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REVIEW

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Antibiotics profile map of clinical *A. baumannii* strains isolated from health institutions in Turkey: a database search study and analysis of publications from 2011 to 2022

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Abstract

Background *Acinetobacter baumannii* is recognized as a major threat that causes healthcare-associated infections and causes a huge challenge to the health system worldwide. This research study was designed to detect the types and profiles of antibiotics tested against *A. baumannii* clinical strains in Turkey to evaluate their effectiveness and reevaluate their usage.

Main body of the abstract The study depended on data search strategy using the online electronic database. We carried out a detailed analysis to all original research articles from 2011 to 2022 all conducted in Turkey. The study involved 91 articles and revealed about 40 antibiotics tested from 2006 to 2021 against *A. baumannii* with a different frequency. The more frequency antibiotics tested by health institutions in Turkey during this period included 15 antibiotics which are (Amikacin, Gentamicin, Imipenem, Meropenem, Cefoperazone–sulbactam, Ceftazidime, Cefepime, Ampicillin/sulbactam, Piperacillin, Piperacillin/tazobactam, Ciprofloxacin, Levofloxacin, Trimethoprim–Sulfamethoxazole, Colistin and Tigecycline). The frequency of resistance rate with percentage of (80–100%) shown by *A. baumannii* against these antibiotics was as follows (40.96%, 50.64%, 77.77%, 78.31%, 46.15%, 94.11%, 88.23%, 80.85%, 95.46%, 91.93%, 93.42%, 82.85%, 53.57%, 2.66%, 3.70%), respectively. From 2016 to 2021, an increase in resistance rates by *A. baumannii* against Colistin and Tigecycline was indicated noticeably. The 0% resistance rates during this period against Colistin were reported in a percentage of 16.6%, while the appearance of highly noticeable resistance (from 80 to 100 = 3.70%) against Tigecycline and the continuous elevation of resistance rates against this drug was worrisome.

Short conclusion Stability in high resistance rates against some antibiotics for the last 10 years and the increase in resistance rates against effective antibiotics by *A. baumannii* should undergo for more studies and re-evaluation.

Keywords *Acinetobacter baumannii*, *Acinetobacter* spp., Antibiotics profile, Antibiotic susceptibility test, Turkey

Introduction

Acinetobacter baumannii is a major threat that causing healthcare-associated infections. And because of the increasing rates of resistance and the high mortality caused by *A. baumannii*, as well as the lack of effective treatment options due to the very few available drugs that can control these bacteria, the world health organization has been designated this bacteria as a priority 1-critical

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that urgently requires a new antibiotic innovation to control them (Tacconelli et al. 2018). Serious nosocomial infections caused by *A. baumannii* include pulmonary, meningitis, bacteremia/sepsis, urinary tract, wound and soft tissue infections as well peritonitis, osteomyelitis, synovitis and conjunctivitis (Gedefie et al. 2021; Roy et al. 2022; Nguyen and Joshi 2021). The rate of these infections increases obviously in intensive care units (ICUs) particularly patients requiring special equipment such as mechanical ventilation, endotracheal incubators and catheters in addition to patients suffering of trauma or burn and patients who underwent a recent surgery (Falcone et al. 2021; Ababneh et al. 2022). Infections due to *A. baumannii* are correlated with a high rate of mortality through causing serious infections, septic shock, and deaths (Vrancianu et al. 2020; Lee et al. 2022), besides increased costs and duration of hospitalization and limited therapeutic choices especially in (ICUs) (Ibrahim et al. 2021; Mohd Sazlly Lim et al. 2019). Even with suitable treatment, the mortality rate of infections caused by these bacteria can increase highly after one month stay in hospital (Falcone et al. 2022). Although *A. baumannii* resistance rates are reported in a variable value from region to region, they have been developing steadily and are occurring more rapidly than the innovation of novel antibiotics. Various clinical studies comparing single therapy to combination therapies showed similar mortality rates with no significant statistical difference in clinical cure. Mortality of 30 days in combination and in the monotherapy group was 43.3% and 42.9%, respectively (Giamarellou and Karaiskos 2022). Significant increase in resistance shown by *Acinetobacter* species to nearly all present anti-microbial drugs makes treatment options very limited for patients with *A. baumannii* infection and put the health institutions around the world in great concern. Our study is designed to introduce a detailed profile of antibiotics tested against *A. baumannii* between 2006 and 2021 in different health associations of Turkey. The study may provide a review about the antibiotics used in the past and re-evaluate the antibiotics policies to be applied in the future.

Materials and methods

The online electronic database was searched for studies regarding *A. baumannii* isolated from clinical samples in health institutions of Turkey to detect the antibiotics profile of these isolates.

Search strategy

The studies were screened in PubMed, Google Scholar and Google search for articles published in English and Turkish between 2011 and 2022. During the screening process, the text words or search terms used in combinations were "*Acinetobacter* spp.," "*A. baumannii*," "antibiotic resistance," "antibiotic susceptibility" and "Turkey."

Criteria for studies

The research involved only studies that contained antibiotics profile of *A. baumannii* isolated from clinical samples. These studies were published in English and Turkish. Case reports, antibiotics profile of *Acinetobacter* spp. and antibiotics profile of *A. baumannii* isolated only from environmental samples are excluded from the study.

Article selection and data collection

The studies should have been conducted in Turkey, the data presented should have been published in the years 2011–2022, the language should be English or Turkish, and papers should be original research articles providing access to the full text. The contents of the articles including titles, abstracts, materials and methods, results and discussion were all examined and assessed for data extraction. We extracted the following information from the articles that was finally included: all numerical values given in the studies regarding the rates of susceptibility and resistance of all antibiotics tested through the antibiotic susceptibility test against the clinical strains of *A. baumannii*, Date and year of publication, Duration of study, Number of isolates, Types of samples or site of infection, Ward of isolation, Mortality rates, The institution where the study was conducted and which region in Turkey.

Results

Study characteristics of included publications

All the details of study characteristics are summarized in Table 1. The study included 91 articles carried out in Turkey. The institutions, where the studies conducted in, involved state hospitals and clinic centers which included 92 and about 67 teaching hospitals. All these health institutions were distributed in different regions of Turkey and covered 41 states of Turkey which are Adana, Adiyaman, Afyonkarahisar, Amasya, Ankara, Balikesir, Bolu, Bursa, Çanakkale, Diyarbakir, Düzce, Elaziğ, Erzurum, Gaziantep, Giresun, Isparta, İstanbul, İzmir, Kahramanmaraş, Karabük, Kayseri, Kirikkale, Kirşehir, Kocaeli, Konya, Manisa, Mardin, Mersin, Muğla, Niğde, Ordu, Rize, Sakarya, Samsun, Şanliurfa, Tekirdağ, Tokat, Trabzon, Van, Zonguldak and Kuzey Kıbrıs (Northern Cyprus). With exclusion articles that indicated different cities or institutions as a source of isolates, we found that frequency of studies was more in Ankara, Istanbul and Izmir with (13, 12, 8 articles), respectively. The studies were published between 2011 and 2022 with a frequency numbers of 3 articles in 2011, 4 in 2012, 13 in 2013, 17

