. Routine maintenance visits

Other factors to consider are:

- a. The radiation dose associated with certain procedures, such as the preparation of radiotherapy products, may limit the frequency with which they may be used
- b. The time required for provision of an information service for radiopharmaceuticals is difficult to quantify and may vary depending on the complexity of the enquiry.
- c. Increases in demand in one area of the service may adversely affect other areas. In this case the capacity plan should be reviewed using this toolkit.
- d. The potential impact of an on call service.

Conclusion

In order to ensure the quality of the products prepared in a Radiopharmacy, staffing levels must allow for sufficient resource to be allocated to maintenance of the pharmaceutical quality system. The capacity plan should be used as a management tool to ensure that no more than 80% of the staffing resource of a Radiopharmacy be allocated to Production duties, which constitutes all aspects of supplying the products to customers.

Capacity plans, risk assessments and associated action plans must be agreed with all stakeholders, particularly when changes in service provision are being considered.

References

1. Medicines and Healthcare Products Regulatory Agency (MHRA). MHRA Guidance for Specials Manufacturers. Revision 1, January 2015 at: https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/400232/Guidance_for_specials_manufacturers.pdf
2. Beaney AM. Quality Assurance of Aseptic Preparation Services: Standards. Part A 5th Edition. Royal Pharmaceutical Society, 2016.
3. Report of a Joint Working Group of the British Institute of Radiology, the British Nuclear Medicine Society and the UK Radiopharmacy Group. Guidelines for the provision of radiopharmacy support to nuclear medicine. Nucl Med Commun, 2003; **24**: 429-433.
4. Report on behalf of the Professional Standards and Education Committee of the British Nuclear Medicine Society. Training of staff for the delivery of PET/CT services in the UK. Nucl Med Commun, 2006; **27**:1005-1010
5. Radiopharmacy National Occupational Standard (NOS) 15 <http://www.skillsforhealth.org.uk/tools/viewcomp.php?id=3287> accessed 18/4/2008
6. The Human Medicines Regulations SI 2012, No 1916.

Table 1: Production/Preparation Duties

Duties	Specific examples	Examples of estimated time taken in hours	Fill in actual and / or proposed activities and times here
<p><u>Manufacturing/preparation and Supply</u></p> <p>Acting as Production Manager (licensed unit) or Supervising Pharmacist (section 10 exemption)</p> <p>Manufacture/Preparation of radiopharmaceuticals within the terms of the Human Medicines Regulations (6)</p> <p>Ensuring manufacture complies with GMP</p> <p>Release of products must be in accordance with the Human Medicines Regulations e.g. a pharmacist in unlicensed units or in the case of a Special's Licensed unit, personnel approved by the MHRA and named on the license. (Note that in Specials licensed units, the task of release can be delegated by the person responsible for Quality Control. The responsibility for release cannot be delegated).</p> <p>Notes:</p> <ol style="list-style-type: none"> 1. Times may vary depending on facilities – isolator production may take longer 2. Timings for points 1-4 are based on one production run per day. 3. Timings per week based on a 5-day week 	<ol style="list-style-type: none"> 1a. Preparation of radiopharmaceutical kits for use in own hospital – supply is in multi-dose vials. This does not include drawing up into individual syringes. 1b. Supply in individual doses to own hospital (this timing includes making up kits) 2. Supply in multi-dose vials to external customers 3. Supply in syringes to external customers 4. Second production run for extra kits / doses plus shutdown (e.g. glove leak test of isolators, cleaning down of laminar flow cabinets) 5. Manufacture of PET radiopharmaceuticals – e.g. FDG 6. Blood labelling 7. Manufacture/Preparation of complex products, such as therapy doses from licensed starting materials 	<p>2 - 3 hours per person; min. 3 people required to ensure robust service (continuation of service in case of absence). Total = 30 hours per week</p> <p>3 hours per person; min 3 people required. Total = 45 hours per week</p> <p>Depends on number of customers; E.g. for 7 customers: 2.5 hours per person per day – min 3 people. Total = 37.5 hours per week = 5.4 hours per customer per week.</p> <p>Depends on number of customers; E.g. for 7 customers: 3.5 hours per person per day – min 3 people. Total = 55 hours per week = 5.4 hours per customer per week.</p> <p>1 hour per day; min. 2 people required</p> <p>Manufacturing – 2 hours per day Quality control – 1 hour per day Total: 15 hours per week.</p> <p>2 - 5 hours per labelling depending on procedure</p> <p>2 - 3 hours total per labelling. Minimum of 2 people.</p>	

