Journal of Hospital Infection 169 (2026) 143—150

Available online at www.sciencedirect.com

Journal of Hospital Infection

journal homepage: www.elsevier.com/locate/jhin

Travel-associated carbapenem-resistant organisms at a time of increasing geopolitical instability: a UK perspective

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https://doi.org/10.1016/j.jhin.2025.11.045

ARTICLE INFO

Article history:
Received 19 August 2025
Accepted 21 November 2025
Available online 16 December 2025

Keywords:
Antimicrobial resistance
Infection prevention and control
Surveillance
Screening
Global health security

SUMMARY

Background: Conflict and catastrophe compromise multi-national healthcare delivery and present risks for the spread of carbapenem-resistant organisms (CROs). The risk of and ability to detect travel-associated CROs in the UK remain unclear.
Methods: A 10-question survey was sent to microbiology/infection prevention and control (IPC) practitioners of 108 UK acute NHS Trusts/Regions/Boards, exploring recent experience and IPC practices for travel-associated CROs and approaches to extended-spectrum antimicrobial testing. Additionally, major trauma network centres were invited to review detected carbapenemase-producing organism (CPO) molecular data from March 2022 to April 2024, comparing associated travel by the World Health Organization global region using one-way analysis of variance.
Results: Seventy-three surveys were returned. IPC approaches were highly variable, with 19 of 73 (26.0%) centres requiring modification to national screening guidelines. Twenty-four of 73 (32.9%) centres reported CROs associated with recent travel to major conflict areas. Twelve major trauma network centres contributed to review of detected CPOs, finding 297 of 1290 (23.0%) individuals with travel to 52 different countries. In total, 227 of 297 (76.4%) were screening results; 279 of 297 (93.9%) were Enterobacterales. A total of 112 of 297 (37.7%) had travelled to Europe, where carbapenemase diversity was greater than elsewhere ($P < 0.001$).
Interpretation: A considerable range of UK centres are detecting CROs associated with travel to areas of current major conflict. A more didactic approach to travel history on the first contact with healthcare services is required to stratify CPO risk at admission. These data should be collected prospectively in parallel with projects which successfully embed taking an effective travel history to assess the risk of travel-associated infectious disease. This will allow clearer understanding of travel behaviours and trends, delineate risk and inform effective IPC.

Introduction

The risk of spread of antimicrobial resistance (AMR) has long been associated with cross-border travel, particularly with healthcare admission while overseas [1]. On return to the UK, carbapenem-resistant organisms (CROs) may present challenges for the ongoing individual patient care and hospital capacity for effective infection prevention and control (IPC) [2,3]. Recent shifts in global geopolitical stability with increases in conflict and catastrophe present a challenge to UK health security from travel-associated AMR [4].

Following the 2024 United Nations High-Level Meeting on Antimicrobial Resistance, the resultant political declaration recognised the '*devastating impact*' that conflict and catastrophic events can have on health infrastructure and the risk of AMR spread [5]. In Europe, evidence continues to accumulate for the spread of Gram-negative CROs from the ongoing major conflict in Ukraine and its associated humanitarian crisis [6–9]. Of these CROs, the most serious threat arises from carbapenemase-producing organisms (CPOs), for which carbapenem resistance is typically mediated by plasmids, thereby facilitating horizontal spread [10]. In the UK, recent evidence suggests increased colonisation with CPOs following travel abroad [10], presenting risks to both individual patient outcomes and hospital operational activity. The widespread disruption to hygiene, sanitation, and healthcare infrastructure and services due to recent conflicts (and natural disaster events) may further augment the risk of travel-associated CPO acquisition and warrants consideration in the wider context of UK health security measures [9,11].

UK Health Security Agency (UKHSA) guidance on containing CROs, including CPOs, allows for screening processes that contextualise and reflect local epidemiology [10]. Meanwhile, the 2025 UK National Audit Office report on AMR has raised concerns around limited progress for addressing AMR in the UK [12]. Contemporary shared understanding of current UK experience could therefore be of value. We aim to survey acute National Health Service organisations across the UK to better understand the array of approaches currently in place to identify and manage travel-associated CROs and CPOs to better understand the current UK experience and to identify emerging trends for the risk associated with recent travel to areas of conflict.

