Exploring the coverage of antimicrobial stewardship across UK clinical postgraduate training curricula

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**Abstract**

**Background**

Antimicrobial resistance (AMR) is a global political and patient safety issue. With ongoing strategic interventions to improve the shape of UK postgraduate clinical training, ensuring that all clinicians have appropriate knowledge and practical skills in the area of AMR is essential. To assess this, a cross-sectional analysis was undertaken of the coverage and quality of antimicrobial stewardship (AMS) and AMR within UK postgraduate clinical training curricula.

**Method**

UK clinical specialty training curricula were identified. Topics and individual learning points relating to AMS or AMR were extracted for each specialty. Learning points were quality assessed against the expected level of clinical competence. Inter-specialty analysis was performed.

**Results**

Overall 37 specialties were assessed, equating to 2318 topics and 42527 learning points. Of these, 8/2318 (0.3%) topics and 184/42527 (0.4%) learning points were related to AMS-AMR. Infectious diseases represented all eight topics, and 43/184 (23%) of the learning points. In contrast, primary care who are responsible for the highest proportion of antimicrobial usage, had no topics and only 2/1368 (0.15%) AMS-AMR learning points. This paucity of representation was reflected across most of the remaining specialties. On quality assessment, the majority of learning points (111/184;60%) required knowledge only, with no demonstration of behaviour in clinical practice required.

**Conclusion**

Coverage of AMS-AMR is poor across the majority of UK postgraduate clinical training curricula, with little depth of learning required. Given the threat of AMR, and evolving changes in clinical training pathways, we call for cross-specialty action to address this current lack of engagement.

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**Introduction**

The threat to human health and safety posed by antimicrobial resistance (AMR) is a leading topic in international political agendas.1–3 Infection specialists and policy makers have engaged a wide range of actors in the field to produce guidelines and interventions, which aim to optimise the therapeutic benefit of antimicrobials whilst minimising their harmful sequelae.2–5 Despite a wide uptake of antimicrobial stewardship (AMS) within the infection community there remains a paucity of evidence to describe cross-specialty engagement with AMS and AMR (AMS-AMR), which is vital given that the majority of antimicrobial prescribing is done by individuals who are not experts in infection management. 6–10

For AMS to be successful there must be clinical leadership and self-governance from within each clinical specialty to drive changes in behaviour and clinical practice.11–13 Furthermore, mechanisms to identify “high risk” specialties (i.e. high rates of antimicrobial usage and healthcare associated infections) for AMS interventions and a process to monitor their impact and reach is urgently required to ensure on-going political and financial support from policy makers currently invested in the AMR agenda.10

Within this context, cross-specialty engagement in AMS-AMR education has an important role in promoting knowledge and practical skills related to the subject.10,14 Whilst the state of postgraduate training within infectious disease has been previously explored,15 there remains a paucity of information describing engagement with AMS-AMR at the strategic level of postgraduate medical education across other clinical disciplines. In the UK, trainees will progress through a number of different training pathways following qualification from medical school. All junior doctors initially undertake two years of foundation training. This is then usually followed by a core training pathway for a further two years (e.g. core medical or core surgical training) with the trainee then progressing onto speciality training, which they will remain in for several years until they reach their certification of completion of training (CCT).16 Whilst some specialties may miss out core-training, progressing from foundation year directly into specialty training (e.g. general practice and obstetrics & gynaecology), these often still have a core specialty training pathway within their structure before the trainee undertakes further specialisation. Therefore, this means that all trainees will be exposed to a number of postgraduate training curricula in the years following graduation from medical school as they progress towards completion of training over an approximate 6 to 10 year period.

Following the recent report from the Greenway S*hape of Training review;* it was highlighted that postgraduate training must be able to adapt to ensure that trainees are able to provide safe and effective care for patients across medical specialties.17 Given then growing threat of AMR and the requirement for cross-specialty engagement with this subject, we performed a cross-sectional analysis of the current coverage and quality of AMS-AMR within UK clinical specialty curricula.

**Method**

UK clinical specialties were identified and electronic postgraduate training curricula extracted for interrogation. All training curricula were reviewed by the authors. Those with deemed to have a narrow or low clinical focus were excluded from analysis. Curriculum information was recorded including the date of initial publication, date of revision, as well as the total number of curriculum topics and individual learning points within. Previously validated broad based search criteria (***figure 1***)10 were used to identify (i) all curriculum topics, and (ii) all curriculum learning points, which met the electronic search criteria. Curriculum learning points in the context of UK training curricula are defined as individual learning goals that the trainee is expected to achieve during training. As these points are selected by the specialty education training board, their numbers may vary between specialties depending on the number of topics and the depth in which the trainee is expected to demonstrate their knowledge and skills. Two authors (TMR & LSPM) reviewed all electronically identified points independently, excluding those not directly related to AMS or AMR based on the definitions in ***figure 1***. For the purpose of our investigation we focused on bacterial resistance and stewardship. Individual learning points relating solely to antiviral, antifungal, antiprotozoal or antimycobacterial resistance were excluded. This focus was selected given that anti-bacterial agents make up over 93% of all antimicrobials prescribed for systemic use.18 Furthermore, the large variation in prescribing of other antimicrobial classes across different specialties may have influenced the results. Furthermore, duplicate learning points within the same curriculum were not counted twice. Where disagreement arose during the selection of learning points three authors (TB, TMR, LSPM) met to discuss them and reach a consensus.