<p><u>Manufacturing and Supply</u></p> <p>Includes preparation of documentation; setting up equipment; spraying into unit; manufacture; shutting down equipment and 'daily' cleaning</p> <p>Some staff may take longer than allotted times. Fill in hours required based on experience in own department. Minimum number of staff depends on factors other than numbers of doses – e.g. facilities.</p>	<p>8. Manufacture of complex in-house products, such as radio-labelled antibodies or C-11 products</p> <p>9. Manufacture of other extemporaneous products such as: gastric emptying meals; colonic transit capsules; C-14 capsules</p> <p><u>Routine Quality Control of manufactured/prepared products</u></p> <p>Radiochemical purity determination using</p> <ol style="list-style-type: none"> 1. planar chromatographic methods or sep-pak cartridges 2. Electrophoresis 3. HPLC 	<p>3 - 5 hours total per dose including quality control tests (2 people involved)</p> <p>Variable depending on meal used and number of patients Approximately 2 hours (1 person)</p> <p>3 - 5 hours per week, depending on frequency of testing required</p> <p>2 hours per test 1-2 hours per test</p>	
<p><u>Transport</u></p> <p>Ensuring compliance with transport regulations</p>	<ol style="list-style-type: none"> 1. Packaging material for dispatch in accordance with transport regulations (includes preparing documentation and signing returned items back in as well as dispatch) 2. Maintaining a quality assurance system for transport – e.g. containers, driver training 	<p>10 hours per week (1 person) for several customers</p> <p>Average 5 minutes per container per day</p>	
<p><u>Quality Control</u></p> <p>Maintaining the schedule of sampling and testing in line with GMP requirements</p>	<ol style="list-style-type: none"> 1. Environmental monitoring - particulate and microbiological monitoring 2. Temperature monitoring 3. Sterility testing plus EOS broth fill 	<p>2 hours per week for routine (plus 2 hours per month trend analysis)</p> <p>1-2 hours per week 1-2 hours per week</p>	

<u>Equipment calibration and maintenance of facilities</u>	Daily, monthly and annual equipment and facilities checks Weekly, monthly, quarterly and annual cleaning	2.5 hours per week Varies, depending on size of unit and grade of room; minimum 2 hours per week for 'weekly clean'	
<u>Procurement and receipt of goods</u> Purchase of starting materials of appropriate quality	Calculation of most appropriate reference date and activity for use Placing orders Maintaining knowledge of PL status of products Maintaining systems for purchase of non-licensed products Maintaining awareness of new product development Procuring drugs for interventional studies Receiving and logging in deliveries Maintaining suitable storage conditions for procured items	Total per week if doing own orders: 5 hours per week	
<u>Radiation Protection</u>	Daily monitoring of facilities and record-keeping Radioactive waste management	1-2 hours per week in total	
<u>Participation in Clinical Trials</u>	Procurement, custody and storage of clinical trial supplies Documentation of receipt, storage, dispensing, administration and destruction of clinical trial supplies	Manufacture and record keeping: 2-4 hours depending on complexity of manufacture.	
Total Production/preparation hours Divide this by 0.85 to correct for leave			
Total Production corrected hours			

Table 2: Pharmaceutical Quality System (PQS)

<p><u>Quality Assurance</u></p> <p>Acting as Quality Controller if required Maintaining a comprehensive quality assurance program</p>	<ol style="list-style-type: none"> 1. Operator validation (3-6 monthly) 2. Process validation (includes spraying-in validations) 3. Trend analysis of QA results 4. Associated record keeping and documentation 5. Method validation 	<p>15 minutes per person per week 30 minutes per week, depending on procedure (averaged out over year) 1-2 hours per week 2.5 hours per week</p> <p>Depends on procedure in question</p>	
<p><u>Quality systems</u></p> <p>Maintaining good PQS</p>	<p>Writing and approval of Standard Operating Procedures Writing of procedure manuals and site master files Self-inspection/internal audit Maintaining Change control system – assessment of proposed changes. Tracking of actions to implement changes. Maintaining a complaints and product recall system Recording, reviewing and trending error, near-miss and deviation reports; reflecting to inform practice Product and process quality review</p>	<p>Total for quality systems: 10- 20 hours per week</p>	
<p><u>Equipment validation</u></p>	<p>Equipment validation</p>	<p>Varies depending on piece of equipment in question</p>	
<p><u>Adverse Event and Drug Defect Monitoring</u></p>	<p>Investigation of adverse events, including root cause analysis. Investigating and reporting unusual biodistributions, drug interactions and mis- or maladministrations. Reporting incidents both locally and nationally</p>	<p>Total per week: 1 hour (averaged out)</p>	

<u>Education and Training</u>	<p>Training of radiopharmacy staff in Good Manufacturing Practice</p> <p>Training of other cover staff</p> <p>Provision of pharmaceutical training as required under IR(ME)R</p> <p>Education and training of other NHS staff groups:</p> <p>Work experience students and trainees</p> <p>Specific training for Specialist Radiologists and Nuclear Medicine Consultants to meet the appropriate regulatory requirements.</p> <p>Pre-registration pharmacists; grade A physicists and Nuclear Medicine technologists who require work-based practice and theory to qualify)</p> <p>Lecturing (eg PTQA,CPS)</p>	<p>Total training per week: 7.5 hours on average</p> <p>It is expected that some staff may only require a short time in Radiopharmacy to complete their training or work experience; some staff may be in radiopharmacy full-time for a week or more. Teaching hospitals will require more staff time for training.</p>	
<u>Continuing Professional Development</u>	<p>Continuous Professional Development</p> <p>Continuing Education</p> <p>Fulfillment of continuing requirements for registration – such as with HPC and RPSGB</p> <p>Maintaining own KSF</p> <p>Staff appraisal / KSF interview</p> <p>Reflective practice</p> <p>Corporate Mandatory training</p> <p>Attending conferences</p>	<p>1-2 hours per person per week</p>	

