

## *Current Infectious Disease Reports*

# Defining international critical care pharmacist contributions to sepsis and exploring variability

Robert Oakley<sup>1,2</sup>, Sarraa Al-Mahdi<sup>3</sup>, Sonja Guntschnig<sup>4</sup>, Ha Trinh<sup>1</sup>, Dr Marco Custodio<sup>5</sup>, Sarah Korshid<sup>1</sup>, Professor Andries Gous<sup>6</sup>, Dr Dagan O Lonsdale<sup>2,7</sup>

Corresponding author: Mr Robert Oakley, [robert.oakley@nhs.net](mailto:robert.oakley@nhs.net), <https://orcid.org/0000-0001-6329-8658>

1. Pharmacy Department, St George's University Hospitals NHS Foundation Trust, Blackshaw Road, Tooting, London, SW17 0QT, United Kingdom (UK)
2. Clinical Pharmacology Department, St George's, University of London, Cranmer Terrace, London, SW17 0RE, UK
3. Pharmacy Department, London North West University Healthcare NHS Trust, Watford Road, Harrow, HA1 3UJ, UK
4. Pharmacy Department, Tauernkliniken, Zell am See, Paracelsusstraße 8, 5700, Austria
5. Pharmacy Department, Chesapeake Regional Medical Center, 736 Battlefield Blvd, North Chesapeake, VA 23320, United States of America (USA)
6. Pharmacy Department, Sefako Makgatho Health Science University, Molotlegi Street, Ga-rankuwa 0204, South Africa
7. Critical Care Directorate, St George's University Hospitals NHS Foundation Trust, Blackshaw Road, London, SW17 0QT England

**Online Resource 5 (Supplementary Table).** An overview of themes, sub-themes and codes for Aspirations of Intensive Care Unit (ICU) Clinical Pharmacists to Further Contribute to Sepsis Management

Themes	Subthemes	Codes
<p><i>Multidisciplinary Team (MDT) Integration</i></p>	<p><i>Overcoming Physical Barriers</i></p>	<p>Physical presence at ICU bedside, access to patients' laboratory/microbiology results, separate ICU and infectious diseases developmental pathways, therapeutic drug monitoring (TDM) payment structures to reimburse pharmacists, 24-hour seven-day service, embedment in nursing teams for administration activities, focus less on drug charts and more on MDT discussions, hospital board representation, shared professional responsibilities, pharmacists embedded in every ICU MDT, better pharmacy communication, greater use of pharmacy technicians for medicines management/reconciliation activities, nationally commissioned ICU pharmacy service, increased funding, enforced international guidelines for the provision of intensive care services (GPICS), clinical pharmacists prioritised to ICUs, access to patient records from any speciality, investment into electronic prescribing and medicines administration (ePMA) systems, improved professional advocacy, tackle socially associated barriers</p>
	<p><i>Overcoming Social Barriers</i></p>	<p>Involvement in therapeutic decision making, microbiology communication, emergency department (ED) to ICU link, closer pharmacy/intensivist/infection prevention control (IPC)/microbiology relationships, greater interpersonal discussions, competency standardisation, improved perceptions of clinical pharmacists, increased trust in pharmacists, increased microbiology responsibilities, understanding of the clinical pharmacists' role, medical receptiveness to pharmacist input, transfer of care communication, making the MDT feel safer with a pharmacist, greater ICU clinical pharmacist evidence base, shared residency programmes with doctors, leadership, association of ICU services with pharmacists, capturing delivery time of interventions after medical decision making, interventions to demonstrate cost-savings, advocacy, fact sheet of ICU clinical pharmacist capabilities, presentations at MDT discussions, contribution to MDT ward rounds/ICU journals/ICU conferences, increased public and stakeholder awareness of ICU clinical pharmacist role, pharmacist and stakeholder education</p>

