# CAREERS THROUGH MATHS: ONCOLOGIST

## JOB DESCRIPTION

An oncologist is a medical doctor who specialises in the diagnosis and treatment of cancer. Their daily responsibilities are multifaceted, involving direct patient care in NHS hospitals and private clinics, multidisciplinary team (MDT) meetings, and research. A typical day might include reviewing complex patient scans, calculating precise chemotherapy drug dosages based on body surface area, discussing treatment plans with radiologists and surgeons, and counselling patients and their families on prognosis and therapeutic options. The work environment is primarily hospital-based, within specialist oncology wards, radiotherapy departments, and outpatient clinics, and is inherently high-pressure, requiring meticulous attention to detail and strong decision-making skills.

The key duties of an oncologist are divided into three main branches: medical oncology (using systemic therapies like chemotherapy, immunotherapy, and targeted therapy), clinical oncology (using both radiotherapy and systemic therapy), and surgical oncology. Central to all these roles is the application of mathematics. For instance, determining the correct radiation dose for a tumour requires sophisticated mathematical modelling to maximise cancer cell death while minimising damage to surrounding healthy tissues—a concept known as the therapeutic ratio. Similarly, analysing data from clinical trials, such as those run by Cancer Research UK, to understand survival rates and treatment efficacy is a core mathematical task.

Oncologists are at the forefront of personalised medicine, where treatment is increasingly tailored to the genetic makeup of an individual's cancer. This involves interpreting complex genomic data and using statistical models to predict which patients are most likely to benefit from a specific, often very expensive, targeted drug. Their work is not just clinical; many oncologists contribute to academic research within UK universities like The Institute of Cancer Research, London, or the Cancer Research UK Cambridge Centre, designing studies and applying biostatistics to advance the field and improve national cancer outcomes.

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## HOW MATHEMATICS IS USED

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- **Biostatistics and Epidemiology:** This is the cornerstone of evidence-based oncology. Oncologists use statistical methods to interpret the results of clinical trials, which form the basis of national treatment guidelines from the National Institute for Health and Care Excellence (NICE). For example, they calculate and compare overall survival (OS) and progression-free survival (PFS) rates between treatment groups using Kaplan-Meier curves and log-rank tests. They also use epidemiological data from sources like the UK Office for National Statistics (ONS) to understand cancer incidence, prevalence, and mortality trends across different UK demographics, which informs public health strategy and resource allocation within the NHS.

- **Dosimetry and Radiophysics:** For clinical oncologists, mathematics is physically applied in planning radiotherapy. This involves using complex algorithms and integral calculus to model how radiation beams of varying energies will deposit dose within a three-dimensional volume (the patient's body). The goal is to achieve a homogeneous tumour dose (e.g., 60 Gray delivered in 30 fractions) while ensuring critical organs like the spinal cord or kidneys receive a dose below their specific tolerance thresholds. This planning is done using software that solves millions of calculations to create a viable and safe treatment plan.

- **Pharmacokinetics and Pharmacodynamics:** Medical oncologists use mathematical modelling to understand how the body processes anti-cancer drugs (pharmacokinetics) and how those drugs affect the body (pharmacodynamics). Dosage calculations are rarely simple; they are based on a patient's Body Surface Area (BSA), calculated using the Du Bois formula (BSA = 0.007184 × Height(cm)^0.725 × Weight(kg)^0.425). Furthermore, they model drug clearance rates and area-under-the-curve (AUC) calculations for drugs like carboplatin to determine the optimal dose that will be effective without causing excessive toxicity.

- **Predictive Modelling and Machine Learning:** A rapidly growing area involves using statistical classifiers and machine learning algorithms to analyse large datasets. For instance, researchers at The Alan Turing Institute may develop models that combine genomic, radiological, and clinical data to predict a tumour's aggressiveness or its likelihood of responding to immunotherapy. Within the NHS, similar models are being developed to forecast patient demand and optimise radiotherapy machine scheduling to reduce waiting times.