Following the identification of learning points for inclusion, inter-specialty variation was assessed in two ways. First, proportions of AMS-AMR learning points were calculated for each specialty using total number of learning points as a denominator. As a comparator, learning points relating to infection prevention and control (IPC) were also extracted and analysed to provide a reference for our observations of AMS-AMR coverage. IPC was selected as it is another infection related patient safety issue, which has been a long-term, ubiquitous healthcare priority and has been promoted through a distributed model requiring specialty engagement.19 A number of search criteria used to identify IPC points were tested. The use of the same search criteria used for identification of AMS-AMR learning points was finally selected, as the search term “infect” was the most sensitive term for identifying IPC points with other tested terms (such as, “aseptic”, “control”, and “prevent”) not adding to the sensitivity of the search.

Secondly, the frequency of individual learning points per specialty training curricula was categorised according to the determined level of achievement that each individual learning point was expected to display. To assess the level of achievement, each individual learning point was rated using a modified version of Miller’s pyramid for the assessment of clinical competence.20 This allowed learning points to be weighted based on the type of knowledge or skill demonstrated (***figure 2***)20: Level one - demonstration of knowledge (i.e., *“knows”*); level two – demonstration of an ability to understand knowledge in a clinical context (*“knows how”*); level three – demonstration of a behaviour in a controlled environment (*“shows how”*); and level four – demonstration of a behaviour in a free working environment (“*does”*)*.*20 **Figure 2** provides examples of learning points that were classified at each level. The rating of learning points relating to AMS-AMR was achieved by anonymising and presenting them in a randomised order to three authors (TMR & TB & LSPM). The authors independently reviewed each learning point rating the expected level that achievement of the learning point would demonstrate. Ratings were then compared, and the mode calculated. When consensus could not be reached using the mode, a fourth author (ECS) reviewed the individual learning point and rated its level in the hierarchy. This rating was then compared against the three authors’ scores, and discussion held to reach consensus on the appropriate level. Statistical analysis was performed using Chi-squared with Yates correction. Ethics approval was not required for this observational study of information in the public domain.

**Results**

Thirty-seven UK clinical specialty training curricula were selected for inclusion within this study (***table 1***). These were initially published between 2009 and 2015; eighteen have been updated since their initial publication. In total, among these curricula there were 2,318 topics and 42,527 learning points. ***Figure 3*** provides information of the topic (***figure 3a***) and learning point (***figure 3b***) selection process using the criteria defined in ***figure 1***. Overall, 8/2318 (0.3%) topics were identified relating to AMS-AMR. These were all within the combined infectious diseases training curriculum (8/65; 12%).21 In contrast 184/42527 (0.4%) individual learning points were identified as relating to AMS-AMR. These were distributed across 33/37 (89%) specialties. Psychiatry core training,22 rehabilitation medicine,23 nuclear medicine,24 and hepatology25 did not have any learning points related to AMS-AMR. In contrast to this, IPC made up 20/2318 (0.9%) curriculum topics, spread over 20/37 (54%) specialty curricula. Furthermore, 278/42527 (0.7%) individual learning points were identified across the same 33/37 (89%) specialty curricula. This was a significantly greater proportion of IPC coverage for both curriculum topics (*p=0*.*04*) and individual learning points (*p<0*.*01*) compared to AMS-AMR coverage in UK postgraduate training curricula.

On analysis of the inter-specialty emphasis of AMS-AMR within curricula learning points, (***figure 4***), combined infection training had the greatest proportion (43/747, 5.8%); significantly higher than the other clinical specialties (*p<0.01* for all), which all had less than 1% coverage. Core surgical training had the second largest frequency (4/409; 0.98%),26 endocrinology third (4/509; 0.8%),27 gastroenterology fourth (9/1290; 0.7%),28 and core medical training fifth (12/1752, 0.7%)*.*29

The frequency of individual learning points per curriculum related to AMS-AMR were then compared, with the number of learning points meeting each level of the hierarchy of knowledge or skill demonstrated compared (***figure 5***). In terms of the raw numbers of learning points, infectious diseases had the greatest frequency related to AMS-AMR (n=43), with intensive care second (n= 14),30–32 and core medical training third (n=12). Analysis of the expected level of achievement to be demonstrated for each learning point showed that the median expectation was ”knows how” with 67/184 (36%) expecting demonstration of “an ability to apply facts to a clinical context”20. Of those remaining, 44/184 (24%) were categorised as “knows”, 39/184 (21%) as “shows how” and 34/184 as (18%) “does”. Therefore, 60% (111/184) of perceived learning outcomes relating to AMS-AMR do not currently require any demonstration of behaviour as part of the expected level of achievement. This trend towards learning points solely necessitating knowledge rather than behaviours related to AMS-AMR was observed across most specialties, regardless of the frequency of learning points identified. For example, despite infectious diseases having the greatest number of individual learning points related to AMS-AMR, 31/43 (72%) of these did not require any demonstration of behaviour in clinical practice (11/43 “knows” & 20/43 “knows how”). However, in contrast general curricula such as general internal medicine (4/9 “shows how” or 1/9 “does”), acute internal medicine (3/8 “shows how” or 1/8 “does”) and core medical training (3/12“shows how” or 4/12 “does”) had greater numbers of learning points requiring demonstration of behaviour in clinical practice, despite having a low frequencies of individual AMS-AMR learning points within their curricula.