Methods

A meeting was convened in January 2024 following recognition of increasing AMR associated with conflict-associated infections in Europe. Participants were invited through snowball recruitment of clinicians and public health practitioners and learned societies, industry partners and academics with interest in conflict-associated AMR from both the UK and the Netherlands. A survey was subsequently developed to broadly explore whether the UK was experiencing similar shifts in travel-associated AMR risk to inform wider UK clinical experience and preparedness. The initial survey strategy was

derived as a balance between the scope of questions on CRO screening practices and time burden for completion to optimise representative feedback. Following this, major trauma network centres were invited to participate in a more detailed review of detected CPOs, being those CROs of significant risk, to consider trends in detected carbapenemase families and any associated travel risks. Acknowledging difficulties in determining travel-associated risk and potential confounding factors, major trauma network centres were selected for further review of data to ensure inclusion of patients requiring urgent ongoing care post injury on repatriation from an overseas healthcare institution while limiting potential bias introduced by risks of CPO colonisation associated with regular hospital admission to specialist centres but no travel.

Part 1: 'Experience and management of travel-associated CROs' survey

An initial scoping survey of 11 questions was developed (Supplementary Table 1). Broadly, the survey explored the current IPC practices in respect to detection and management of patients with travel-associated CROs, any recognition of travel to areas experiencing major conflict for detected CROs (based on United Nations High Commissioner for Refugees listed emergencies at the time of travel) [13] and approaches to antimicrobial susceptibly testing (AST) and interpretation for these organisms. An invitation to complete the survey was emailed to a named microbiology consultant/IPC representative for laboratories providing diagnostic services and/or clinical microbiology advice to all acute NHS Trusts in England, regional NHS Boards in Scotland, Public Health Wales and the Royal Victoria Hospital in Northern Ireland. Where a named microbiology consultant for a site was not identified, invites were extended to pathology service leads and/or laboratory managers. When no reply was received at six weeks, a follow-up invitation with inclusion of a second named representative was sent.

Part 2: Assessment of patterns for travel-associated CPOs

Concurrently, laboratories associated with major trauma network centres were invited to contribute travel-associated CPO data for the period of April 2022–April 2024 with detailed analyses of carbapenemase genes detected to gain deeper understanding. The start date was selected to coincide with the outbreak of major conflict in Ukraine. Participating sites registered service evaluations locally, and anonymised data were deduplicated and pooled. Electronic health records were retrospectively evaluated for evidence of travel overseas in the preceding six months and recorded as countries visited. Data collection included organism, species, whether the isolate was clinical or screening in nature and any identified carbapenemase genes.

Statistical analysis

Anonymised data were extracted to Microsoft Excel and assessed using GraphPad Prism 10. Descriptive statistics were used to report trends in survey responses and travel-associated CPO data including organism prevalence, associated country of travel and detected carbapenemase genes. Diversity of CPOs detected across World Health Organization regions were compared by one-way analysis of variance. Significance was set at 0.05.

Results

Of 108 invitations, a total of 73 (67.6%) individual survey answers were returned (65 England, two Wales, five Scotland and one Northern Ireland). For each survey, all questions were answered. For England, responses were provided for NHS Trusts or integrated laboratory services representing centres across 37 of 42 (88.1%) of regional Integrated Care Boards (Supplementary Figure 1).

Part 1: Recent UK experience of travel-associated CROs

Infection prevention and control: Most centres reported basing screening for CROs on the UKHSA 2021 criteria (41/73, 56.2%) or Scottish Antimicrobial Resistance and Healthcare Associated Infection (ARHAI) guidelines (3/73, 4.1%) [14], while a small number of centres screened all admissions (3/73, 4.1%), used the 2013 UKHSA criteria (5/73, 6.8%) or screened augmented care areas only (2/73, 2.7%). The remainder (19/73, 26.0%) reported using guidelines based on the UKHSA 2021 criteria with local modifications for screening of high-risk groups based on centre specialisation (e.g. dialysis and haematology) or local experiences (e.g. travel to specific overseas regions or admission from centres of perceived high risk). Travel was considered an IPC risk by most centres but with varied impact on screening practices. Fifty-four of 73 (74.0%) respondents considered travel as a risk only if associated with confirmed overseas (and/or other UK) healthcare contact, while 17 of 73 (23.3%) viewed any foreign travel as a risk. Of these, 13 of 54 (24.1%) healthcare contact and 3 of 17 (17.6%) all-travel risks were considered for specific geographical regions only. For the remaining centres, 1 of 73 (1.4%) assessed travel risk as part of wider patient cohort risk and 1 of 73 (1.4%) centres did not consider travel to be a risk. Additionally, 10 of 73 (13.7%) reported including travel risk as part of retrospective investigations if a CRO was identified.

