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RESEARCH

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Cultivating global antimicrobial stewardship: prescribing quality and implementability insights from Portugal's First Hospital National Antimicrobial Prescribing Survey

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Abstract

Background Assessing the quality of antimicrobial prescribing is critical to combating antimicrobial resistance. The Australian Hospital National Antimicrobial Prescribing Survey (Hospital NAPS) assists in the assessment of antimicrobial prescribing appropriateness using consensus definitions, extending beyond guidelines compliance. Applying the Hospital NAPS in Portugal can address a knowledge gap.

Objectives To assess the quality of antibiotic prescribing in a sample of Portuguese hospitals and evaluate Hospital NAPS implementability.

Methods A point prevalence audit using the translated and culturally validated Hospital NAPS definitions for Portugal and Hospital NAPS methodology was conducted across eight Portuguese hospitals from October 2023 to February 2024. Antimicrobial stewardship teams were surveyed to explore implementability.

Results Among 2178 non-critical adult inpatients, 719 (33%) received antibiotics, resulting in 881 prescriptions (1.2 per patient). Most were male (68%), with a median age of 74 years, admitted to medical wards (46%) and managed by internal medicine (39%). Treatment indications accounted for 86% of prescriptions. High documentation rates were observed for indication (95%) and review/stop dates (91%). Guideline compliance was 68% Unnecessary prescribing occurred in 7%. Overall prescriptions inappropriateness was 42%. Spectrum too broad (41%) or incorrect dose or frequency (29%) were the main reasons for prescriptions being deemed inappropriate. Surgical prophylaxis > 24 h occurred in 26% of surgeries. Participants reported that Hospital NAPS has potential for implementation in Portugal.

Conclusions The First Portugal Hospital NAPS increased knowledge about antibiotic prescribing, identified areas for improvement and demonstrated the potential for Hospital NAPS implementation in Portugal, contributing to global antimicrobial stewardship efforts.

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Background

Addressing antimicrobial resistance (AMR), a silent and overlooked pandemic, has become a priority for international organizations and national governments, within the One Health framework [1–7].

Inappropriate antibiotic use remains the primary driver of antibacterial resistance, a naturally adaptive process that makes it a "deadly emergent disease" [8–10].

Globally, in 2021, AMR caused around 4.71 million deaths (1.14 million directly attributable). This number equals the four-year mortality of the COVID-19 pandemic and surpasses annual deaths from influenza, tuberculosis, and HIV/AIDS combined. By 2050, deaths could increase to 8.22 to 10 million (1,91 million directly attributable) due to rising antibiotic use [11–14].

AMR causes long-term disability, strains health systems, imposes economic and environmental burdens, and hinders progress on WHO's Sustainable Development Goals [15–20].

According to the Organisation for Economic Co-operation and Development (OECD), Portugal will be significantly impacted by AMR between 2015 and 2050 with an annual average of 1167 deaths, an additional 127,500 hospitalization days, 26,560 disability-adjusted life years, and 50 million USD in healthcare costs [21].

In 2023, Portugal's hospital antibiotic consumption levels surpassed those of the EU/EEA, both in terms of total antibiotic use (1.72 vs 1.61 DDD/1000 inhabitants per day) and the hospital´s ECDC/EFSA/EMA antimicrobial consumption secondary indicator (43.7% vs. 40.1%), reflecting a high proportion of broad-spectrum antibacterials for systemic use.

Since 2010, hospital consumption of antibiotics in Portugal has increased by 0.7%, above the EU/EEA average, a situation that worsened between 2019 and 2023 (increase of 11.1% vs 0.4%) [22, 23].

Several factors may explain this situation. These include a higher prevalence of healthcare-associated infections in Portugal (11.6 vs 6.8% in the EU/EEA) and a higher composite index of antimicrobial resistance (32.9 vs 21.8%) [24, 25].

Cultural factors in Portugal, as described by Hofstede cultural dimensions theory, likely influence prescribing behaviors and the adoption of AMS interventions [26, 27]. High uncertainty avoidance may contribute to clinician anxiety and a tendency to favor broad-spectrum antibiotics "just in case." High power distance reflects a strong deference to hierarchical decision-making, which can limit junior staff engagement in prescribing decisions, a phenomenon often referred as "prescribing etiquette" [28]. A relatively low long-term orientation suggests a focus on immediate outcomes over future consequences, potentially reducing motivation to preserve antimicrobial effectiveness.

Gaps in antimicrobial education, knowledge and attitudes among medical students and physicians, coupled with broader economic and organizational constraints, may further impact implementation of AMS activities [29–32].

Portuguese regulations require hospitals to establish AMS teams and to perform audit and feedback, within 72 h, at a minimum for the use of quinolones, carbapenems, and antibiotics classified as Reserve by the WHO's *Access, Watch and Reserve* (AWaRe) classification system. Antibiotic consumption targets have been added to hospital contractualization [33–35]. The degree of compliance with these regulations is unclear, hindered by the absence of a national accreditation framework and limited guidance on antibiotic prescribing practices.

Although the National Authority of Medicines and Health Products oversee monitoring data on antimicrobial consumption, the lack of standardized definitions for appropriateness of antibiotic prescribing limits the ability to assess the quality of prescribing in Portuguese hospitals, making it difficult to identify targets for AMS programs.