Table 1 Study characteristics of the included publications

No.	Institution	Date of study and publication	*A. baumannii* isolates number	Types of samples or infection	Ward of isolation	Notes	References
1	Tertiary care educational hospital, Izmir	Between January 2009 and March 2011/2011	72	Deep tracheal aspirate		Overall mortality was 55.5%	Tasbakan et al. 2011)
2	Gazi University Hospital, Ankara,	From 2007 – 2010/2011	39	Pneumonia, primary bloodstream infections, catheter related, bloodstream infections, urinary tract infections, and skin–soft tissue infection	Intensive care unit (ICU)	Mortality rate 83%	Turkoglu et al. 2011)
3	Department of Pediatrics Intensive Care Unit of Ankara University Medical School, Turkey	Between January 2008 and December 2008/2011	15	Ventilator-associated pneumonia, Catheter-related infection and Meningitis	ICU	Mortality rate 33.3%	Ozdemir et al. 2011)
4	İzmir Atatürk Training and Research Hospital, Izmir	2011/2012	161	blood cultures	ICU		Uzun et al. 2012)
5	Farabi Hospital, a university hospital in Trabzon, Turkey	Between January 2007 and September 2010/2012	30	Cerebrospinal fluid (CSF)	Neurosurgical intensive care unit (NSICU)	Mortality in the clinically significant group 85.7%, in the clinically insignificant group 33.3%	Bayramoglu et al. 2012)
6	Süleyman Demirel University Hospital in Isparta, Turkey	Between February 2009 and February 2011/2012	34	Tracheal aspirate, blood and wound	ICUs		Aye et al. 2012)
7	Diyarbakir Children's Hospital's (Diyarbakir, Turkey)	2006 and 2007/2012	64	Blood sample and tracheal aspiration	Neonatal Intensive Care Unit (NICU)	Neonates' mortality with sepsis (82.8%)	Hosoglu et al. 2012)
8	Nine different state hospitals in Turkey	Between 2011 and 2012/2013	281	All strains were isolated from different hospitals			Çiçek et al. 2013)
9	82.Yil Rize State Hospital	June 2011/2013	6	Wound, urine and sputum samples	ICU	All the patients died as a result of A. baumannii sepsis	Cicek et al. 2013)
10	Dokuz Eylul Hospital, Izmir Turkey	2012 and 2013/2013	21	Blood, peritoneal fluid, tracheal aspirate and central venous catheter (CVC)	ICU 90.74%		Sarı et al. 2013)
11	Van Regional Training and Research Hospital, Van, Turkey	Between 2007 and 2011/2013	377	Tracheal aspirate, blood, wound swab, urine, sputum, cerebrospinal fluid, aspiration fluid, catheter tip, ear, paracentesis fluid, throat swab, and abscess	Surgical services, chest diseases service, pediatric service and internal ward		Bayram et al. 2015)
12	Ümraniye Training and Research Hospital, Istanbul	November 2010 and December 2011/2013	172	Tracheal aspirate, wounds, blood, and, urine	ICU		Dede et al. 2013)

Table 1 (continued)

No.	Institution	Date of study and publication	*A. baumannii* isolates number	Types of samples or infection	Ward of isolation	Notes	References
13	Suleyman Demirel University	Between June 2009 and February 2011/2013	20	Tracheal aspirate and blood sample	ICU		Cetin et al. 2013)
14	Kayseri Training and Research Hospital	Between March 2011 and November 2012/2013	161	Tracheal aspirate, blood, urine, sputum, and wound			Gozutok et al. 2013)
15	The Erciyes University Hospital in central Anatolia, the Asian part of Turkey	Between February 2007 and March 2008/2013	98	Blood samples			Metan et al. 2013 Jun)
16	Sakarya University Training and Research Hospital,	2012/2013	20	Urine, sputum, and pus	From hospitalized patient		Ertugrul et al. 2013)
17	medical centers in 13 provinces (Afyonkarahisar, Ankara, Bolu, Elazig, Erzurum, Isparta, Istanbul, Kahramanmaras, Konya, Sakarya, Van	Between 2008 and 2011/2013	834	Tracheal aspirate, blood, urine and wound samples	ICU, neurology, general surgery and internal medicine departments		Çiftc et al. (2013
18	Faculty of Medicine, Dicle University, Diyarbakir, Turkey	Between 2007 and 2010/2013	127	Mid-stream urine samples, blood samples and wound swabs	(42%) from the intensive care unit (58%) from the non-intensive care unit		Deveci et al. 2013)
19	Ahi Evran University Research and Training Hospital, Kırsehir	November 2008 to June 2012/2013	37	Urine samples	From inpatients and outpatients		Demir and Buyukguclu 2013)
20	Van Training and Research Hospital Van, Turkey	January 2009 to December 2011/2013	59	Wound specimens and wound swaps	The burn unit		Bayram et al. 2013)
21	Ankara Training and Research Hospital, Ankara, Turkey	Between January 2010 and March 2012/2014	30	Tracheal aspirates, blood, catheter, wound infection, urine samples and peritoneal fluid samples	ICU		Altun et al. (2014)
22	Ege University Medical School Hospital, Izmir, Turkey	From 1 March to 1 September 2012/2014	60	Blood samples	ICUs (respiratory and anesthesiology)	Fifteen patients died within the first 48 h (mortality rate 100%). The overall crude mortality rate for the 45 patients was 55.6%	Zeka et al. 2014)
23	9 university hospitals and 2 state hospitals in Turkey	Between 2008 and 2011/2014	763	Various clinical isolates			Aşik et al. 2014)
24	Bezmialem University Hospital, Istanbul. Turkey	November 2011 and July 2012/2014	101	Tracheal aspirates, sputum, wound, blood, catheter, abdominal specimen, cerebrospinal fluid, pleural fluid, and urine	Intensive care unit, pediatric intensive care unit, internal units (nephrology, pulmonology, etc.) and surgical clinics,		Cicek et al. 2014)

Table 1 (continued)