Once a travel risk is identified, 30 of 73 (41.1%) of centres have a mechanism in place for (i) informing the IPC team (e.g. via an electronic initial assessment form or clinician-led contact via email or phone), (ii) 24 of 73 (32.9%) for formally recording in the patient notes and (iii) 17 of 73 (23.3%) for formally adding to the patient notes as a risk flag. For 24 of 73 (32.9%) returns, no formal mechanism exists for recording travel-associated IPC risks. Free-text survey comments included the observation that recording in the medical notes could be '*hit and miss*', and while a mechanism existed for flagging travel risks, these were rarely used unless retrospectively when a CRO was detected. If a risk was identified, most centres would ideally seek to isolate the patient in a side room pending a formal CRO screen (58/73, 79.5%), whereas 4 of 73 (5.5%) would await the outcome of a CRO screen, while 1 of 73 (1.4%) made no action. For the remaining centres (10/73, 13.7%), a case-by-case approach was taken with comments highlighting decisions were often limited by side-room availability and a

need to balance risk based on other infectious, clinical or service needs at the time.

In total, 24 of 73 (32.9%) centres reported that within the study period, they detected CROs associated with recent travel to an area with current conflict-associated humanitarian emergencies (Ukraine, Syrian Arab Republic, Islamic Emirate of Afghanistan, Republic of the Sudan, Federal Republic of Somalia, Myanmar, Republic of Cameroon and Federal Republic of Nigeria) [13].

Extended AST for CROs: Among survey respondents, once travel-associated CROs were detected, further AST (e.g. for ceftazidime-avibactam, cefiderocol or colistin) was mostly conducted on a case-by-case basis, as guided by the microbiologist (43/73, 58.9%), automatically on all positive samples (first screen or clinical) in 20 of 73 (27.4%) and automatically on clinical samples only for 7 of 73 (9.6%) centres. A note was also made of some centres where automatic workup would occur on screening isolates, but clinical isolates may require prompting, and at other centres *vice versa*, while one centre reported no established consistent method. Where extended AST was made available, the majority were released on a case-by-case basis (48/73, 65.8%), while some centres opted to release only resistant results (7/73, 9.6%), all results (3/73, 4.1%) or no results at all (15/73, 20.5%). Where results fell in the European Committee on Antimicrobial Susceptibility Testing (EUCAST) 'area of technical uncertainty' [15], results were typically released with an interpretative comment (29/73, 39.7%), not released (28/73, 38.4%), released as resistant (5/73, 6.8%) or released on a case-by-case basis and sent for further confirmation testing at the reference laboratory (11/73, 15.1%). One centre reported no established consistent method.

Part 2: Major trauma network centre experience of travel-associated CPOs

Twelve centres were able to provide data (11 from England and one from Wales), which incorporated the positive CPO screening results from 1290 individuals across the study period. A total of 297 of 1290 (23.0%) had evidence of recent overseas travel to 52 separate countries (Figure 1). For eight centres, this included detection of carbapenemase-producing Enterobacterales, *Pseudomonas* spp. and/or *Acinetobacter* spp., while four centres reported carbapenemase-producing Enterobacterales only. All centres reported on retrospective identification of travel-associated risk through this process. Seven of 297 (2.4%) individuals had samples with more than one bacterial species detected, harbouring a carbapenemase (5/297, 1.7% *Escherichia coli* and *Klebsiella pneumoniae* [each with New Delhi Metallo-β-lactamase {NDM} and OXA-48]; 2/297, 0.07% *K. pneumoniae* and *Acinetobacter baumannii* [one sample with NDM and OXA-48 and one sample where each organism produced NDM only]). For the remaining 290 individuals, each was associated with a single detected CPO, of which 273 of 290 (94.1%) were Enterobacterales (122/290 [42.1%] *E. coli*, 112/290 [38.6%] *Klebsiella* spp., 27/290 [9.3%] *Enterobacter* spp., 8/290 [2.8%] *Citrobacter* spp., 3/290 (1.0%) *Proteus mirabilis* and 1/290 (0.03%) *Morganella morganii*). The remaining 9 of 290 (3.1%) were *Pseudomonas* spp. and 8 of 290 (2.8%) were *Acinetobacter* spp.