Defining and measuring appropriate antibiotic prescribing remains challenging, as it is influenced by cultural, contextual, and moral factors, as well as differing professional perspectives. Although several qualitative proxies and indicators have been proposed, the most accurate understanding of prescribing quality is achieved through the assessment of individual prescriptions, which provides a robust basis for audit and feedback activities [36–42]. Several AMS programs have made efforts to clarify prescribing practices and reduce subjective assessments influenced by "the eye of the interpreter" [43–47].

The absence of microbiological data or specific guidelines should not prevent the evaluation of appropriateness, given the empirical nature of most prescriptions and the lack of guidelines for many infections, as noted by the ECDC's guidelines and checklist for prudent antimicrobial use [48].

To address these challenges, an online platform, the Hospital National Antimicrobial Prescribing Survey (Hospital NAPS), was developed in Australia using standardized, consensus-driven definitions of appropriateness that extend beyond guidelines or microbiological results. This platform incorporates key prescribing indicators and enables both internal and external benchmarking of prescribing practices. Since 2013, the Hospital NAPS has been implemented successfully in Australia across various settings by physicians, pharmacists, and nurses, and has expanded to twelve countries of differing income levels [49–55].

The First Portugal Hospital NAPS was conducted to address a knowledge gap and provide an initial step

toward possible national implementation of Hospital NAPS.

Methods

The First Portugal Hospital NAPS was conducted as a one-day prevalence audit carried out in eight Portuguese acute care hospitals with two aims:

- Primary aim: assess the quality of antibiotic prescribing for non-critical adult patients in a sample of Portuguese hospitals, using the Hospital NAPS definitions validated for Portugal, along with the established Hospital NAPS platform and methodology.
- Secondary aim: evaluate the implementation of Hospital NAPS in Portugal.

The development of the Portugal Hospital NAPS is summarized in accordance with the EPIS framework [56] (Fig. 1).

Ten hospitals were purposely invited to represent diverse geographic regions and institutional characteristics, such as hospital size, teaching affiliation, funding models, and the readiness of their AMS teams to participate, thereby facilitating their engagement. Authorization for participation was granted by the board and the ethics committee of each hospital.

Data was de-identified and securely stored on servers at Melbourne Health and the NOVA National School of Public Health (NOVA-NSPH), with controlled and restricted access. These measures and the observational nature of the study enabled the waiver of informed consent for patients and prescribers and ensured compliance with the European General Data Protection Regulation.

Included prescriptions were active systemic antibiotics (WHO ATC J01) for adult inpatients at 8 a.m. on survey day, including ED patients awaiting ward beds or those given prophylaxis from 8 a.m. the previous day [57]. Exclusions were day-stay wards, outpatient clinics, and clinical trial prescriptions.

Reflecting the routines of most AMS teams in Portugal, the study excluded antifungals, antivirals and topical antibacterials, pediatric and critically ill patients.

Assessors, each with at least one year of experience in AMS (eleven infectious diseases specialists, eight internal medicine specialists, and two clinical pharmacists), were organized into local teams led by coordinators. They received remote online training on the Hospital NAPS,