**Discussion**

On assessment of UK postgraduate specialty training curricula we have observed a low coverage and poor depth of learning expected for AMS-AMR learning outcomes across the majority of clinical specialties. This includes specialties responsible for large volumes of antimicrobial usage, such as primary care and other general specialties.

Overall, AMS-AMR makes up a significantly lower proportion of learning points when compared to other infection related patient safety issues such as IPC. This low coverage of AMS-AMR was observed across the majority of general curricula, such as primary care (2/1368, 0.15%), foundation training (2/435, 0.46%), general internal medicine (9/1405, 0.64%), acute internal medicine (8/1680, 0.48%), core medical training (12/1752, 0.68%) and core surgical training (4/409, 0.98%). This is especially concerning within primary care who are responsible for prescribing 74% of all antimicrobials within the UK,33 yet have only two learning points in their postgraduate training curriculum. Moreover only one of these requires demonstration of a behaviour (“shows how”). In contrast, general internal medicine, acute internal medicine, and core medical training had greater numbers of learning points requiring demonstration of AMS-AMR behaviour in clinical practice (“shows how” or “does”), but still had low overall frequencies of AMS-AMR learning points in their curricula. Recently these specialties have been the target of numerous AMS interventions, including persuasive, restrictive, structural and behavioural approaches34 as they are responsible for much of antimicrobial initiation, with a third of all European hospital inpatients on antimicrobial therapy at any one time.35 Despite this, very little importance appears to be placed on AMS-AMR within their training curricula compared to other learning topics, many of which are symptom or presentation specific conditions.25

A second observation is that certain specialties who have high rates of antimicrobial usage and healthcare associated infections, such as haematology and renal medicine,9,10 have both low coverage of AMS-AMR in their training curricula and few training outcomes which require AMS-AMR behaviours. Yet, other specialties such as infectious diseases and intensive care, who also use high amounts of antimicrobials and deal with high rates of healthcare associated infections, do appear to have greater frequency of AMS-AMR coverage. However, despite having relatively high frequency of coverage, the quality of learning points related to demonstration of behaviour remains poor. Moreover, our findings also highlight the “*top-down*” expectation of AMS-AMR understanding and behaviour, where specialists are expected to have a greater understanding of AMS-AMR and demonstrate a greater frequency of skills compared to generalists and trainees. This supports evidence in the literature which has clearly demonstrated junior doctors poor understanding of AMS and AMR.6

Since the implementation of the UK Five Year Antimicrobial Resistance Strategy in 2013,3 a position of key policy makers has been to advocate for individual prescriber responsibility and clinical leadership of AMS from within all specialties.2,3 This has included supporting a greater emphasis on developing behaviour change to improve the quality of antimicrobial prescribing.3 Despite this, our findings demonstrate that steps promoting behaviour change towards antimicrobial usage do not yet appear to have been translated into formal training outcomes for the majority of UK clinical specialties. For the development of clinical leadership from within each specialty, AMS-AMR must have a presence and an emphasis towards implementation “on the ground”. Whilst demonstration of knowledge and its application to clinical scenarios can show that a trainee understands a concept, setting standards at this level does not explore the ability of the trainee to transfer this awareness into clinical practice.36 Therefore, to promote active engagement in AMS and promote emphasis of positive actions and leadership, it is imperative that standards and outcomes require demonstration of behaviour in clinical practice. For this to be achieved, current standards must be reviewed, requiring engagement from both the General Medical Council and the Academy of Medical Royal Colleges. This must ensure that accountability for engagement with this leading patient safety issue is emphasised across all clinical specialties and that mechanisms are put in place to promote the evaluation of AMS-AMR behaviours as part of clinical training. Furthermore, with the growing understanding of the importance of beginning AMS education as early as possible to promote sustainable changes in practice, standards for junior trainees during their foundation years must be prioritised to break the current “top-down” expectation taken towards AMS-AMR.14

Within this study, we only fully review UK postgraduate training curricula meaning that our results study may not be generalizable to other settings. However, by ensuring that our methodology is replicable this may offer an opportunity for future review in other settings, such as, the USA, Australia and Europe where training curricula do not currently fully facilitate direct comparison with the UK. For example, in the case of the USA nationally standardised training guidelines were not evident for comparison. In Europe, the European Union of Medical Specialties (UEMS) harmonized training curricula were reviewed. These were found to have very few references to AMS-AMR across specialties, making meaningful analysis difficult.37 Individual European national curricula were not reviewed. Within national Australian curricula, the Advanced Training curricula developed by the Royal Australian College of Physicians were found to be most similar to UK clinical training curricula. Review of these identified similar rates of AMS-AMR coverage within most specialities described compared to UK postgraduate training curricula.38 Despite individual national European curricula not being reviewed, the lack of AMS-AMR topics and learning points observed within the UEMS curricula should be considered a priority for review given the commitment of the European Commission to improve education and training within this field.39