No.	Institution	Date of study and publication	*A. baumannii* isolates number	Types of samples or infection	Ward of isolation	Notes	References
25	Medipol University, Istanbul, University, (Istanbul) and Canakkale Onsekiz Mart University, Canakkale, Turkey	2010–2011/2014	60	Blood specimens	Bacteremia patients admitted to the various hospitals in Turkey		Bozkurt-Guzel et al. 2014)
26	Atatürk University Faculty of Medicine Research Hospital	Between October 2011 and May 2013/2014	82	Blood samples			Gultekin et al. 2014)
27	Recep Tayyip Erdogan University Hospital (RTEUH) east Black Sea region of Turkey	Between January 2011 and May 2012/2014	109	Bronchoalveolar lavage, urine, blood, catheter, gaita, vagina, wound and tracheal aspirate	Four ICUs (surgery, medical, cardiovascular surgery, coronary care unit)	AB isolates were 64 clinical materials 42 samples from environmental samples, and 3 from workers hands	Ertürk et al. 2014)
28	Kocaeli University Medical Faculty Infection and Clinical Microbiology Laboratory	Between January 1, 2008, and December 31, 2012/2014	385	Respiratory tract, blood, soft tissue, urine samples, catheter, Sterile body fluid and drain	ICUs		Sargin Altunok and Koc 2014)
29	Istanbul University Cerrahpasa Medical School hospital	Between January 2012 and November 2013/2014	36	Blood samples	ICU and various departments of the hospital		Cakirlar and Gonullu 2014)
30	Erciyes University Hospital	Between January and December 2011/2014	87	Endotracheal aspirates and bronchial lavage samples	ICUs	The overall mortality rate 60.7%	Kalin et al. 2014)
31	Tepecik Education and Research Hospital, Izmir, Turkey	Between January 2011 and October 2012/2014	98	Wound, respiratory specimen, urine, blood and CSF	99.2% from ICU		Ece et al. 2014)
32	Ataturk Training and Research Hospital	Between 2008 and 2011/2014	252	Ventilator-associated pneumonia, primary bacteremia catheter related, bloodstream infection, Soft tissue infection Pneumonia, Urinary tract infection, Meningitis	ICUs		Güven et al. 2014)
33	Ankara Numune Training and Research Hospital, Turkey	01 January 2012–28 December 2012/2014	47	Blood samples	ICUs,		Karagöz et al. 2014)
34	Ibni Sina Hospital Central Bacteriology Laboratory, Ankara University School of Medicine, Turkey	From April 2010 to December 2011/2014	201	Tracheal aspirate, blood and abscess material	Reanimation services are the most frequently isolated A. baumannii strains. emergency services including neurosurgery general surgery clinics		Keskin et al. 2014)

Table 1 (continued)

No.	Institution	Date of study and publication	*A. baumannii* isolates number	Types of samples or infection	Ward of isolation	Notes	References
35	Meram Medical Faculty Hospital	Between June 2011 and December 2013/2014	1462	Bronchial lavage, blood, wound, tracheal aspirate, throat swab, urine, sputum, catheter tip, cerebrospinal fluid, thoracentesis material, pleural fluid and peritoneal fluid	Intensive care units (66.2%) and other clinics (30.3%)		Doğan et al. (2014)
36	Erciyes University Hospital	January 2012 and July 2013/2014	29	Blood, catheter tip, bronchoalveolar lavage fluid, endotracheal aspirate, Endotracheal aspirate and sputum	ICU	Mortality rate 82.1%	Metan et al. 2014)
37	Baskent University Adana Research and Practice Center, Turkey	Between 16 February 2012 and 31 December 2014/2014	135	Blood samples			Çolakoğlu et al. 2014)
38	Sakarya University Training and Research Hospital Microbiology Laboratory (Turkey	/2015	32	Various clinics samples			Atasoy et al. 2015)
39	Izmir University School of Medicine Hospital	Between January 1, 2013, and June 30, 2013/2015	33	Wound, blood, and tracheal secretion specimens	ICU		Ece et al. 2015
40	Sabuncuoglu Serefeddin Education and Research Hospital	Between January 2012 and June 2015/2015	163	Respiratory tract, blood, surgical scars and urinary samples	Intensive Care Units 85.2%). Surgery clinics And Other Clinics		Guckan et al. (2017)
41	Dicle University, Medicine Faculty Hospital	/2015	80	Sputum, blood samples, wound swabs, catheter swabs, urine samples and drain fluid			Özcan et al. (2015) Direkel et al. (2015)
42	Giresun Prof. Dr. Atilla ilhan Ozdemir State Hospital	Between January 2012 and June 2014/2015	531	Tracheal aspirate, urine, blood, wounds, sputum and catheter	ICUs(neurological Intensive Care Unit, Surgical Intensive Care Unit and Coronary Intensive Care Unit)		
43	Ankara Training and Research Hospital	Between June 2011 and June 2012/2015	30	Blood samples	Different clinics		Temocin et al. 2015)

Table 1 (continued)

No.	Institution	Date of study and publication	*A. baumannii* isolates number	Types of samples or infection	Ward of isolation	Notes	References
44	Medeniyet University Goztepe Training and Research Hospital, Istanbul, Turkey	Between June 2011 and July 2012/2016	54	Blood specimens	Burn intensive care unit, surgical intensive care unit, department of internal medicine, department of infectious diseases, the department of general surgery		Ak et al. 2016)
45	Ankara Training and Research Hospital	Between June 2011 and June 2012/2016	44	Tracheal aspirates, urine, catheters, skin mucosa, blood, cerebrospinal fluid, and pleural fluid samples	Mainly from ICU		Altun et al. 2016)
46	Ataturk Training and Research Hospital, Izmir, Turkey	Between 2009 and 2013/2016	88	Blood samples	(ICUs)	Overall mortality was 63.6%	Nemli and Demirdal (2016)
47	12 hospitals located at different provinces of Turkey (Bolu ($n=67$), Tokat ($n=47$), Trabzon ($n=25$), Ordu ($n=27$), Diyarbakır ($n=47$), Niğde ($n=31$), Kayseri ($n=36$), Ankara ($n=41$), Kirikkale ($n=26$),Kahramanmaraş ($n=25$), Mersin ($n=40$), Istanbul ($n=107$	Between 2011 and 2012/2016	519				Beriş et al. 2016)
48	Gebze Fatih state hospital, Kocaeli	Between January 2011 and June 2011/2016	100	Tracheal aspirate samples, sputum, blood, urine, wound, exudate, discharge, and various clinical samples (abscess, surgical material and cerebrospinal fluid)	intensive care unit, Chest diseases and Internal medicine		Gür Vural and Durupinar (2016)
49	Mersin University Medical School Hospital	Between May 2012 and January 2013/2016	79	Respiratory tract samples, wound, blood, catheters, tissue, urine and abscess	General Surgery, Reanimation and anesthesiology		Direkel et al. 2016)
50	Near East University (NEU) Hospital, North Cyprus	Between 01 August 2010 and 31 December 2014/2016	61	Wound material, sputum, deep tracheal aspirate, Urine, blood and catheter	Specimens sent by various departments		Ruh et al. 2016)

Table 1 (continued)