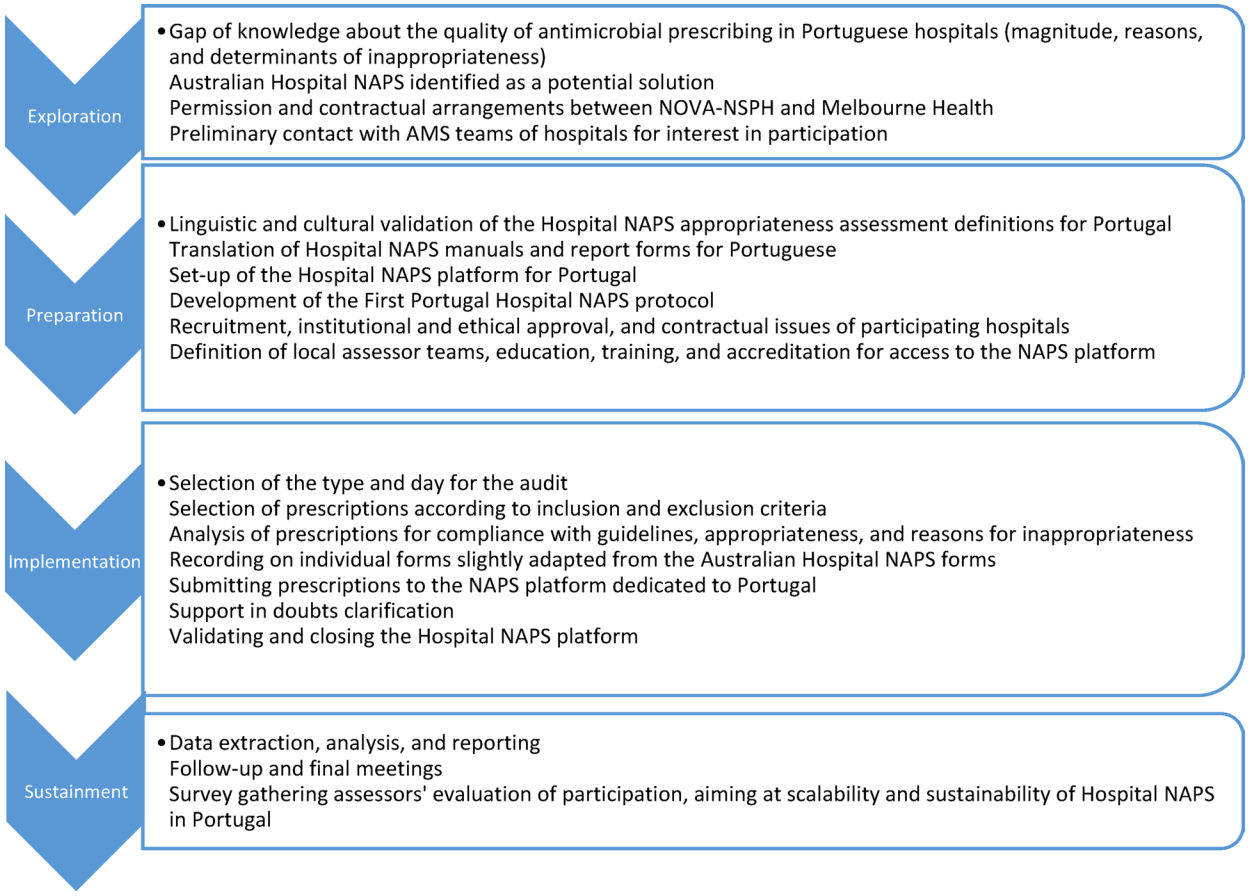

Fig. 1 Multi-step approach of First Portugal Hospital NAPS using the EPIS framework

completed vignette-based assessments using Microsoft Forms® based on the Portuguese-validated appropriateness definitions, and engaged in discussions with the Australian NAPS support team. Each prescription was ideally evaluated by two assessors, with additional support from the NAPS team whenever needed. The information was recorded on paper forms, de-identified and then entered on the online platform.

Hospital NAPS key indicators were calculated for documentation of indication, documentation of review or stop date in clinical files, surgical prophylaxis > 24 h, compliance with guidelines (national or local), and appropriateness.

Guideline compliance was assessed according to National Directorate of Health guidance for urinary and respiratory tract infections, diabetic foot infections treatment, antibiotic duration, and surgical prophylaxis, as well as any locally developed and endorsed guidelines. Prescriptions were classified as compliant or non-compliant whenever guidelines existed, no guidelines available, directed therapy, or not assessable.

Appropriateness was classified according to the Hospital NAPS assessment definitions previously translated culturally validated for Portugal by the authors [58].

In Hospital NAPS, prescriptions are classified as appropriate; inappropriate; or not assessable. Appropriate prescriptions are divided into optimal, denoting full compliance with parameters such as indication, spectrum, dose, duration, route, allergy status, and microbiological findings; and adequate, where only minor, clinically acceptable deviations are present. Inappropriate prescriptions are categorized as suboptimal, involving deviations unlikely to affect treatment outcomes but potentially contributing to AMR; and inadequate, where prescriptions are not necessary or likely to result in treatment failure or severe patient harm. Prescriptions were deemed not assessable when information was missing or patients were deemed too complex.

One or more reasons for inappropriateness were selected: antimicrobial not indicated, spectrum too broad, spectrum too narrow, incorrect dose or frequency, incorrect duration, incorrect route, allergy mismatch and microbiology mismatch [49].

Data from the NAPS platform were exported to Microsoft Excel® for descriptive statistical analysis (means, medians, and percentages) to summarize numeric variables. No inferential statistical tests were performed for this paper.

To evaluate the implementability of the Hospital NAPS in Portugal, assessors completed an anonymous Microsoft Forms® questionnaire grounded in the conceptual framework that identifies acceptability (agreement), fidelity (willingness to follow), and feasibility (capacity to implement) as key determinants of scalability (transferability to other settings) and sustainability (long-term integration) [59].

Results

Hospital data

The Hospital NAPS was conducted in eight Portuguese acute care hospitals, each selecting one working day for data collection between late October 2023 and early February 2024, providing flexibility for participating institutions while ensuring reasonable consistency in relation to seasonal prescribing patterns. These included one tertiary hospital and seven secondary hospitals, totaling 3394 beds (mean: 424; range: 150–1128). Seven were public and six were non-university hospitals. Five hospitals conducted a hospital wide survey of all eligible patients' prescriptions, while three performed a survey sampling every second eligible patient.

Patient data

Of the 2,178 patients, 719 (33%; hospital range 27–46%) received antibiotics, with a total of 881 prescriptions (1.2 prescriptions per patient; hospital range 1.1–1.3). The median age was 74 years (range 18–97) and 60% were male. Most patients (78%) were prescribed one antibiotic; 21% received two.

Overview of antibiotic prescriptions

Most antibiotics were prescribed by internal medicine (38%), general surgery (17%), and infectious diseases physicians (6%). Specialists in training accounted for 41% of prescriptions, junior specialists for 37%, and senior specialists for 18%. Most prescriptions (80%) were written during full hospital operation hours when the permanent team staff were on duty, which differed from hospital to hospital.