This study had several strengths and limitations. Within our methodology a validated search criteria and quality assessment tool were utilised to identify and appraise learning points.10,20 This standardised approach will facilitate future replication of our methodology. Inter-rater subjectivity was a potential bias during eligibility screening and quality assessment of learning points. To account for this we ensured that points were reviewed by multiple authors independently with good results. For example, on assessing the level of achievement of learning points, two or more researchers agreed in 179/184 (97%) of cases with only 5 learning points requiring review by a fourth researcher. Finally, this method only offers a proxy indicator for the attributed importance of AMS-AMR within UK clinical postgraduate specialty training and does not account for individual and informal promotion of the topic. Furthermore, there is currently no comparison to determine what is an “appropriate level” of AMS-AMR coverage within individual training curricula. To address this, we drew comparison with another infection related patient safety issue, IPC, which has been the focus of similar national and international campaigns as AMS-AMR, but over a longer period of time.40 Following demonstration of our findings compared to IPC, we hope that this analysis will serve as a baseline to highlight the current low rates across most UK clinical specialties and allow for future quantification of the effect of targeted interventions within this field.

In conclusion, coverage and quality of AMS-AMR across UK clinical speciality training curricula is poor with the majority of learning points not promoting development of positive behaviours in practice. To maintain support from national policy makers, and promote the development of interest and clinical leadership within specialties within the UK we call for a greater emphasis on the demonstration of AMS behaviours to be incorporated into clinical specialty training curricula outcomes. With the current focus on reviewing and adapting postgraduate training in the UK, this offers an ideal opportunity for these changes to be implemented to promote the importance of AMS-AMR education for improving patient safety. We call for cross-specialty action in prioritising AMS-AMR education as a key element of postgraduate training and suggest that this method of assessing postgraduate clinical training curricula may act as a possible mechanism to serially assess engagement within training curricula both in the UK and internationally.

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**Transparency declaration**

A.H.H. has consulted for bioMérieux. L.S.P.M has consulted for bioMérieux and DNA electronics. T.M.R, E.C.S, F.C & T.B have no conflicts of interest to declare.

*Author contributions:* TMR & LSPM devisedthe study design, TMR, TPB, LSPM & ECS collected and analysed data. TMR drafted the initial manuscript draft. All authors had a significant involvement in data interpretation and finalisation of the manuscript for submission. All authors agreed to submission of the manuscript in its current form.

**Disclaimer**

The views expressed in this publication are those of the authors and not necessarily those of the NHS, the National Institute for Health Research or the UK Department of Health.

**Contribution statement**

TMR, LSPM & AH devised the study idea and protocol. TMR & TB performed data collection. TMR, TB, LSPM & ECS analysed the data. TMR produced the initial manuscript draft. All authors contributed significantly to review of the manuscript and preparation for final submission. All authors agreed on submission of the manuscript in its current form.

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**Figure 1: Accepted curriculum search criteria and definitions**

**Curriculum search criteria:**

1. Anti\* (wildcard search accepting antibiotic, antimicrobial or similar)
2. Resist\* (wildcard search accepting resistant, resistance or similar)
3. Infect\* (wildcard search accepting infection, infective, infected or similar)
4. Stewardship