No.	Institution	Date of study and publication	*A. baumannii* isolates number	Types of samples or infection	Ward of isolation	Notes	References
51	Ordu University Faculty of Medicine, Department of Medical Microbiology, Ordu, Turkey	Between January 2013 and August 2014/2016	50	Tracheal aspirates, blood, urine and wound samples			Çetinkol et al. 2016)
52	Adana Kadirli State Hospital	March 2014/2016	7	Three tracheal aspirates and four environmental samples (ventilator surface)	ICU		Guven Gokmen et al. 2016)
53	Balikesir Ataturk State Hospital Balikesir, Turkey	Between January 2010 and May 2016/2016	707	Respiratory tract, blood, wounds, urine, and another	ICU (83.4%) others from internal units and surgical units		Şafak et al. (2016)
54	Ankara Numune Research and Training Hospital in Ankara, Turkey	Between June 2012 and August 2012/2016	18	Endotracheal aspirates	ICU		Yavaş et al. 2016)
55	Şişli Hamidiye Etfal Training and Research Hospital	Between March 2014 and March 2015/2017	131	Blood, urine, respiratory tract samples, sterile body fluid, skin-soft tissue and Catheter	Pediatric and adult ICUs		Barış et al. 2017)
56	İzmir Katip Çelebi University Atatürk Training and Research Hospital	Between 2009 and 2010/2017	84				Büyük et al. 2017)
57	Erciyes University Hospital Turkey	Between March 2014 and May 2015/2017	52	Endotracheal aspirate	(ICUs)		Alp et al. 2017)
58	Giresun Prof. Dr. A. Ilhan Ozdemir State Hospital in Turkey	Between 2013 June and 2014 September/2017	135	Tracheal aspirates, sputum, bronchoalveolar lavage, blood, urine, wound, catheter tips, cerebrospinal fluid, pleural fluid, abscess and tissue culture	intensive care unit, internal units (cardiology, pulmonology, etc.) and surgery clinics		Uzunoglu and Direkel 2017)
59	Mugla Sitki Kocman University Research Hospital, Mugla, Turkey	January to December 2015/2017	50	Tracheal aspirate blood, wound, mucus, urine, throat cultures, catheter, abscess and nose cultures	ICU		Ceyhan-Guüvensen et al. 2017)
60	Bursa Yuksek Ihtisas Education and Research Hospital Turkey	2014 and 2016/2017	89 (2014) 73 (2016)	Blood, cerebrospinal fluid, urine, wound, tissue and tracheal aspirate	ICU		Karadag Gecgel and Demir (2017)
61	Sultan Abdulhamid Han Training and Research hospital, Istanbul, Turkey	Between 03 January 2015 and 10 January 2015/2018	8	Blood, respiratory catheter, bronchoalveolar lavage and respiratory secretion samples	Anesthesiology and Reanimation ICU		Atik et al. 2018)

Table 1 (continued)

No.	Institution	Date of study and publication	*A. baumannii* isolates number	Types of samples or infection	Ward of isolation	Notes	References
62	20 tertiary care centers from different geographic regions of Turkey	2014 and 2015/2018	437	Bloodstream infections			Aydın et al. 2018)
63	Bezmialem Vakif University Hospital Istanbul, Turkey	From January 2012 to November 2015/2018	350	Bloodstream infections pneumonias and urinary tract infections,	Five ICUs (anesthesia and reanimation I and II, respiratory, and neurology units), surgical unit (cardiovascular surgery) medical unit (coronary ICU)		Durdu et al. 2018)
64	Kahramanmaraş Sütçü İmam University (KSU) Medical Faculty Hospital	Between 01.01.2012 and 31.12.2017/2019	717	Tracheal aspirate, sputum, blood, wound, urine and bronchoalveolar lavage (BAL) fluid	63.1% in surgical branches ICUs and 69.1% in internal branches ICUs		Şahin et al. 2019)
65	Karabuk University Training and Research Hospital	From 2014 to 2015/2019	69	Endotracheal aspirates, blood, wounds, urine sputum and bronchoalveolar lavage fluid	(78.3%) in the surgical intensive care unit and reanimation intensive care unit, (21.7%) in the wards		Asgin et al. 2019)
66	10 different medical centers located in five different geographical regions (Aegean, Central and Eastern Anatolia, Marmara, Mediterranean) of Turkey	2012/2019	176	Blood, cerebrospinal fluid (CSF), bronchoalveolar lavage fluid (BAL), pleural fluid, tissue and catheter	ICUs of medical centers, medicine, surgery, burns units and emergency medicine service	Mortality 58.5%	Boral et al. 2019)
67	Hacettepe University Hospital	Between June 2016 and January 2017/2019	200	Bronchoalveolar lavage, deep tracheal aspirate, sputum blood, abscess, urine, CSF, bile, pericardial, peritoneal, pleural fluids, and catheter			Çağlan et al. 2019)
68	Hacettepe University Medical Faculty Hospital	Between December 2017 and December 2018/2019	91	Blood samples	ICU 65.93%		Gür and Hazırolan 2019)
69	Duzce University Hospital in Turkey	Between January 2014 and July 2015/2019	96	Tracheal aspirates, sputum, bronchoalveolar lavage, wound, urine, blood, and cerebrospinal fluid	Intensive care unit, internal units (cardiology, pulmonology, etc.) surgery clinics		Say Coskun et al. 2019)
70	Sultan Abdülhamid Han Training Hospital	January 2012 and December 2014/2019	100	Deep tracheal aspirate, bronchoalveolar lavage fluid, blood, tissue, sterile body fluid-pleural effusion, peritoneal fluid and urine	Anesthesiology and Reanimation Intensive Care Unit (ARIC), Internal Medicine and Intensive Care Unit (IMICU)		Atik et al. 2019)

Table 1 (continued)

No.	Institution	Date of study and publication	*A. baumannii* isolates number	Types of samples or infection	Ward of isolation	Notes	References
71	Giresun University A. İlhan Özdemir Training and Research Hospital	Between January 2015 and 2018/2019	609	Tracheal aspirate, sputum, leather-soft tissue material, urine and blood	General ICU, Anesthesia ICU, Neurology ICU, Internal ICU, Surgical ICU and Coronary ICU		Uğur and Genç 2019)
72	Okmeydani Training and Research Hospital	January 2014 and December 2018/2020	655	Respiratory tract, skin and soft tissue samples, cerebrospinal fluid, catheter samples, blood, Urine and sterile body fluids	ICU 47.5%		Arabaci and Karabulut 2020)
73	Yıldırım Beyazıt Üniversitesi Tıp Fakültesi Tıbbi Mikrobiyoloji AD, Ankara	January 2012 and June 2014/2020	112	Blood samples	ICUs		Gozalan et al. 2020)
74	Recep Tayyip Erdoğan Training and Research Hospital (RTETRH)	March 2014 and March 2015/2020	86	Tracheal aspirates, bronchoalveolar lavage, sputum, bronchial washing fluid/bronchial brushing, transbronchial biopsy, pleural fluid and lung aspirates/abscess	ICUs		Kostakoğlu et al. 2020)
75	Clinics of Afyonkarahisar Health Sciences University	Between January 2015 and December 2018/2020	1265	Tracheal aspirate, sputum and blood samples	Intensive care units (70.4%) as well as other clinics (29.6%)		Şimşek and Demir 2020)
76	Tertiary Research Hospital Black Sea region of Turkey Recep Tayyip Erdogan University, Rize, Turkey	Between June 2014 and February 2015/2020	70	Endotracheal aspirates, bronchoalveolar lavage, sputum, bronchial washing fluid or brushing, lung aspirates, abscesses, pleural fluid (three isolates were from ambient cultures from the isolation chamber of IMICU)	ICUs (SICU, MICU, ARICU), pulmonary diseases department, and infectious diseases department	Mortality 59.1%	Ozyurt et al. 2020)
77	Istanbul Medeniyet University Faculty of Medicine, Istanbul	Between January 1, 2015, and December 31, 2018/2020	1148	Blood, tracheal aspirate, urine, Aspirate, Wound, Sputum, Tissue biopsy, catheter,			Ozekinci et al. 2020)
78	Hacettepe University Central Laboratory	Between September 2017 and November 2019/2020	44	Bloodstream infections			Özkul and Hazırolan 2020)
79	Marmara University Hospital	Between 2015 and 2016/2020	29				Yilmaz et al. 2020)