<u>Provision of Clinical Activities</u>	<ol style="list-style-type: none"> 1. Liaison with other professional groups 2. Information on MA status 3. Preparation of Patient Information Leaflets 4. Use of medicines in interventional procedures 5. Assisting in reporting scans 6. Checking scans prior to patient leaving department 7. Checking medication prior to scan 8. Arranging for medicines to be stopped if appropriate 9. Arranging medicines to enhance scan 10. Giving advice to patients on radiation protection after test 11. Running clinics (e.g. I-131 for hyperthyroidism) 12. Authorising referral under IRMER 13. Administration of diagnostic or therapeutic radiopharmaceuticals 14. Involvement in planning of care pathways and protocols 15. Checking blood counts prior to therapy 16. Dose of isotopes based on age 17. Advising clinicians / patients on how medicines may affect the scans 18. Helping to write protocols on which medicines should be stopped prior to coming in for scan 	<p>Total per week: 10 hours. This is dependent on the level of clinical involvement and the number of different tasks undertaken.</p>	
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<u>Support for applications to Administration of Radioactive Substances Advisory Committee (ARSAC)</u>	Checking protocols and countersigning applications (part C) Provision of support as the individual responsible for the supply of radiopharmaceuticals Ensuring use of radiopharmaceuticals is covered by ARSAC licence-holders certificate	30 minutes per week	
<u>Radiation Protection</u> Includes acting as Radiation Protection Supervisor (RPS).	Development of safe procedures for the production and manipulation of radioactive pharmaceutical products Acting as RPS – includes writing and updating local rules Undertaking radiological risk assessments (before new procedures and reviewing existing) Reviewing radiation doses and using to inform practice	1-2 hours per week in total	
<u>Health and Safety</u> <u>In compliance with the Ionising Radiation Regulations 1999 (IRR99)</u>	Perform risk assessments for all work Mandatory training for all staff Ensure process complies with IRR 99 Clinical waste management	30 minutes per week (averaged over the year)	
<u>Participation in Clinical Trials</u>	Writing protocols Development of systems of GMP Good Manufacturing Practice and Good Clinical Practice (GCP) for the preparation of clinical trial materials Maintaining SOPs Writing and maintaining Product Specification Files Maintaining Investigative Investigational Product (IMP) licence	Depends on number of trials undertaken; average per trial: setting up: 2 hours per week for the life of the trial	

<u>Research and Development</u>	Development of novel radiolabelling methods Undertaking of practice-based local research within own department Participation in interdisciplinary research Provision of scientific and technical support to other research studies within the hospital or academic environment Undertaking stability assessments (shelf-life, in vivo and in vitro stability)	Depends on research programme undertaken	
<u>Managerial Duties</u>	Business planning Recruitment (inc writing job descriptions etc.) Accounting / finances / budget management Tenders Staff appraisal Workload and capacity planning	Total per week: 10 hours	

<p>Audit: 1. Clinical audit</p> <p>2. Organisational audit</p> <p>3. Quality audit</p>	<p>Multidisciplinary clinical audit and external audit Clinical governance compliance</p> <p>BNMS audit; Health and Safety; Healthcare commission (IRMER inspections); Health and Safety Executive, Environment Agency</p> <p>Internal audit (self-inspection or peer review) MHRA or EL audit Department for Transport</p> <p>Reflection on audit findings, development of action plans, and implementation of changes (change control)</p>	<p>Total: 2 hours per week (averaged from yearly)</p>	
<p>Meetings</p>	<p>Staff meetings Clinical meetings Clinical governance meetings Hospital management briefings Departmental meetings Regional meetings UK Radiopharmacy Group meetings</p>	<p>Average = 2 hours per week per staff member. Dependent on staff member – departmental manager spends more time in meetings. Fill in time in column to the right depending on individual circumstances.</p>	
<p>Professional activities/ Committee work / problem solving</p>	<p>Involvement in hospital committees (including radiation safety) and activities associated with relevant professional societies Solving any problems which arise!</p>	<p>3 hours per week (may be a lot more!)</p>	
<p>Total Quality Systems hours Divide this by 0.85 to correct for leave</p>			
<p>Total Quality Systems corrected hours</p>			

Table 3: Evaluation of Staffing Resource Attributable to Production/Preparation Duties

Total Production corrected hours			
Total Quality Systems corrected hours			
Total corrected hours (Production and Quality Systems)			
Percentage of staffing resource attributable to Production duties: (<80%)	$\frac{\text{Total Production/preparation corrected hours}}{\text{Total corrected hours}} \times 100$		