- **Statistical and Analytical Methods:** Beyond clinical trials, data analysis is used daily. Oncologists analyse audit data from the National Cancer Registration and Analysis Service (NCRAS) to benchmark their hospital's performance against national standards. They use statistical measures like hazard ratios and confidence intervals to communicate risk and benefit to patients in a quantifiable way, enabling shared decision-making. Regression analysis is used to identify which patient or tumour factors are independent predictors of outcome.

## KEY SKILLS & TOOLS

| Skill/Tool | Application |
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| Treatment Planning Systems (TPS) | Software like Varian's Eclipse or Elekta's Monaco is used to calculate and visualise radiation dose distribution. Mathematical operations include solving inverse problems—optimising beam angles and intensities to meet dose constraints on tumours and organs-at-risk—a process heavily reliant on linear algebra and optimisation algorithms. |
| Statistical Software (R, SPSS, Stata) | Used extensively for academic research and audit. An oncologist might use R to perform a survival analysis on a cohort of breast cancer patients, employing Kaplan-Meier estimators and Cox proportional hazards models to identify significant prognostic factors. |

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| Electronic Patient Record (EPR) | Systems like Epic or Cerner hold vast amounts of patient data. Oncologists mathematically analyse this data to track outcomes, monitor toxicity rates from chemotherapy, and calculate average time from diagnosis to treatment for service improvement projects. |
| Programming Languages (Python, SQL) | Python is used for developing custom machine learning models for genomic analysis or for automating the extraction and analysis of large datasets from hospital databases using SQL queries. |
| Medical Imaging Software | Tools for reviewing CT, MRI, and PET scans involve mathematics for image reconstruction, fusion (aligning images from different modalities), and measuring tumour volumes, which is critical for assessing treatment response using criteria like RECIST. |
| Multidisciplinary Team (MDT) Presentation | Oncologists must present complex statistical data, such as clinical trial results or survival metrics, to a diverse team of healthcare professionals in a clear, concise, and actionable manner to reach a consensus on patient care. |
| Quality Assurance (QA) Protocols | Radiotherapy departments adhere to strict QA protocols based on statistical process control. This involves regularly measuring and analysing the output of linear accelerators using mathematical tolerances to ensure every treatment delivered is within a margin of error of less than 2-3%. |

**Typical Pathway:** The pathway begins with excelling in GCSEs and A-levels, with a strong emphasis on Chemistry, Biology, and Mathematics or Physics. Students must then complete a medical degree (usually 5-6 years) recognised by the General Medical Council (GMC) at a UK university. This is followed by a two-year foundation programme as a junior doctor. Entry into oncology specialty training is highly competitive and requires passing exams to enter the 5-7 year run-through training programme in either Medical Oncology or Clinical Oncology, overseen by the Royal College of Physicians (RCP) or Royal College of Radiologists (RCR). Key milestones include passing the MRCP(UK) or FRCR exams to achieve Certificate of Completion of Training (CCT) and becoming a consultant. Continuous professional development is mandatory, with consultants often pursuing further sub-specialisation or research degrees (MD/PhD).

**Industry Demand:** Demand for oncologists in the UK is consistently high. An ageing population and advances in early detection are increasing cancer prevalence. NHS

Long Term Plan commitments to improve cancer outcomes have made oncology a national priority. This, coupled with the complexity of new treatments requiring specialist knowledge, ensures strong job prospects. The Health Education England's *Shape of Training* report highlights a need for more specialised medical roles, including oncology, to meet future healthcare challenges.

**Real-World Impact:** Oncologists have a direct and profound impact on UK society, improving survival rates and quality of life for hundreds of thousands of patients diagnosed with cancer each year. Their mathematical work in designing and interpreting clinical trials for the NHS and UK-based charities like Cancer Research UK has been fundamental in developing life-saving treatments now used worldwide. By optimising resource allocation and treatment protocols within the NHS, they ensure the sustainability of the healthcare system, delivering high-quality, evidence-based care that benefits communities across the nation.