Most of the 881 prescribed antibiotics (85%) were prescribed for treatment, with 74% used empirically. Surgical prophylaxis made up 12% of prescriptions, and medical prophylaxis accounted for 3%.

The average duration of treatment up until the audit day was seven days. The intravenous (IV) route was used in 91% of cases (89% excluding prophylaxis). Most prescriptions remained unchanged until the audit day (79%).

Antibiotics in the *Watch* category of the *AWaRe* classification system were the most prescribed (54%), followed by Access (42%) and Reserve (4%).

Twenty-two prescriptions were excluded from analysis regarding guideline compliance and appropriateness due to the absence of a known reason for prescribing.

Compliance with existing guidelines was observed in 68% of prescriptions, while 15% of prescriptions had no applicable guidelines.

Assessors classified 360 of 859 prescriptions (42%) as inappropriate. Of these, 223 (68%) were suboptimal and 137 (32%) were inadequate.

Antibiotic use was deemed not indicated for 57 prescriptions (16% of inappropriate cases; 7% of all prescriptions).

When antibiotics were deemed indicated but inappropriate (n = 303), recorded reasons for inappropriateness were spectrum too broad (n = 124; 41%), incorrect dose or frequency (n = 88; 29%), incorrect duration (n = 77; 25%), incorrect route (n = 40; 13%), and spectrum too narrow (n = 38; 13%).

Table 1 summarizes observed key indicators and reasons for inappropriateness.

Antibiotic use across all indications

Piperacillin-tazobactam, amoxicillin-clavulanic acid and ceftriaxone were the most prescribed antibiotics, 19%, 18% and 10% respectively. Together, they accounted for most prescriptions deemed inappropriate (57%) and individually demonstrated high rates of inappropriateness, respectively 48%, 50% and 57% (Table 2).

Surgical prophylaxis, community-acquired pneumonia and pyelonephritis were the most common indications for antibiotic prescribing, representing 29% of all prescriptions. Each also demonstrated high rates of inappropriateness, respectively 39%, 40% and 41%. (Fig. 2).

Considering the three most frequently prescribed antibiotics, in the case of piperacillin-tazobactam, hospital-acquired pneumonia was the most common indication for use, showing a relatively low rate of inappropriateness (29%). (Fig. 3).

In the case of amoxicillin-clavulanic acid, community-acquired pneumonia was the most frequent indication, with a moderate rate of inappropriateness (36%). (Fig. 4).

Finally, in the case of ceftriaxone, pyelonephritis was the most common indication for use and demonstrated a high rate of inappropriateness (56%). (Fig. 5).

Among the remaining top ten antibiotics, ciprofloxacin, metronidazole, and meropenem were noteworthy due to their high inappropriate rates, respectively 60% (n = 12), 50% (n = 13), and 46% (n = 21). In all of these, the main reason for inappropriateness was spectrum too broad, which in the case of metronidazole was linked to combination therapies that unnecessarily overlap spectrum to cover anaerobic bacteria (Table 2).

Table 1 Summary of First Portugal Hospital NAPS key indicators and reasons for inappropriateness

	Survey (range)
Hospital NAPS key indicator	
Indication documented	95% (91–100)
Review or stop date documented	91% (81–100)
Surgical prophylaxis > 24h*	26% (0–63)
Compliance with guidelines**	68% (50–84)
Appropriateness	58% (41–77)
Reasons for inappropriateness	
Antibiotic not indicated	7% (0–17)
Antibiotic indicated	
Spectrum too broad***	41% (11–51)
Incorrect dose or frequency***	29% (17–50)
Incorrect duration***	25% (5–38)
Incorrect route***	13% (0–27)
Spectrum too narrow***	13% (6–37)
Allergy mismatch***	0%
Microbiology mismatch****	10% (0–25)

Data considering 859 of 881 prescriptions (22 prescriptions were excluded from the analysis to unknown reason forprescribing). More than one reason could be selected. *% of prescriptions for surgical prophylaxis. **% ofprescriptions excluding not assessable, directed therapy, and no guidelines available. ***% of inappropriateprescriptions excluding antibiotic not indicated. ****% of inappropriate directed therapy prescriptions. Other resultsare expressed as a % of total prescriptions

Antibiotic use in surgical prophylaxis

Surgical prophylaxis accounted for 106 prescriptions (12% of the total). Cefazolin was the most frequently prescribed antibiotic (n = 75; 71%), followed by amoxicillin-clavulanic acid (n = 7; 7%) and cefoxitin (n = 5; 5%).

Assessors considered that surgical prophylaxis was not indicated in six cases (6%). Overall, 41 prescriptions (39%) were considered inappropriate.

Main reasons for inappropriateness in surgical prophylaxis were incorrect dose or frequency (n = 16; 46% of inappropriate cases) and spectrum too broad (n = 5; 14%).

Antibiotic use in medical prophylaxis

Medical prophylaxis made up 3% (n = 23) of prescriptions. Trimethoprim-sulfamethoxazole was the most prescribed antibiotic (30%) and reflective of the most common indication, *Pneumocystis jirovecii* pneumoniae (26%). Inappropriateness was observed in only three prescriptions (13%), due to incorrect dose or frequency and incorrect duration.