Screening accounted for 227 of 297 (76.4%, stool or rectal swab samples) positive CPO results among the major trauma network, while 70 of 297 (23.6%) were from clinical samples (23/70 urine, 17/70 deep wound/bone/joint, 14/70 superficial wound swab, 9/70 deep respiratory, 5/70 blood culture and 2/

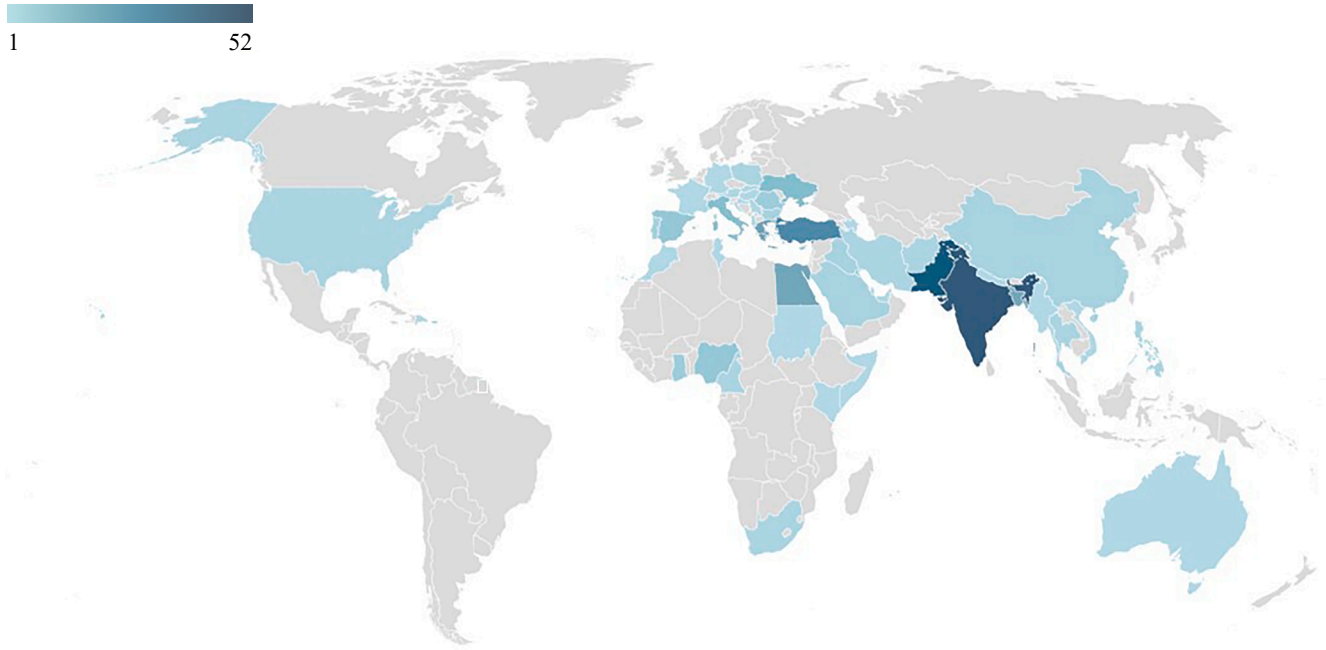

Figure 1. Choropleth representing countries associated with recent travel for patients with microbiological samples positive for CPOs between March 2022 and April 2024. Data were collected from 12 UK major trauma network hospitals. Other countries of relevance, which are not clearly displayed on this choropleth include detection of CPOs from patients who had recently travelled to the Canary Islands ($N = 8$), Cyprus ($N = 7$), Mauritius ($N = 1$) and Malta ($N = 1$). CPO = carbapenemase-producing organism.

70 cerebrospinal fluid). Those patients who had travelled to areas with conflict and/or humanitarian catastrophe were more likely to have positive CPO results detected via clinical sampling than those who had travelled elsewhere ($P < 0.001$).