Table 1 (continued)

No.	Institution	Date of study and publication	*A. baumannii* isolates number	Types of samples or infection	Ward of isolation	Notes	References
80	Samsun Training and Research Hospital	Between January 2018 and December 2018/2020	68	Tracheal aspirate, wound, blood, sputum, urine and catheter samples	ICUs(burn intensive care, and oncological intensive care)		Gorgun et al. 2020)
81	Hasan Kalyoncu University Health Sciences Faculty, Gaziantep, Turkey	Between January 2018 and July 2019/2020	28	Blood, tracheal aspirate, urine samples, wound and cerebrospinal fluid (CSF)	ICUs(pediatric intensive care and neurology intensive care)		Tasdogan 2020)
82	Ordu State Hospital	Between 1 May 2020 and 2 July 2021/2021	31	Blood and tracheal aspirate samples	ICUs	mortality 57.83%	Doğan and Gezer 2021)
83	Harran University Faculty of Medicine Hospital, Sanliurfa, Turkey	Between January 2017 and December 2019/2021	92	Blood samples	Inpatients at various clinics		Albayrak et al. 2021)
84	Ankara Atatürk Research and Training Hospital	Between 2014 and 2018/2021	8	Cerebrospinal fluid (CSF)	Neurosurgical intensive care unit (ICU), anesthesiology and reanimation ICU		Ayhan et al. 2021)
85	Rize Training and Research Hospital Intensive Care Unit Turkey	/2021	41	Tracheal aspirate, blood, urine and bronchoalveolar lavage	ICU		Saral et al. 2021)
86	University Children's Hospital in Adiyaman, Turkey	Between January 2015 and January 2017/2021	46	Respiratory tract specimens, blood, pus, wounds and urine	ICU		Konca et al. 2021)
87	17 centers from 11 cities (Ankara, Adana, Balikesir, Gaziantep, İstanbul, Izmir, Kayseri, Kocaeli, Manisa, Tekirdag, Zonguldak	From January 2016 to January 2019/2021	7533	Sputum, tracheal aspirate, bronchoalveolar lavage (BAL), bronchial washing/brushing and pleural fluid samples			Uskudar Guclu et al. (2021)
88	Mardin Training and research hospital	Between August 2006 and July 2010/2022	84	Blood, deep tracheal aspiration material, urine, wound, catheter	Respiratory intensive care unit	Mortality 87.1%	Çil et al. 2022)
89	Near East University (NEU) Hospital	Between January 2016 and December 2020/2022	33	Blood samples	Intensive Care Cardiology, chest diseases allergy and oncology		Güler et al. 2022)
90	Bafra State Hospital	Between January 2019 and December 2020/2022	74	Endotracheal aspirate (ETA)	ICU		Seda GÜDÜL HAVUZ 2022)
91	Elazığ Fethi Sekin State of Hospital, Recep Tayyip Erdoğan University and Fırat University	Between March 2019 and March 2021/2022	350	Sputum and deep tracheal aspiration (DTA)	ICU, Service and clinical units		Şenol et al. 2022)

in 2014, 6 in 2015, 11 in 2016, 6 in 2017, 3 in 2018, 8 in 2019, 10 in 2020, 6 in 2021 and 4 in 2022. The articles covered studies that were performed between 2006 and 2021. In 5 articles, all the years of study are included in Table 1 because of the absence of the average of resistance rates. The date of study in 3 articles was unclear, so we could not include the rates of resistance in these articles with other numbers in analysis of the results. The total of *A. baumannii* clinical isolates was 24,425 isolates. *A. baumannii* were collected from diverse clinical specimens that included bronchial lavage, tracheal aspirate, bronchial washing fluid/bronchial brushing, transbronchial biopsy, blood, wound, throat swab, urine, sputum, catheter tip, cerebrospinal fluid, thoracentesis material, pleural fluid, peritoneal fluid, aspiration fluid, ear, paracentesis fluid, skin/mucosa, exudates and discharge samples. Majority of samples were taken from hospitalized patients admitted to intensive care units.

Antibiotic resistance shown by *A. baumannii* clinical strains

Analysis of the 91 articles concentrated on the antibiotics tested through antibiotic susceptibility test conducted by the health institutions in Turkey from 2006 to 2021 for detecting resistance and susceptibility of *A. baumannii* against these antibiotics. Antibiotic susceptibility methods used in the articles included: 40 articles used automated system (30 used VITEK 2 system and 10 used Phoenix 100 system). Twenty-six articles used disk diffusion method. Thirteen articles used mixed methods (automated system and disk diffusion method). Six articles used broth microdilution method. One article used only the E-Test method, and five articles did not mention the method. The results of the antibiotic susceptibility test were interpreted based on the recommendation of the Clinical Laboratory Standards Institute (CLSI) in majority of articles 80.5%, while the European Committee on Antimicrobial Susceptibility Testing (EUCAST) recommendations used in 19.5%.

The antibiotics profiles extracted from the studies are detailed in Table 2. The data showed the following results.

Aminoglycosides

Amikacin, Gentamicin, Netilmicin and Tobramycin were the antibiotics of aminoglycoside group used in studies included in the research during the period from 2006 to 2021. Amikacin was used in 76 articles and Gentamycin in 70 articles, while Netilmicin and Tobramycin were used in 27 and 21 articles, respectively. Resistance rate percentages of *A. baumannii* against aminoglycosides were as follows.

Amikacin 2007–2012: 68.1, 86.7, 32, 40, 100, 100, 63, 70.01, 100, 64, 100, 59, 86, 100, 71.7, 62, 74, 60, 52, 73, 53, 60, 75.3, 78.9, 44, 97, 91.8, 88, 84.6, 81.8, 84.2, 65, 56, 46, 71.1, 62, 50.

2012–2016: 73, 67.1, 81, 67.5, 86.3, 85.2, 86.3, 68.1, 60.7, 35.2, 79.3, 55.7, 65.6, 100, 63, 70, 94.81, 82, 92, 89, 94.2, 91.8, 72.92, 40, 81, 53.5, 52.9, 100.

2016–2021: 53, 59.3, 79, 90.7, 55.7, 46.6, 68.2, 73.5, 12.5, 77.6, 100, 97.8, 93.3, 39.2, 87.5, 83.3, 95, 98.5, 53.

The total percentage of resistance rates frequency appears as follows: From 80–100 = 40.97%, from 50–70 = 48.19%, < 50 = 10.84%.

Gentamicin 2007–2012: 80, 39, 100, 48, 34.16, 100, 100, 90, 67, 54, 89, 90, 74.7, 11, 10, 11, 22, 75.7, 86, 77.1, 19.3, 84, 85, 93.9, 96, 76.5, 66, 87.2, 83.4, 82.5, 59.5, 62.

2012–2016: 65, 68.6, 76.8, 87, 74.1, 75.76, 77.2, 82.1, 83.6, 72.1, 100, 69, 84.3, 86.62, 86, 69.7, 74, 92, 95.8, 100, 93.7, 47, 88, 60.5, 55.7, 100.