Hospital NAPS national implementability

All ten assessors who used the NAPS platform and evaluated prescriptions completed an anonymous Microsoft Forms® questionnaire.

Table 2 Summary of indications, guideline compliance and inappropriate use for the top 10 antibiotics prescribed

Antibiotic	N (%)	Main indication N (%)	Non-compliance with guidelines N (%) *	Inappropriateness N (%)	Main reason for inappropriateness N (%) **	Main inappropriate indication N (%) **
All	859 (100)	Surgical prophylaxis 106 (12)	159 (32)	360 (42)	Spectrum too broad 124 (41)	Surgical prophylaxis 41 (11)
Piperacillin–Tazobactam	162 (19)	Hospital-acquired pneumonia, empirical 24 (15)	32 (33)	78 (48)	Spectrum too broad 42 (58)	Ascending cholangitis 9 (12)
Amoxicillin–Clavulanic Acid	158 (18)	Community-acquired pneumonia 47 (30)	37 (31)	79 (50)	Incorrect route 19 (31)	Community-acquired pneumonia 17 (22)
Ceftriaxone	84 (10)	Pyelonephritis 16 (19)	28 (55)	48 (57)	Spectrum too broad 20 (51)	Pyelonephritis 9 (19)
Cefazolin	80 (9)	Surgical prophylaxis 75 (94)	11 (15)	18 (23)	Incorrect dose/frequency 6 (47)	Surgical prophylaxis 18 (100)
Vancomycin	48 (6)	Infected prosthesis, osteomyelitis 5 (10) each	4 (27)	20 (42)	Incorrect duration 8 (40)	Healthcare-associated pneumonia 3 (15)
Meropenem	46 (5)	Pyelonephritis 7 (15)	5 (38)	21 (46)	Spectrum too broad 14 (70)	Peritonitis 4 (19)
Azithromycin	44 (5)	Community-acquired pneumonia 30 (68)	4 (12) ***	12 (32) ***	Incorrect route/duration, spectrum (broad/narrow) 3 (30) each	Community-acquired pneumonia, Hospital-acquired pneumonia 4 (33) each
Metronidazole	26 (3)	Peritonitis due to perforated viscus 7 (27)	6 (43)	13 (50)	Incorrect duration; Spectrum too broad 5 (50) each	Ascending cholangitis 3 (23)
Cotrimoxazole	21 (2)	Medical prophylaxis 7 (33)	0 (0)	0 (0)	NA	NA
Ciprofloxacin	20 (2)	Osteomyelitis 3 (15)	4 (44)	12 (60)	Spectrum too broad 6 (60)	Peritonitis 3 (25)

All prescriptions, excluding unknown reason for prescribing. *Calculation excluding not assessable, directed therapy and no guidelines available (130 cases). **Calculation considering only inappropriate prescriptions. ***Calculation excluding a hospital whose electronic prescription system considers 7 days by default for respiratory infections (9 of 96 prescriptions) NA, Not applicable.

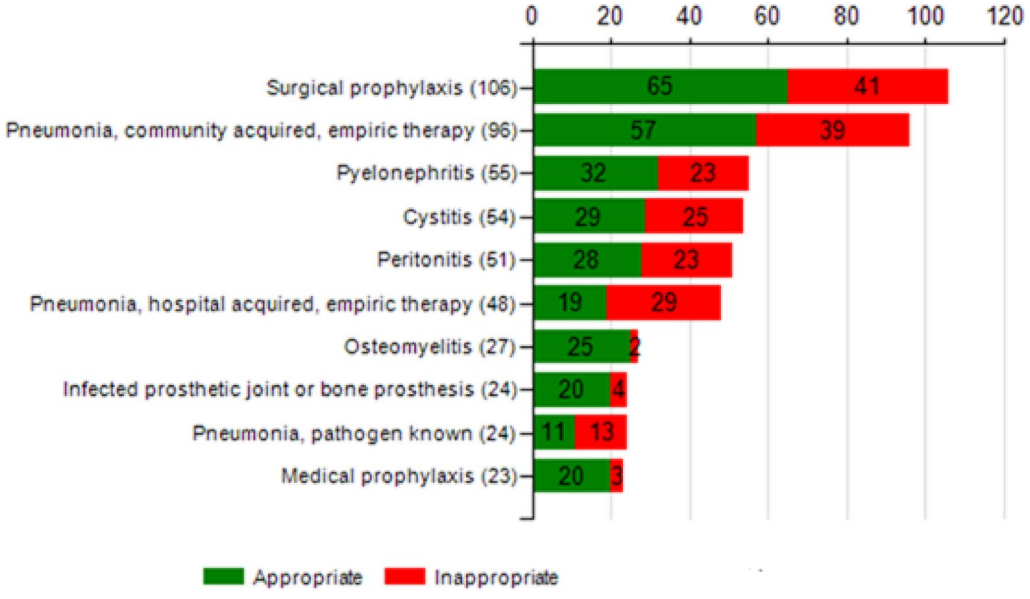

Fig. 2 Top 10 indications for antibiotic prescribing. Green: appropriate (optimal and adequate); red: inappropriate (suboptimal and inadequate), according to Hospital NAPS appropriateness assessment definitions

Responses were highly positive regarding acceptability and feasibility: all found the definitions useful and reported improved awareness, while most considered the platform user-friendly and the time requirements reasonable. In terms of fidelity, all had shared or planned to share results internally, though post-audit local adoption of the NAPS remained limited to 40%. Scalability and sustainability were well supported, with all respondents endorsing national implementability.