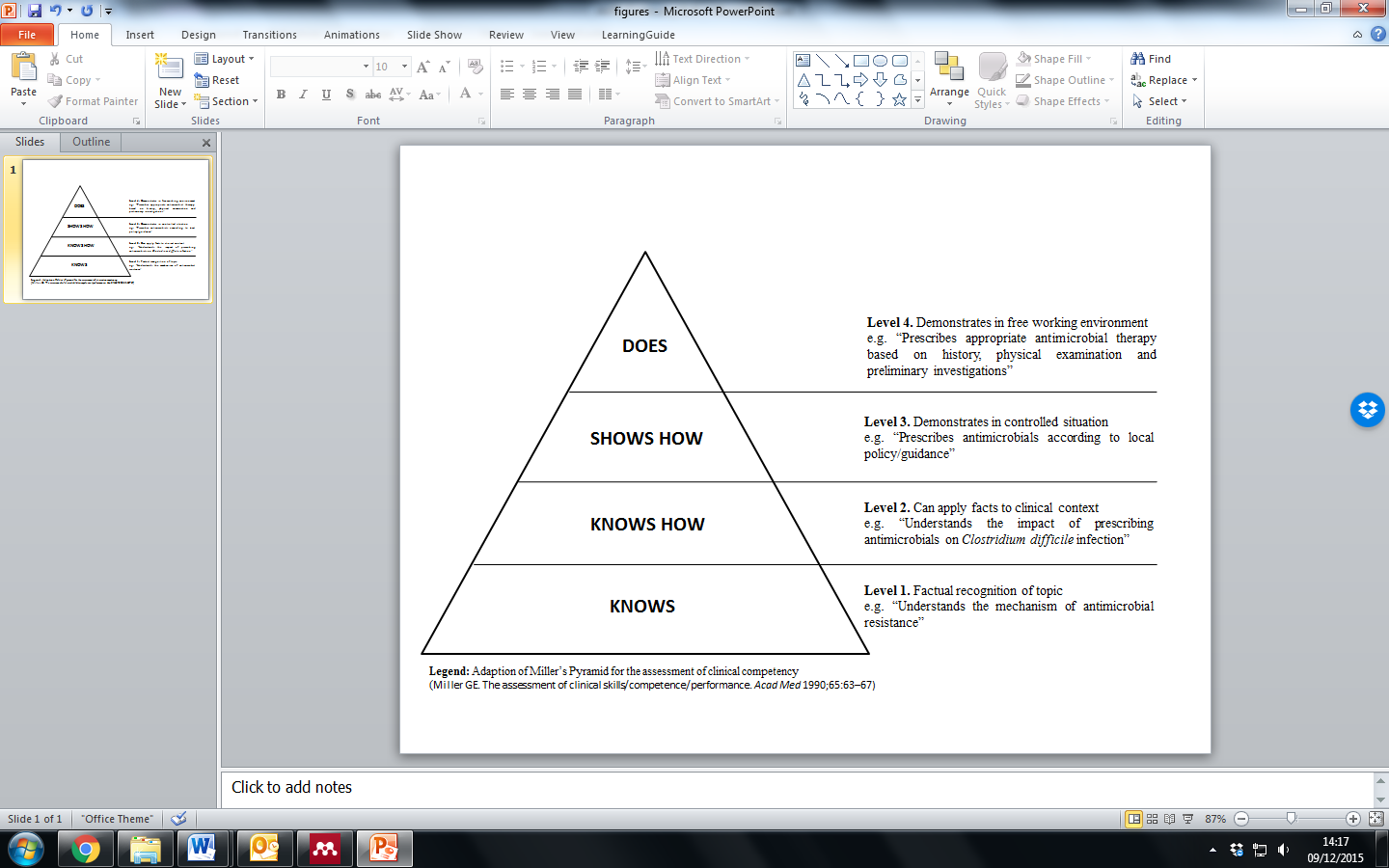
**AMS and AMR definitions:**

**AMS:** “*Optimising the indication, selection, dosing, route of administration and duration of antimicrobial therapy to maximise clinical cure or prevention of infection while limiting the collateral damage of antimicrobial use, including toxicity, selection of pathogenic organisms and emergence of resistance”*

**AMR:** *“Resistance of an organism to an antimicrobial drug that was originally effective for the treatment of infections caused by it”*

AMS = Antimicrobial Stewardship: AMR = Antimicrobial Resistance

**Figure 2.** Adaption of Miller’s pyramid for rating the level of perceived output for individual learning points



**Figure 3.** Selection method to identify antimicrobial stewardship/ antimicrobial resistance curriculum topics and learning points in UK clinical specialty training curricula

**Figure 3b**. Curriculum learning points

**Figure 3a**. Curriculum topics

Points identified for review (n =42527)

No duplicates identified   
(n = 0)

Topics identified using electronic search criteria described in **figure 1**  
(n = 1490)

Records NOT detailing AMR/AMS (i.e. did not meet inclusion criteria) following full review of   
(n = 1306)

IPC = 278

Other Infection = 818

detailing AMR/AMS (as defined in panel 1)   
(n = 184)

Records NOT detailing AMR/AMS using electronic search criteria described in **figure 1**  
(n = 41037)

Topics identified for review (n =2318)

No duplicates identified   
(n = 0)

Topics identified using electronic search criteria described in **figure 1**  
(n = 78)

Records NOT detailing AMR/AMS (i.e. did not meet inclusion criteria) following full review of   
(n = 70)

IPC = 20

Other Infection = 27

Topics detailing AMR/AMS (as defined in panel 1)   
(n = 8)

Records NOT detailing AMR/AMS using electronic search criteria described in **figure 1**  
(n = 2240)