Recent travel to WHO-defined regions are displayed in Figure 1 (Europe, 112/297, 37.7%; Eastern Mediterranean, 83/297, 27.9%; South-East Asia 74/297, 24.9%; Africa 19/297, 6.4%; Western Pacific, 6/297, 2.0% and the Americas, 3/297 (1.0%).

Among these centres, strategies for detecting carbapenemases were skewed towards detection of *Klebsiella pneumoniae* carbapenemase (KPC), NDM, Verona integron-encoded metallo-β-lactamase (VIM), imipenemase (IMP) or OXA carbapenemase families and included use of chromogenic agar (5/12, 41.7%), lateral flow immunochromatography (6/12, 50.0%) and/or in-house polymerase chain reaction (7/12, 58.3%) with a selection sent to the reference laboratory for further investigation. In total, detected carbapenemase families included 134 of 297 (45.1%) NDM only, 68 of 297 (22.9%) OXA only, 27 of 297 (9.1%) KPC only, 8 of 297 (2.7%) VIM only, 4 of 297 (1.3%) IMP only, 1 of 297 (0.03%) OXA 51-like and 1 of 297 (0.03%) NMC-A only. The remainder was mixed including 39 of 297 (13.1%) NDM and OXA, 8 of 297 (2.7%) KPC + VIM, 3 of 297 (1.3%) KPC + NDM, 3 of 297 (1.0%) KPC + OXA and 1 of 297 (0.03%) OXA + VIM + NDM (Figure 2). Detected carbapenemases associated with travel to Europe were significantly more diverse than from other WHO-defined regions ($P < 0.0001$, $Q = 9.1$ when compared with Eastern Mediterranean, 8.3 when compared with Southeast Asia and 8.4 when compared with Africa) (Figure 2). When carbapenemase families were mixed, NDM and OXA were more commonly seen from those who had travelled to South Asia (20/39, 51.3%) followed by those who had travelled to the Eastern Mediterranean (11/39, 28.2%), while combinations of KPC with other carbapenemases were mostly associated with travel to Europe (11/14, 78.6%).

Discussion

Our data show a diverse approach to overseas travel risk for the carriage of CROs when patients are accessing secondary healthcare institutions across the UK. Almost a quarter of reviewed patients with a positive CPO test from among participating major trauma network sites had evidence of recent overseas travel across a wide variety of regions, including to eight separate regions experiencing humanitarian crises due to ongoing conflicts [13]. These observations suggest a dynamic risk approach may be required if centres are to respond with agility to changing global events and inform local risk management practices in a timely manner.

Over the last decade, efforts to improve global surveillance of AMR have offered variable insights into risk of hospital admission overseas. However, recent humanitarian crises have coincided with reductions in available funding for AMR surveillance activity, while analyses suggest long-term viability of current surveillance programme approaches in low- to middle-income countries may be unsustainable [4,16]. In the short to medium term, UK situational awareness on overseas AMR trends is likely to reduce. Compliance to IPC mitigations, including screening measures can be suboptimal [17,18]. Our data highlight a variety of screening strategies across sites, and future work to compare compliance may be beneficial from a wider IPC perspective. Greater understanding of travel-associated CRO and CPO detection trends could therefore have value in providing support to local centres and broader UK health security and informing priorities for targeted screening funding where appropriate. Retrospective identification of associated travel during this study highlights the ongoing challenge of