Participants mentioned an overall positive experience. Challenges included the lack of national guidelines, difficulties in retrieving information in clinical documentation, and time constraints due to the additional fields added in the Hospital NAPS, though these were regarded as valuable for the insights they provided regarding better knowledge about prescribers and contexts of prescribing. Key implementability concerns included platform-related costs, the need for more guidance, and the acceptance of prescribing definitions by assessors. Scalability to other

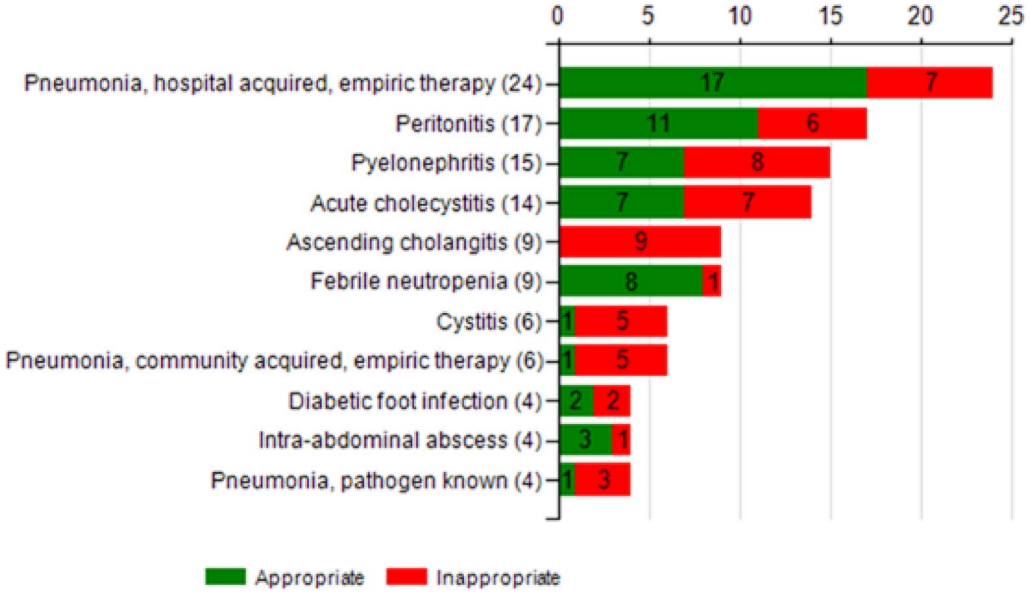

Fig. 3 Top 10 indications for piperacillin-tazobactam prescribing. Green: appropriate (optimal and adequate); red: inappropriate (suboptimal and inadequate), according to Hospital NAPS appropriateness assessment definitions

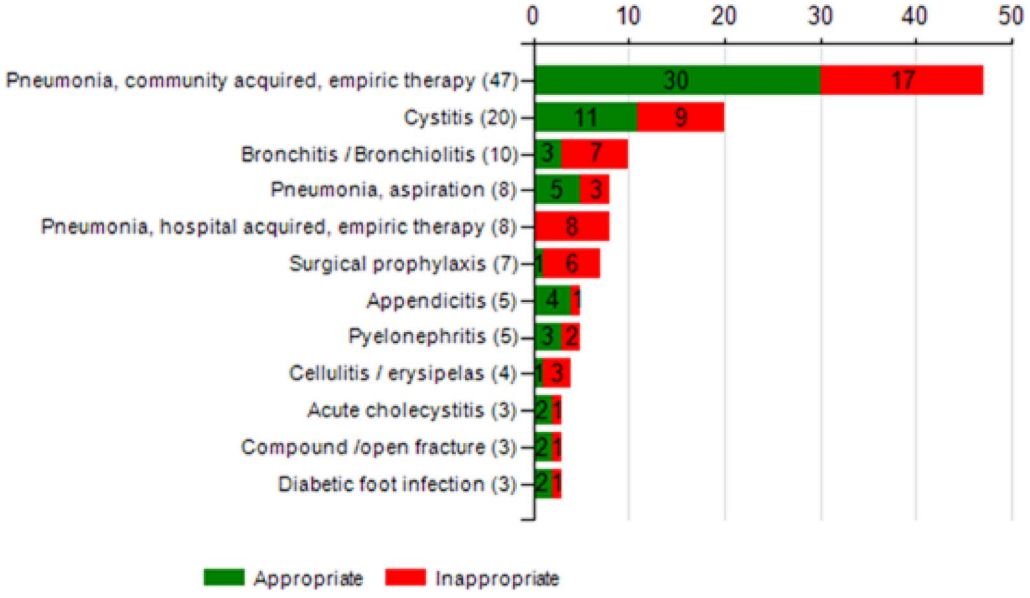

Fig. 4 Top 10 indications for amoxicillin-clavulanic acid prescribing. Green: appropriate (optimal and adequate); red: inappropriate (suboptimal and inadequate), according to Hospital NAPS appropriateness assessment definitions

levels of care was considered feasible, provided appropriate adaptations and pilot testing are undertaken.