|  |  |
| --- | --- |
|  |  |

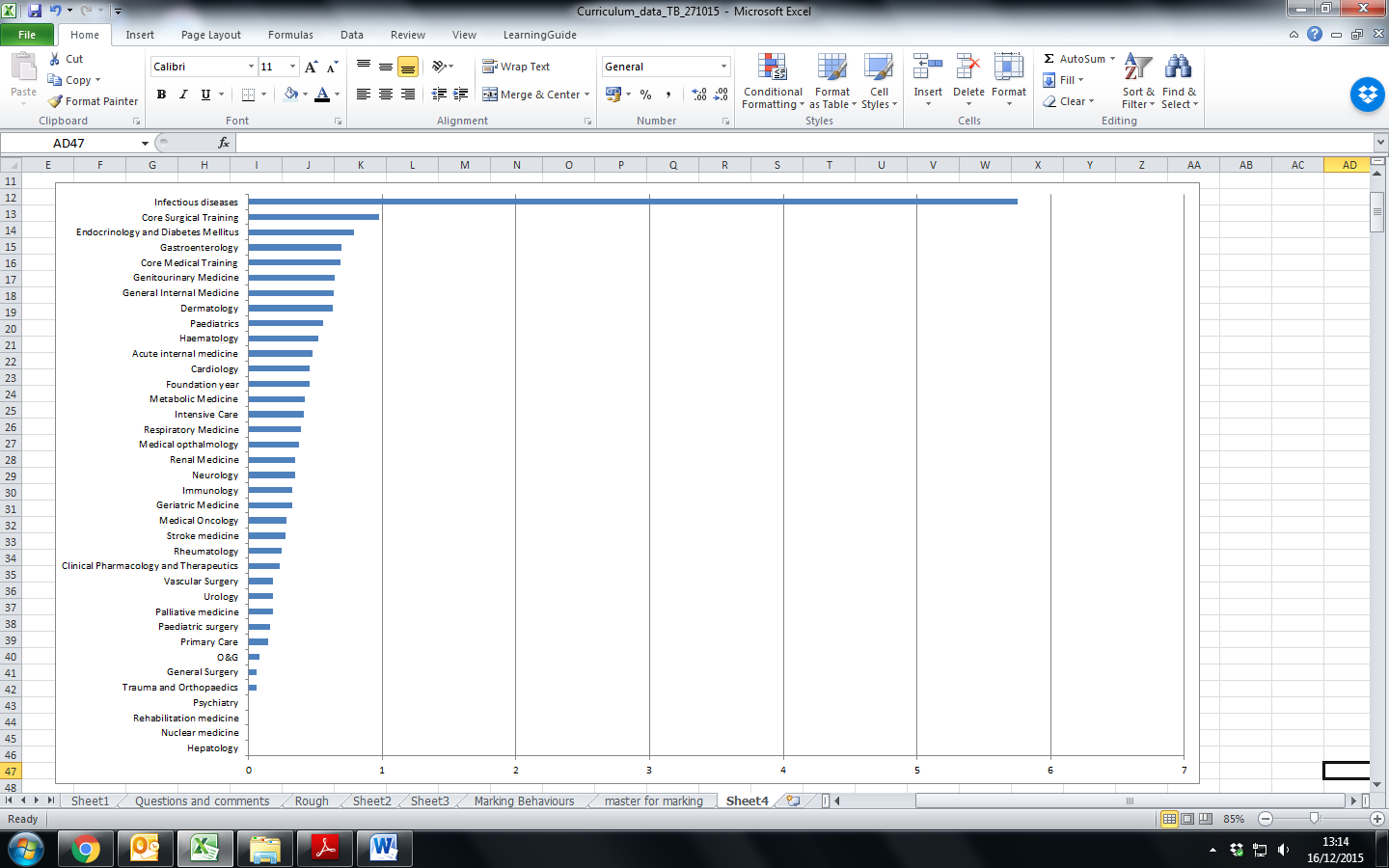
Legend: IPC = Infection Prevention and Control Point; Other infection = infection related point other than AMS-AMR or IPC

Legend: IPC = Infection Prevention and Control Point; Other infection = infection related point other than AMS-AMR or IPC