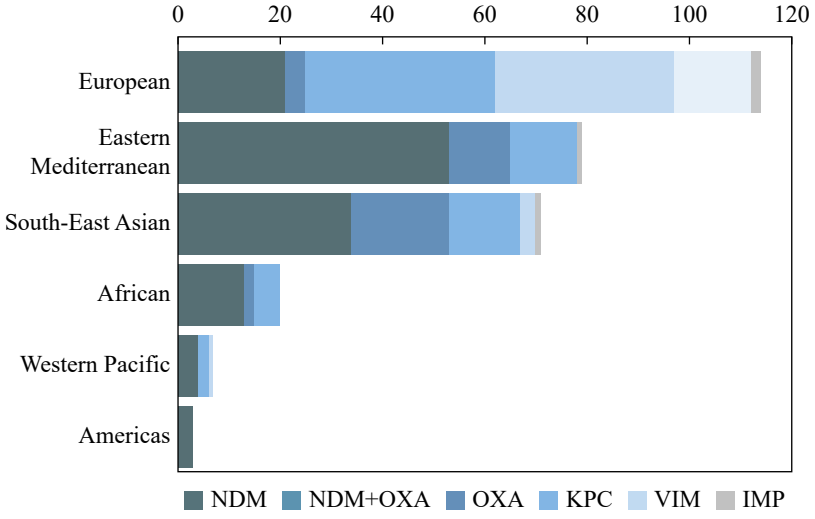

Figure 2. Breakdown of detected carbapenemases in the UK from March 2022 to April 2024 associated with recent overseas travel. NDM = New Delhi metallo-β-lactamase, OXA = OXA carbapenemase, KPC = Klebsiella pneumoniae carbapenemase, VIM = Verona integron-encoded metallo-β-lactamase, IMP = imipenemase. Bars represent 281 of 297 (94.6%) of reviewed positive CPO samples across participating UK trauma centres. The remainder included less common combinations of carbapenemases including 8 of 297 (2.7%) KPC + VIM, 3 of 297 (1.3%) KPC + NDM, 3/297 (1.0%) KPC + OXA, 1 of 297 (0.03%) OXA + VIM + NDM and 1 of 297 (0.03%) NMC-A. CPO = carbapenemase-producing organism.

assessing the risk at admission. Considering shifting patterns of travel-associated risk and growing geopolitical instability, a more didactic stance from national guidance may be required to improve engagement with meaningful risk assessment, shifting advice from '*should make efforts to capture (international travel) information*' [10] to considering questions as a mandatory part of the admission process.

Among our data, NDM was the most frequent carbapenemase observed, being detected in 58.8% of reviewed individuals with a positive CPO test and evidence of recent travel. In the UK, travel-related risks for acquisition of NDM carbapenemases have been linked to South Asia [19]. While this remains the case for 55.2% of the cases where NDM carbapenemases were detected, the remaining had a highly diverse travel history to 39 different nations spread across all the remaining WHO geographic regions, in keeping with recognition of worldwide geographic distribution [20]. Detection of carbapenemase family combinations, including, for example, *K. pneumoniae* coproducing KPC and NDM, continues to increase, severely limiting antibiotic choice for patients affected [21]. Meanwhile, spread of hypervirulent *K. pneumoniae* ST23 carrying carbapenemase genes in Europe is a concern that reinforces the importance of ensuring a travel history is effectively taken to inform both individual and population risk [22]. Overall, the greatest burden of CPOs was associated with travel to Europe where observations were broadly in keeping with those from the European Centre of Disease Prevention and Control 2025 carbapenem-resistant Enterobacterales update report [23]. The burden of observed travel risks however was not reflective of overall international travel patterns for UK residents during the study period [24]. This highlights the complexities of interpreting travel-associated risk factors and the potential for travel data to further optimise UK quarterly reports for the detection of CPOs.

Determining the relative role of travel (and specific activities or exposures while overseas) regarding the acquisition of CPOs is inherently challenged by irregular, incomplete and often retrospective data collection. Completion of travel history at admission is often poorly taken [25]. This may result in overestimation of travel's role through inappropriate association or underestimation due to lack of recording, limiting observations to broad trends. A good representation across UK centres, particularly England and Wales, however supports observations of a diversifying of travel's impact when compared with data from early studies subject to similar limitations [26]. Our observations include increased recognition of a potential link for travel to areas experiencing geopolitical instability. Acquisition of colonisation with resistant organisms is also associated with additional risk factors however, including antimicrobial use, age, hospital length of stay and coexistence of chronic disease [27], while applied screening methods focus on detection of 'big 5' carbapenemase families mean we are unable to comment on trends in other gene families (e.g. Guiana Extended Spectrum, Kyorin University Hospital metallo-β-lactamase). Prospective data collection would help delineate exposure risks of travel to these regions and provide support for risk-based mitigations while avoiding unnecessarily broad IPC measures or inappropriately disenfranchising populations.