2016–2021: 25, 60.5, 63.5, 66.9, 50.4, 70.5, 73.5, 78.9, 100, 95.7, 86, 89, 92.9, 93.2, 87.5, 82.3, 83.3, 90.7, 74.

The total percentage of resistance rates frequency appears as follows: From 80–100 = 50.65%, from 50–70 = 36.36%, < 50 = 12.99%.

Netilmicin 2007–2012: 54.2, 39, 0, 89, 0, 6, 26.6, 13.7, 55, 41.7, 52.1, 57.6, 53, 57.

2012–2016: 36, 85.2, 58.7, 19.5, 97.2, 27.8, 94.3, 21, 36.

2016–2019: 92, 43.3, 72.7, 79.4, 75.8.

2019–2021: no data found.

The total percentage of resistance rates frequency appears as follows:

From 80–100 = 17.85%, from 50–70 = 35.72%, < 50 = 46.43%

Tobramycin 2007–2012: 36.3, 40.56, 58, 36.5, 55, 21.1, 84, 54.2, 54, 46.3, 68.1, 22.9.

2012–2016: 100, 37.8, 25.4, 0, 78, 100.

2016–2021: 47.5, 60.8, 100, 67.

The total percentage of resistance rates frequency appears as follows: From 80–100 = 18.18%, from 50–70 = 36.36%, < 50 = 45.46%.

Carbapenems

Doripenem, Ertapenem, Imipenem and Meropenem were the antibiotics of Carbapenem group used in studies included in the research during the period from 2006 to 2021. Imipenem was found in 72 articles and Meropenem in 74 articles, while Ertapenem was found in 2 articles and Doripenem in 1 article. Resistance rate percentages of *A. baumannii* against Carbapenems were as follows.

Imipenem 2007–2012: 91.7, 53.3, 86, 20, 100, 100, 95, 80.07, 100, 71, 92, 100, 91, 57, 72.1, 50, 77, 78, 80, 70.2,

Table 2 Antibiotic Susceptibility profile Shown by *A. baumannii* clinical strains

N0	Antibiotics profile %														
	R/S	AMC	AMP	AMS	ATM	AMK	CFPM	CTX	CS	CAZ	CRO	CIP	GEN	IPM	LVX
1.	R					68.1			63.9,	100		100		91. 7	
2.	S								35						
3.	S	0	0	60		13.3			73.3	13.3	0	46.7	20	53.3	
4.	R			100		32	92	97	57	94	97	81	93	86	
5.	R			53.3		40			36.6	86.6				20	60
6.	R					100	100							100	
7.	R		100	100	100	100	100		0	100	100		100	100	
8.	R			79.35		70.01		3.55		80.78		87.54	34.16	80.07	69.75
9.	R			100		100	100			100	100		100	100	100
10.	R								100	100		100	100	100	
11.	R					64	95	96	89	94		92	90	71	
12.	R					64			79			76	67	92	73
13.	R			100		100	100		100			100		100	
14.	R					59	95		92			92	54	91	94
15.	R			82		86				95			89	57	
16.	R			100		100				100	100	100	90	100	
17.	R	96.8				71.7			73.5			86.8	74.7	72.1	
18.	S2007					38							11	50	
	08					26							10	23	
	09					40							11	22	
	10					48							22	20	
19.	R	70.3	100			73						81.1	75.7	70.2	
20.	R					53	86			93		86	86	86	
21.	R					60									
22.	R					73							65		
23.	R					75.3	94.8	100	73.6	100	100		77.1	74.5	
24.	R			97		63	97		87	97		94	48	95	89
25.	R											95			
26.	R			76.8		67.1	82.9	84.1		86.6	85.4	84.1	76.8	73.2	
27.	R			72.5		78.9	97.2			76.2		98.2	19.3	91.9	
28.	R			96.8		44	95.3		94.2	96.1		95.7	84	93	
29.	R					81	89	78		89		89	78		
30.	R					79	78	85	77	84		85	85	91	
31.	S					8.2	0		11.2	1.1		0	6.1	0	
32.	R2008			95.7		88	97.6	98	45.7	100		98	96	54	
	09			97.9		84.6	100	100	88.4	97.8		100	76.5	92.3	
	10			90.6		81.8	100	98	78	97.9		96.2	66	94.4	
	11			93.5		84.2	96.8	97.8	90.3	98.9		97.8	87.2	98.9	
33.	S			0		14.8	0		1.85,	0		0	16.6	0	
34.	R			87.5		65	89.5		89	94.5		97	82.5	91.5	95.5
35.	R			91.4		67.5	91.1			93.4		93.2	68.6	91.3	90.9
36.	S					13.7			20.7						
37.	S			11.1		31.9	17.8	4.4	22.2	13.3		17	25.9	20	17.8
38.	R					59.375							53.125	56.25	
39.	S					39.39	3.03		6.06	3.03			24.24	9.09	
40.	R					35.2	93.7		79	96.8		97.3	77.2	89.1	95.2
41.	S			0		16.25	0	0		0	0	0		0	
42.	R			91.7		79.3	94.7	98.9	69.5	94.9		91.7	82.1	91.1	89.5

Table 2 (continued)

N0	Antibiotics profile %														
	R/S	AMC	AMP	AMS	ATM	AMK	CFPM	CTX	CS	CAZ	CRO	CIP	GEN	IPM	LVX
43.	R					56						100			
44.	R								100					100	
45.	R						100			100		100			
46.	R					46									
47.	R	15.2	61.8	11.9		71.1	67.8		21	89.4	23.9	82.9	59.5	87.5	81.1
48.	R					62	100			100		99	62	100	90
49.	R			69.6		55.7			93.6	88.6		96.2	83.6	94.9	86
50.	R			13.1		65.6	32.8	92.7		78.7		77	72.1	73.8	74.6
51.	S														
52.	R			100		100	100			100		100	100	100	100
53.	S			3.9		37				5.7		6.6	31	16	
54.	S														
55.	S					30	4			1		5	15,7	5,7	
56.	R					50						90.47			
57.	R														
58.	R			94.07		94.81	97.03			98.51		98.51	86.62	98.51	97.77
59.	R			94		82			100			94	86	96	
60.	R 2014				62.9								69.7		
	16				63								74		
61.	R						100	100		100	100	100		100	100
62.	R														
63.	R			98.3		92	98.3		98.3	98.3		97.7	92	98	97.7
64.	R		99.5	98.6	99.8	89	99		96.2	98.9	100	98.8	95.8	97.1	97.5
65.	R			100		94.2	100				100	100	100	94.2	
66.	R			99.4		91.8				99.4		100		99.4	
67.	R					53				80.5		81	60.5		
68.	R			62.8		59,3	74.6			71.2	72.8	73.7	63.5	73.7	
69.	R			100		72.92	100			100		100	93.7	100	96.9
70.	R			74		40	93		69	95		100	47	95	82
71.	R					79				98		97	86	96	
72.	R			86.1		90.7	97.5			96.7	96.5	95.6	89	94.9	93
73.	R			100		81			91	98.5		100	88		
74.	R			100		53.5				100		97.7	60.5	100	93
75.	R			94.5		55.7	95.6			95.3		94.3	66.9	95.3	95.5
76.	R			100		52.9				100		100	55.7	100	100
77.	R					46.6				81.6		80.5	50.4		
78.	R			72.7		68.2	72.7			75		72.7	70.5	72.7	
79.	R					100						100	100	100	
80.	S					26.5				2.9		2.9	26.5	2.9	2.9
81.	S						4.3							39.1	39.1
82.	R					100						100	100	100	100
83.						53						92	74	88	
84.	R					12.5							25		
85.	R									97.3			62.16	97.3	100.0
86.	R	100		95.7	100	97.8	100			100	100	95.7	95.7	97.8	91.3
87.	R					77.6	95.1			94.2		93.4	78.9	92.8	91
88.	R					93.3						96.6	92.9	96.7	
89.	R2007				100		61.5	100		92.3		92.3		61.5	100