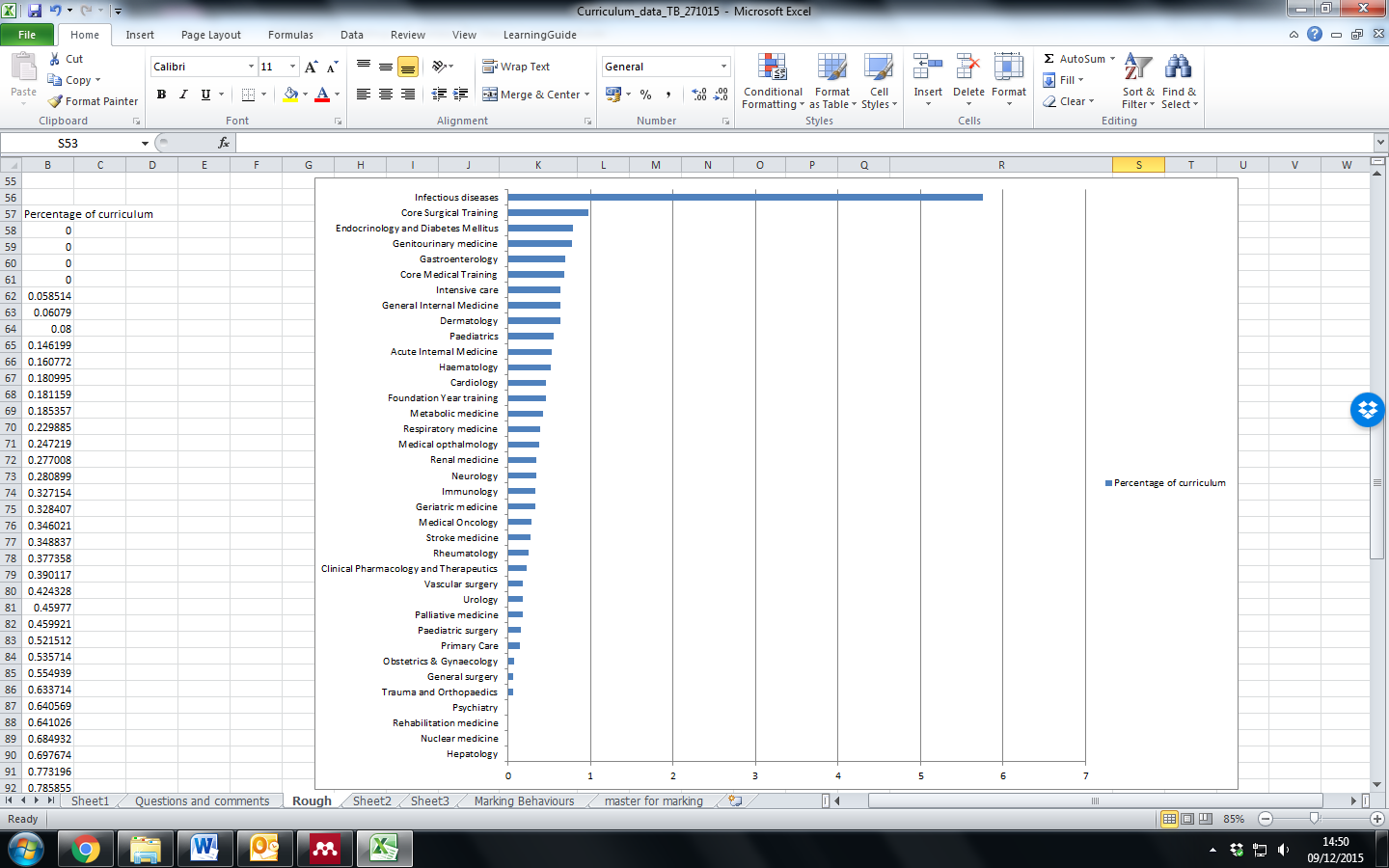
**Table 1.** Summary of current UK clinical specialty training curricula included in our analysis of surrogate markers of cross-specialty engagement with antimicrobial stewardship and antimicrobial resistance.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Specialty curriculum** | **Date of publication** | **Date updated** | **Total number of categories** | **Total number of individual learning points** |
| Acute internal medicine41 | Aug-09 | Aug-12 | 121 | 1680 |
| Cardiology42 | Aug-10 | NA | 91 | 1522 |
| Clinical Pharmacology and Therapeutics43 | Aug-10 | Dec-11 | 42 | 870 |
| Core Medical Training29 | Aug-09 | Aug-13 | 110 | 1752 |
| Core Surgical Training26 | Jul-13 | NA | 35 | 409 |
| Dermatology44 | Aug-10 | Aug-12 | 53 | 789 |
| Endocrinology and Diabetes Mellitus27 | Aug-10 | Aug-12 | 40 | 509 |
| Foundation year45 | Jul-12 | Aug-14 | 42 | 435 |
| Gastroenterology28 | Aug-10 | Aug-13 | 11 | 1290 |
| General Internal Medicine46 | Aug-09 | Aug-12 | 112 | 1405 |
| General Surgery47 | Jul-13 | NA | 157 | 3290 |
| Genitourinary Medicine48 | Aug-10 | Aug-12 | 44 | 776 |
| Geriatric Medicine49 | Aug-10 | Aug-13 | 50 | 917 |
| Haematology50 | Aug-10 | Aug-12 | 45 | 767 |
| Hepatology25 | Aug-10 | Aug-13 | 10 | 91 |
| Immunology51 | Aug-10 | NA | 36 | 609 |
| Infectious diseases 21 | May-14 | NA | 65 | 747 |
| Intensive Care30–32,52 | Jan-15 | NA | 164 | 3594 |
| Medical Oncology53 | Aug-10 | NA | 68 | 1424 |
| Medical ophthalmology54 | Aug-10 | NA | 38 | 530 |
| Metabolic Medicine55 | Aug-10 | NA | 44 | 707 |
| Neurology56 | Aug-10 | Aug-13 | 51 | 289 |
| Nuclear medicine24 | Aug-14 | NA | 10 | 745 |
| Obstetrics & Gynaecology57 | Aug-13 | NA | 19 | 1250 |
| Paediatric surgery58 | Jan-15 | NA | 193 | 2488 |
| Paediatrics59 | Sep-10 | NA | 23 | 1802 |
| Palliative medicine60 | Jan-10 | Oct-14 | 66 | 1105 |
| Primary Care61,62 | Oct-15 | NA | 37 | 1368 |
| Psychiatry22 | Jul-13 | Mar-15 | 44 | 313 |
| Rehabilitation medicine23 | Aug-10 | NA | 36 | 490 |
| Renal Medicine63 | Aug-10 | Aug-12 | 114 | 860 |
| Respiratory Medicine64 | Aug-10 | May-14 | 81 | 1538 |
| Rheumatology65 | Aug-10 | NA | 58 | 809 |
| Stroke medicine66 | Aug-10 | Aug-13 | 18 | 361 |
| Trauma and Orthopaedics67 | Aug-15 | NA | 27 | 1709 |
| Urology68 | Jan-15 | NA | 109 | 2208 |
| Vascular Surgery69 | Jul-14 | NA | 54 | 1079 |