In conclusion, in the UK, almost a third of centres had recent experience of detecting CROs associated with recent travel to conflict areas. Where travel-associated CPOs are detected in major trauma network centres, recent travel was identified to 52 different countries, with association to areas experiencing ongoing conflict in around a quarter of such cases. A more didactic approach to travel history on the first contact with UK healthcare services is required to stratify CPO risk at admission. These data should be collected prospectively in parallel with projects which successfully embed taking an effective travel history to assess the risk of travel-associated infectious disease. This will allow a clearer understanding of travel behaviours and trends, delineate risk and inform effective IPC.

CRediT authorship contribution statement

S.J.C. Pallett: Writing — original draft, Project administration, Methodology, Investigation, Funding acquisition, Formal analysis, Data curation, Conceptualization. **S.E. Boyd:** Writing — review & editing, Writing — original draft, Methodology, Funding acquisition, Conceptualization. **A. Khanijau:** Project administration, Investigation. **R. Banerjee:** Project administration, Investigation. **N. Reece:** Project administration, Investigation. **S. Jawad:** Project administration, Investigation. **V. Daniel:** Project administration, Investigation. **M. Routledge:** Project administration, Investigation. **H. Navalan:** Project administration, Investigation. **C. Ward:** Project administration, Investigation. **K. Saeed:** Resources, Methodology. **J. Lambourne:** Project administration, Investigation. **D.A. Enoch:** Project administration, Investigation. **G. Shanks:** Project administration, Investigation. **J. Cai:** Investigation. **A. Wild:** Project administration, Investigation. **N. Mahida:** Project administration, Investigation. **H. Hiles:** Resources, Methodology. **H. Parsons:** Writing — review & editing, Project administration, Investigation. **M. Tickell-Painter:** Writing — review & editing, Project administration, Investigation. **R. Shorten:** Writing — review & editing, Project administration, Investigation. **V. Srirathan:** Writing — review & editing, Project administration, Investigation. **J. Suich:** Writing — review & editing, Project administration, Investigation. **D. Wearmouth:** Writing — review & editing, Investigation. **R. Dhillon:** Writing — review & editing, Writing — original draft, Project administration, Methodology, Investigation, Conceptualization. **N. Mughal:** Writing — review & editing, Project administration, Methodology, Investigation, Conceptualization. **S.D. Woolley:** Writing — review & editing, Writing — original draft, Project administration, Methodology, Investigation, Funding acquisition, Conceptualization. **M.K. O'Shea:** Writing — review & editing, Project administration, Methodology, Investigation. **L.S.P. Moore:** Writing — review & editing, Writing — original draft, Supervision, Project administration, Methodology, Investigation, Funding acquisition, Conceptualization.

Ethics statement

Where centres contributed data, collection was registered locally as Service Evaluations. Data were anonymised for both individual isolate and centre. No patient demographic information was included.

Funding sources

This study received funding from the Healthcare Infection Society and Shionogi & Co., Ltd.

Conflict of interest statement

L.S.P.M. has consulted for or received speaker fees from bioMerieux (2013—2025), Eumedica (2016—2025), Pfizer (2018—2025), Sumitovant (2021—2023), Shionogi (2021—2025), Qiagen (2023), Gilead (2024), BioNTech (2024), Insmed (2024) and Advanz (2024—2025) and received research grants from the National Institute for Health and Care Research (2013—2025), CW+ Charity (2018—2025), North West London Pathology (2022—2024), LifeArc (2020—2022), Shionogi (2024—2025), Infectopharm (2022—2024), the Joint Programming Initiative on AntiMicrobial Resistance (2023—2025) and the Healthcare Infection Society (2024—2025). S.J.C.P. has received research grants from the Drummond Foundation, John Muir Trust and Healthcare Infection Society not in connection with this work. S.J.C.P. was a Parliamentary Intern to the Office of Dr Danny Chambers MP on behalf of the British Society for Antimicrobial Chemotherapy (2024—2025). All remaining authors have nothing to declare.

Acknowledgements

Dr Luke Moore acknowledges support in part from the NIHR Imperial Biomedical Research Centre. The authors would like to thank the British Society for Antimicrobial Chemotherapy, the infectious diseases department of the Erasmus University Medical Centre, Netherlands, and Public Health Wales for their inputs to shaping the survey questions and to Shionogi for enabling the meeting. The authors would like to thank representatives of microbiology departments and infection prevention and control nursing teams for participating centres across the UK for their time and contributions to the survey.

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.jhin.2025.11.045.

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