Discussion

The First Portugal Hospital NAPS provides the nation's first assessment of antibiotic prescribing appropriateness in Portuguese hospitals using the Hospital NAPS definitions validated for Portugal, the NAPS methodology and platform. The study has identified key areas for quality improvement activities, further areas of research and support for national scaling of the Hospital NAPS program in Portugal.

A high rate of inappropriate prescribing (42%) was demonstrated, mainly due to suboptimal therapy associated with overuse of broad-spectrum antibiotics, incorrect dosing or frequency, and poor IV-to-oral switching in agents such as amoxicillin–clavulanic acid. These findings are clinically significant and suggestive of overtreatment, raising concerns about antimicrobial resistance and risks like *Clostridioides difficile* infection, drug toxicity and dysbiosis.

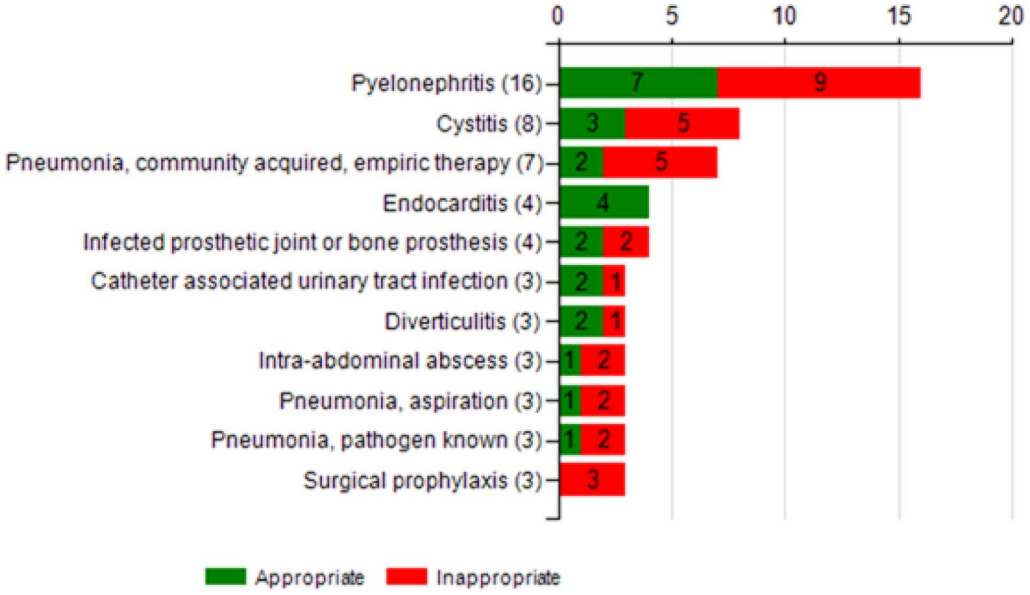

Fig. 5 Top 10 indications for ceftriaxone prescribing. Green: appropriate (optimal and adequate); red: inappropriate (suboptimal and inadequate), according to Hospital NAPS appropriateness assessment definitions

This study establishes a concerning baseline that highlights the urgent need for targeted interventions. It underscores the critical need for improved stewardship and offers a starting point for future work in addressing inappropriate prescribing practices and mitigating their broader public health impact.

High rates of inappropriateness in piperacillin-tazobactam and amoxicillin-clavulanic acid were demonstrated, both of which contribute to the known high consumption of betalactam-betalactamase inhibitors in Portugal that is above the EU/EEA average (0.46 vs. 0.41 DDD/1000 inhabitants/day) [22].

Piperacillin–tazobactam should be reserved for indications such as healthcare-associated infections with suspected or confirmed *Pseudomonas aeruginosa*, septic shock, severe intra-abdominal or skin and soft tissue infections, high-risk febrile neutropenia, and confirmed infections caused by ESBL-producing Gram-negative bacteria [35, 60–65].

Amoxicillin–clavulanic acid prescribing was also due to *incorrect dose or frequency* and spectrum too broad, emphasizing the importance of dose optimization and the consideration of narrower-spectrum alternatives such as amoxicillin in some situations [35, 66–69].

Ceftriaxone is not routinely recommended as a first line of treatment of community-acquired infections and can be substituted with other narrow-spectrum antibiotics, such as amoxicillin or amoxicillin-clavulanic acid, reducing the potential for the development of AMR [35, 70–72].

These findings suggest that these antibiotics should be considered for mandatory inclusion in the audit and feedback activities conducted by local AMS teams, a practice that is not yet standard in Portugal.

Despite being priority targets in the national strategy and contractualization of public hospitals, ciprofloxacin and meropenem showed high rates of inappropriate prescribing, mainly due to spectrum too broad. These findings occurred alongside divergent consumption trends: meropenem use has risen since 2020, exceeding the EU/EEA average (0.09 vs. 0.07 DDD/1,000 inhabitants/day), while ciprofloxacin use has decreased (0.07 vs. 0.13 DDD/1,000 inhabitants/day), likely reflecting the impact of safety awareness campaigns of black box warnings [23, 35, 73–77].