**Figure 4.** Percentage of UK clinical specialty training curricula related to antimicrobial stewardship and/or antimicrobial resistance



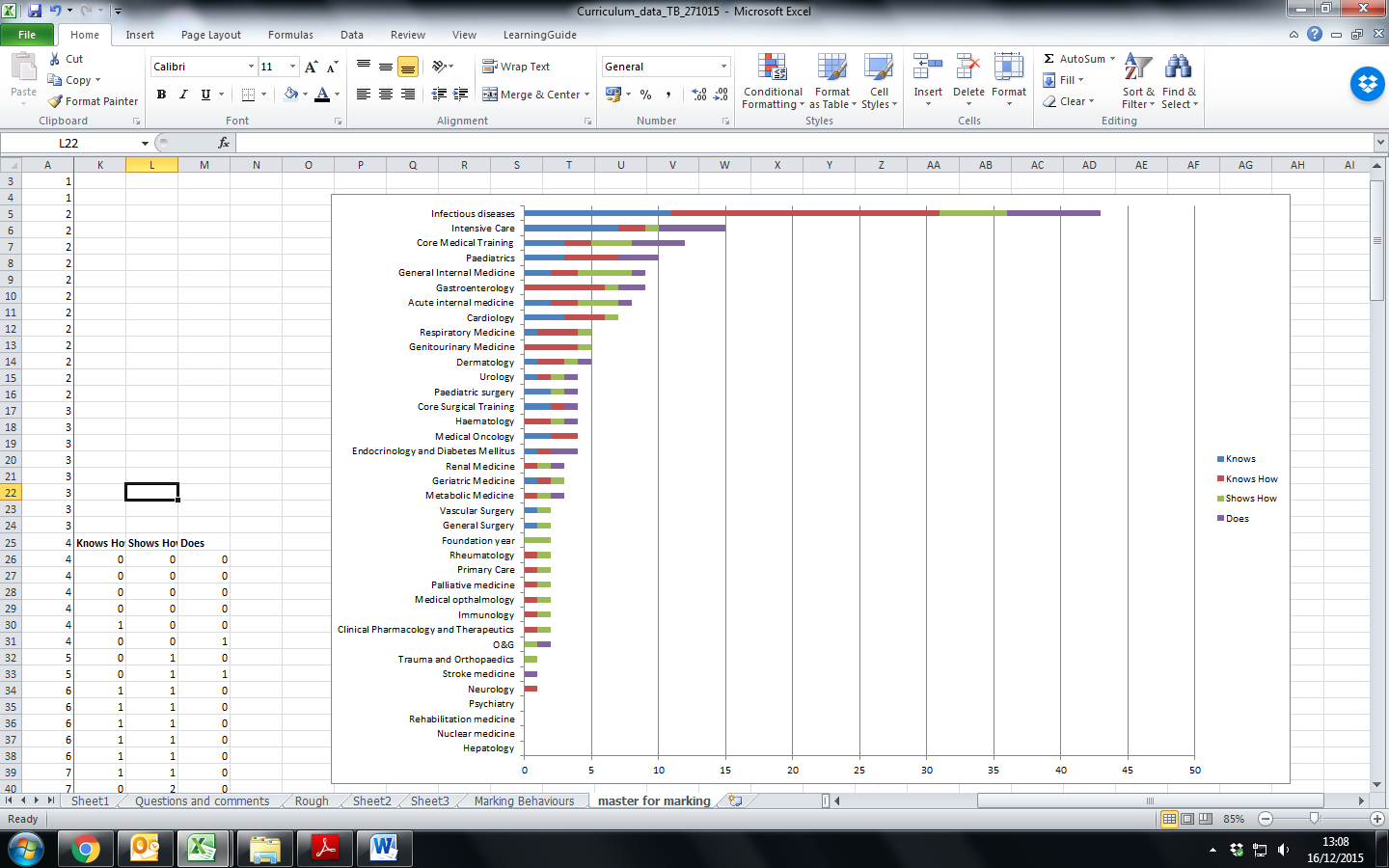
**\***

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**Legend:** Infectious diseases = combined infection & microbiology training; O&G = Obstetrics and Gynaecology; **\*** = p<0.05

**Legend:** \* p<0.01 compared against all other clinical specialities

**Figure 5.** Total number of learning points in UK clinical specialty training curricula related to antimicrobial stewardship and/or antimicrobial resistance with associated levels of clinical competence documented



Number of learning points

**Legend:** Infectious diseases = combined infection & microbiology training; O&G = Obstetrics and Gynaecology