<p><i>Education &amp; Training</i></p>	<p>Residency exposure to ICU, identification and management of sepsis, increased target obtainment, dose tailoring based on patient factors, knowledge of co-variates affecting target exposure, antibiotic-bug-patient matching, competency to discuss patients with medical team, pharmacokinetic/pharmacodynamic (PK/PD) training for individualised dosing and administration, mandatory ICU accreditation, international ICU pharmacy network, low-cost subscription model to post-graduate resources, collaborations between international MDT professional groups, white paper proposals, publication of international ICU standards, stakeholder and pharmacy advocacy, unlicensed loading doses, antibiotic choice given cultures/sensitivities/history, co-variate knowledge to inform precision dosing, dosing strategies for organ dysfunction/extracorporeal circuits, key understanding of PK/PD index of top 5 most used antibiotics, dosing standardisation in key clinical states, dosing of underrepresented drugs, metabolism/genomics knowledge, sepsis recognition, junior medical team education, sepsis related identification and antibiotics, action points and monitoring for different sepsis presentations, prioritisation skills, expertise in poorly understood areas, social and communication skills, business case generation, mentors, professional networks</p>
<p><i>Workforce</i></p>	<p><i>Delivery</i></p> <p>Point of care (POC) testing (rapid diagnostics/TDM), ED pharmacists linked to ICU, more clinical pharmacists, complete professional responsibility and leadership for TDM, increased resources to conduct medicine reconciliations, TDM guideline generation, delivery of proactive medication safety interventions using electronic prescribing and medicines administration (ePMA), widespread adoption of specialist evidence based PK/PD guidance, pharmacist prescribers, enforcement of GPICS, Bayesian dosing, consulting service for specialised TDM with microbiology, remote working capability, hub and spoke consultancy, ePMA capturing all healthcare/antimicrobial encounters, mobile app integration of guidance, faster implementation of recommendations, accessibility/availability of resources, national/local pharmacist led antimicrobial campaigns, ICU advocacy within professional bodies, knowledge synthesis in pharmacy education system, posts for advancing pharmacist prescriber roles, research posts funded by hospitals, integration of specialist pharmacists with associated medical teams, not having to be generalists in everything, sepsis</p>

		recognition in ED, tailor workforce to optimum roles to improve ICU outcomes earlier
	<i>Contributions</i>	Sepsis diagnosis, antimicrobial susceptibility/identification within 1-hour, TDM POC testing, advising on drug interactions, reducing medication errors before ICU admission, optimising TDM by adjusting for novel patient factors, uniformity of dose optimisation/TDM skills, evaluation of sepsis phenotypes to deliver individualised therapies, access to biomarkers to expedite diagnosis/stepdown to narrow spectrum agent, prescribing of initial antibiotic dose, selection of antibiotics, changing antibiotic choice or dose based on clinical or TDM results, minimisation of antibiotic overuse, de-escalation to narrow spectrum agents, management of all antibiotic initiations
<i>Research</i>		Implementation science, novel biomarkers, patients clustered by characteristics to inform precision therapy approaches, POC testing (rapid diagnostics/TDM), comparing prescribing times from decision points between pharmacy and medical staff, evaluation of sepsis endo/phenotypes, pro/anti-inflammatory sepsis phases, tailoring therapeutics to gram positive/negative microorganisms, precision medicine based on patient and microorganism genome, digital system notification of antibiotic initiation, ePMA assistance for medication errors, prioritisation decision support software, sepsis alerted on ePMA systems, antibiotic choices based on site of infection, highlighting problems without a pharmacist, TDM of top used antibiotics, increased loading doses in septic shock, antibiotic concentrations from blood gases, pharmacist research informing policy, correcting doses on daily basis based on patient changes, data mining capture, PK/PD associated interventions, pharmacogenetics/metagenomics, nanopore technologies, gene variant detection for drug resistance, clinical outcome data supporting clinical pharmacist interventions, consistency in therapeutic target obtainment, evidence for unlicensed antibiotic administration based on PK/PD index, clinical decision support using ePMA, early warning scoring/sepsis identification, knowing if antibiotics needed, PK/PD targets in adults/paediatrics, turnaround time from diagnosis to administration of antimicrobials, audit, quality improvement, stakeholder engagement strategies, child PK optimisation, research mentoring, accessible research funding, dosing interventions supported by randomised controlled trials (RCT), reduced variability in clinical and microbiological

outcomes, real-time data capture of clinical pharmacist interventions, increased/updated evidence supporting evolving ICU clinical pharmacist interventions, case studies to inspire non-ICU pharmacists and stakeholders