Table 2 (continued)

N0	Antibiotics profile %														
	R/S	AMC	AMP	AMS	ATM	AMK	CFPM	CTX	CS	CAZ	CRO	CIP	GEN	IPM	LVX
	08				91.7		80	100	0	91.4		91.4		74.3	90.3
	09						100	100	9.1	96.3		96.3		81.5	95.8
	10						100	100	16.7	100		100		100	71.4
90.	R					39.2				98.6		98.6	93.2	98.6	
91.	R 2019–20			87.5		87.5				95		95	87.5	85	
				100		98.5				100		100	82.3	100	
	R 2020–21			66.6		83.3				83.3		83.3	83.3	83.3	
				100		95				100		100	90.7	100	

N0	Antibiotics profile %													References
	R/S	MEM	NET	PIP	TZP	SUL	TET	TOB	SXT	TCC	TGC	CST	Group/less use	
1.	R		54.2		100						0			Tasbakan et al. (2011)
2.	S		61										Quinolones 11% carbapenems 8%	Turkoglu et al. (2011)
3.	S	46.7		0	6.7		0	66.7	6.7			100	CEF 0	Ozdemir et al. (2011)
4.	R	86			94				95		0	0		Uzun et al. (2012)
5.	R	20			80						0	0		Bayramoglu et al. (2012)
6.	R	100											TIC 100%	Aye et al. (2012)
7.	R	100	0	100	0									Hosoglu et al. (2012)
8.	R	78.29		90.03			70.46	40.56	81.13				CFM 81.13%	Çiçek et al. (2013)
9.	R	100	0	100					100		0	0		Cicek et al. (2013)
10.	R	100		100	100			100	100					Sarı et al. (2013)
11.	R	72			96		55					0		Bayram et al. (2015)
12.	R	92			84						0	0		Dede et al. (2013)
13.	R	100											PB 0% RIF 35% TIC 100%	Cetin et al. (2013)
14.	R	91			97						11			Gozutok et al. (2013)
15.	R	75	6	99			78	58	83			0	OFL 98%	Metan et al. (2013 Jun)
16.	R				100				95%					Ertugrul et al. (2013)
17.	R	73										0		Çiftc et al. (2013
18.	S2007	55												Deveci et al. (2013)
	08	29												
	09	25												
	10	12												

Table 2 (continued)

N0	Antibiotics profile %													References
	R/S	MEM	NET	PIP	TZP	SUL	TET	TOB	SXT	TCC	TGC	CST	Group/less use	
19.	R				81.1				64.9				CXM 97.3% cephalosporins 97.3% FOS 48.6%	Demir and Buyukguclu (2013)
20.	R	77			90						0	0		Bayram et al. (2013)
21.	R	86.6	26.6			26.6					6.6	0		Altun et al. (2014)
22.	R		36									0	100% resisters to all b-lactams,. 33% resistant to all aminoglycosides	Zeka et al. (2014)
23.	R	76.3						36.5						Aşik et al. (2014)
24.	R	94	89	97	97		70		69		92	0		Cicek et al. (2014)
25.	R	100						55				14		Bozkurt-Guzel et al. (2014)
26.	R			84.1	81.7			37.8	50.0					Gultekin et al. (2014)
27.	R	93.5	13.7		97.2			21.1	36.7		0	0		Ertürk et al. (2014)
28.	R	92.7			96		87.8		91.9		37.7	0		Sargin Altunok and Koc (2014)
29.	R				78		94		89		0	0		Cakirlar and Gonullu (2014)
30.	R	94	55		96			84	91		25	0		Kalin et al. (2014)
31.	S	0			0						55.1	100		Ece et al. (2014)
32.	R2008	73.5	41.7		91.7			54.2	91.7	97.9				Güven et al. (2014)
	09	98	52.1		100			54	85.4	100	12.5			
	10	94.4	57.6		98.1			46.3	73.6	97.1	34.8			
	11	98.9	53		98.9			68.1	72	98.5	81.3	2.9	DOR 100%	
33.	S	0	14.8	0	0		80.5		22.2		59.2	100		Karagöz et al. (2014)
34.	R	92			96				67.5			6		Keskin et al. (2014)
35.	R	91.6			93.2						6.9	1.4		Doğan et al. (2014)
36.	S		41.3								27.6	99.71		Metan et al. (2014)
37.	S	17.7			17.8									Çolakoğlu et al. (2014)
38.	R	56.25												Atasoy et al. (2015)
39.	S	6.06			3.03						81.81	100		Ece et al. 2015
40.	R	90.3	19.5						68.9		41.3	5.5		Guckan et al. (2017)
41.	S	0	27.5		0			0	12.5		22.5	100		Özcan et al. (2015)

Table 2 (continued)

N0	Antibiotics profile %													References
	R/S	MEM	NET	PIP	TZP	SUL	TET	TOB	SXT	TCC	TGC	CST	Group/less use	
42.	R	89.8	97.2	97.4	92.8		97.7	25.4	81.2		5.1	0.8	NIT 99.1%	Direkel et al. (2015)
43.	R	100				8					23	0		Temocin et al. (2015)
44.	R										1	0		Ak et al. (2016)
45.	R		57	100							2	0		Altun et al. (2016)
46.	R	83.3									5.7	0		Nemli and Demirdal (2016)
47.	R	78.6		69.2	48.6		66.3	22.9	77.5		2.7	0.6		Beriş et al. (2016)
48.	R	100		100	99		72		73			0		Gür Vural and Durupinar (2016)
49.	R	94.9	27.8		97.5		77.2		91.1		3.8	0		Direkel et al. (2016)
50.	R	73.8			75.4		76.4		72.1			5.1		Ruh et al. (2016)
51.	S					0			96		36	100	carbapenem.0%	Çetinkol et al. (2016)
52.	R	100			100		100		100			0		Guven Gokmen et al. (2016)
53.	S	13.1			7.4				11.7		93.9	96.5		Şafak et al. (2016)
54.	S	0				0					11.11	100		Yavaş et al. (2016)
55.	S	5,7			5							100		Barış et al. (2017)
56.	R	58.33									0	0	MOXI 22.62% RIF 47.62%	Büyük et al. (2017)
57.	R										66.7	0	Carbapenem 100%	Alp et al. (2017)
58.	R	98.51			97.77						10.37	0		Uzunoglu and Direkel (2017)
59.	R	96			92						0	100		Ceyhan-Guüvensen et al. (2017)
60.	R 2014											0		Karadag Gecgel and Demir (2017)
	16											6.8		
61.	R	100			100			0				0	DOX 100% MIN 100%	Atik et al. (2018)
62.	R											2.1	Carbapenems 91.8 Fluoroquinolones 89% Third generation Cephalosporins 93.8% Aminoglycosides 70.9%	Aydın et al. (2018)
63.	R	98			98.6		93.7		80.6		26.6	0.3		Durdu et al. (2018)