Metronidazole was often used inappropriately in this setting due to its overlapping spectrum with some betalactams, leading to unnecessary use, resistance, side effects, and higher costs [35, 78, 79].

Compliance with guidelines when available was modest (68%). The absence of local or national recommendations in many clinical situations highlights the urgent need to develop consensus-based, accessible, up-to-date, and contextually relevant antimicrobial prescribing guidelines for Portugal. Although electronic prescribing has improved documentation and review practices, further improvements are needed to meet WHO's Third Global Challenge for Patient Safety [80].

The high use of the intravenous route highlights the need to promote IV-to-oral switch strategies, which are supported by evidence for both clinical efficacy and AMS benefits [81–86].

Implementability of hospital NAPS in Portugal

The results of the assessor's questionnaire on the Hospital NAPS implementability highlight its valuable role in supporting stewardship practices in Portugal, improving knowledge about patterns of prescribing and tailoring interventions in an efficient way that can be integrated in the AMS teams activities.

The questionnaire indicated positive evaluations in terms of acceptability, feasibility, scalability, and sustainability. Although routine adoption of the appropriateness definitions by AMS teams was limited after the study (fidelity), primarily due to the pending publication of this paper, the findings indicate potential for national-scale implementation of Hospital NAPS. Sustained training, national endorsement, and integration into routine quality systems will be essential to scale up NAPS program implementation and support long-term AMS improvement in Portugal.

Benchmarking with other hospital NAPS

Overall inappropriateness rate in Portugal was higher than that observed in Australia in 2022 (26%) and Canada in 2019 (26%), but closer to those found in Bhutan in 2023 (46%) and Malaysia in 2022 (36%) [49–55, 87]. This likely reflects the substantial variation in culture, organization, resources, and the maturity of existing programs across countries that influence both the prioritization and operationalization of stewardship activities.

The high percentage of lack of local or national guidelines stands in contrast to Australia's long-established and widely implemented national guidelines, which are a key component of the national strategy for improving AMS activities and antimicrobial prescribing [88].

Like Australia, almost one in four surgical prophylaxis prescriptions were prolonged beyond 24 h. Although the Portuguese results showed higher documentation of indication in the clinical notes (95%) and review/stop date (91%) compared to Australia (85% and 54%), this may partly reflect the universal use of electronic medical records in Portuguese hospitals.

Strengths and limitations

The First Portugal Hospital NAPS was pioneering in assessing antibiotic prescribing quality in the country. Strengths include minimizing subjectivity through cultural validation of definitions, translation of materials, standardized procedures, and vignette-based discussions with the Australian NAPS support team. Involvement of experienced AMS assessors further enhanced reliability, although some variation in appropriateness classification is inherently expected.

The hospitals were purposefully selected, and participation was voluntary, which may have introduced some selection bias. However, this approach was essential for the feasibility and initiation of the study. Hospitals willing to participate were likely more engaged in AMS and may have demonstrated higher rates of prescribing quality, offering valuable insights into the impact of AMS programs in motivated institutions. While the sample may not fully represent all Portuguese hospitals, the diversity of participating settings still provided meaningful data. Additionally, these hospitals had participated in the most recent ECDC Point Prevalence Survey, where the top ten antibiotics were comparable. As this was the first study conducted in Portugal to inform a national program, such self-selection, where hospitals choose to participate based on their interest in AMS, is common and expected. Future studies would aim to include a broader range of hospitals to enhance representativeness and support nationwide implementation.

As a point prevalence methodology, findings reflect a single time point. Pediatric, critical care patients and non-J01 antimicrobials were excluded, and should be considered for inclusion in future scaling of the Hospital NAPS program in Portugal.

The infrequent prescription of certain antibiotics highlights the need for caution in interpreting these findings and avoiding overstatement of their implication.

Conclusions

The first Portugal Hospital NAPS enabled the initial national assessment of antibiotic prescribing quality using the Hospital NAPS appropriateness assessment definitions validated for Portugal, along with the NAPS methodology and online platform.

For the participating hospitals, the study identified a high rate of inappropriate prescribing, largely due to suboptimal use of commonly prescribed antibiotics (piperacillin-tazobactam, amoxicillin-clavulanic acid, ceftriaxone) and frequent indications (surgical prophylaxis, community-acquired pneumonia, pyelonephritis), often involving unnecessary broad-spectrum use.

Key areas for improvement include narrowing the spectrum, optimizing doses and frequency, increasing IV-to-oral conversion, reducing duration of surgical prophylaxis, as well as developing new guidelines and supporting adherence to existing ones, as part of an integrated national AMS strategy.

Following OECD recommendations to improve AMS policies in Portugal, the First Portugal Hospital NAPS paves the way for nationwide adoption of Hospital NAPS towards the goal of strengthening AMS initiatives globally.

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Author contributions
CP was responsible for the study conception, data analysis, and interpretation. CI and RJ contributed to data analysis and interpretation. PS, JAP, and KT contributed to the discussion of the results. All authors were involved in drafting the manuscript, critically revising it, and approved the final version for submission.

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Data availability
The datasets generated and/or analyzed during the current study are not publicly available due to confidentiality data agreements but are available from the corresponding author on reasonable request.

Declarations

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Not applicable.

Consent for publication
Not applicable.

Competing interests
The authors declare no competing interests.

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