Table 2 (continued)

N0	Antibiotics profile %													References
	R/S	MEM	NET	PIP	TZP	SUL	TET	TOB	SXT	TCC	TGC	CST	Group/less use	
64.	R	97.7	94.3	99.5	98.1		86.4		76.8	99.3	49.3	2.9	FO 100% ETP 99,6%	Şahin et al. (2019)
65.	R	94.2			94.2						0	0		Asgin et al. (2019)
66.	R										1.7	1.2		Boral et al. (2019)
67.	R	81.5			82						30	28		Çağlan et al. (2019)
68.	R	72.8			74.6				61.9					Gür and Hazırolan (2019)
69.	R	100			100						45.8	0		Say Coskun et al. (2019)
70.	R	95	21	100	100		83		53		2	0		Atik et al. (2019)
71.	R	96			99							0,5		Uğur and Genç (2019)
72.	R	95.2	92		97.6				73.9	97.5	11	2.5		Arabaci and Karabulut (2020)
73.	R		36	89	93			78	96					Gozalan et al. (2020)
74.	R	100			100				73.3		9.3	0		Kostakoğlu et al. (2020)
75.	R	96.1	43.3	99.6	98.9			47.5	68.9		21.7	3		Şimşek and Demir (2020)
76.	R	100			100				100		11.4	0		Ozyurt et al. (2020)
77.	R	81.7			83.5				59		22	1.8		Ozekinci et al. (2020)
78.	R	72.7	72.7		72.7				81.8			13.6		Özkul and Hazırolan (2020)
79.	R	100						100	79.3			100		Yilmaz et al. (2020)
80.	S	2.9	20.6		2.9				17.7		41.2	82.4	DOX 8.8% MIN 23.5%	Gorgun et al. (2020)
81.	S	7.1			4.3	26.1						100	CFP 34.8%	Tasdogan (2020)
82.	R	100						100	100					Doğan and Gezer (2021)
83.		88						67	63		10			Albayrak et al. (2021)
84.	R								100			12.5	Carbapenems 75% Cephalosporins, Quinolones100%	Ayhan et al. (2021)
85.	R	97.3	62.16	100	97.3			67.57	83.78		0	0		Saral et al. (2021)
86.	R	97.8			100				58.7		73.9	2.2	CEF 100% ETP 97.8% NIT 97.8%	Konca et al. (2021)
87.	R	93.1	75.7	96.2	91.6			60.8	75.6		18.6	12.8		Uskudar Guclu et al. (2021)

Table 2 (continued)

N0	Antibiotics profile %													References
	R/S	MEM	NET	PIP	TZP	SUL	TET	TOB	SXT	TCC	TGC	CST	Group/less use	
88.	R	96.9							85.7		5.9	9.1		Çil et al. (2022)
89.	R2007	58.3		100					92.3				CPL 100%	Güler et al. (2022)
	08	71.4		100	95.5				85.7			0	CPL 100%	
	09	81.5		100	100				96.3					
	10	100		100	85.7				71.4			0		
90.	R	95.9			98.6				93.2		6.8	1.4		Güdül Havuz (2022)
91.	R 2019–20	97.5							90			0	Sputum	Şenol et al. (2022)
		100							83.8			10.5	Deep tracheal aspirate	
	R 2020–21	83.3							50			0	sputum	
		100							93.8			9.2	Deep tracheal aspirate	

R(Resistance),S(Ssusceptible), Amoxicillin/clavulanate (AMC), Ampicillin (AMP), Ampicillin/sulbactam (AMS), Aztreonam (ATM), Amikacin (AMK), Cefepime (CFPM), Cefixime (CFM), Cefotaxime(CTX), Cefoperazone-sulbactam(CS), Ceftazidime (CAZ), Ceftriaxone (CRO), Ciprofloxacin (CIP), Doxycycline (DOX), Ertapenem (ETP), Gentamicin (GEN),Imipenem (IPM),Levofloxacin (LVX),Meropenem (MEM), Minocycline (MIN), Netilmicin (NET), Nitrofurantoin (NIT), Ofloxacin (OFL), Piperacillin (PIP), Piperacillin/tazobactam (TZP), Sulbactam (SUL), Tetracycline (TET),Tobramycin (TOB), Trimethoprim-Sulfamethoxazole (SXT), Ticarcillin (TIC), Ticarcillin/clavulanate (TCC), Tigecycline(TGC), Colistin (CST), Cefoperazone(CFP), Cephalothin (CEF), Cefuroxime(*CXM),* Polymyxin B (PB), Fosfomycin (FO), Rifampicin (RIF), Doripenem (DOR), Moxifloxacin (MOXI), Chloramphenicol

86, 74.5, 91.9, 93, 91, 100, 54, 92.3, 94.4, 98.9, 91.5, 100, 87.5, 100, 61.5, 74.3, 81.5, 100.

2012–2016: 100, 100, 73.2, 100, 91.3, 80, 90.91, 89.1, 91.1, 94.9, 73.8, 100, 84, 94.3, 98.5, 96, 100, 98, 97.1, 94.2, 99.4, 100, 95, 100, 95.3, 100, 100.

2016–2021: 73.7, 96, 94.4, 72.7, 97.1, 60.9, 100, 97.8, 92.8, 96.7, 98.6, 85, 100, 83.3, 100, 88. The total percentage of resistance rates frequency appears as follows: From 80–100 = 77.78%, from 50–70 = 20.99%, < 50 = 1.23%.

Meropenem 2007–2012:0.53.3, 86, 20, 100, 100, 94, 78.29, 100, 72, 92, 100, 91, 75, 73, 45, 71, 75, 88, 77, 86.6, 76.3, 100, 93.5, 92.7, 94, 100, 73.5, 98, 94.4, 98.9, 92, 100, 83.3, 78.6, 100, 58.3, 58.3, 71.4, 81.5, 100.

2012–2016: 100, 100, 91.6, 82.3, 93.94, 90.3, 89.8, 94.9, 73.8, 100, 86.9, 100, 94.3, 98.5, 96, 100, 98, 97.7, 94.2, 100, 95, 100, 100, 100.

2016–2021: 81.5, 72.8, 96, 95.2, 96.1, 81.7, 72.7, 97.1, 92.9, 100, 97.8, 93.1, 96.9, 95.9, 97.5, 100, 83.3, 100, 88.

The total percentage of resistance rates frequency appears as follows: From 80–100 = 78.32%, from 50–70 = 19.28%, < 50 = 2.40%.

Ertapenem 2007–2012: no data found.

2012–2017: 99.6, 97.8.

2017–2021: no data found.

Doripenem 2007–2012: 100.

2012–2021: no data found.

Cephalosporins

(First generation) Cephalothin and (second generation) Cefuroxime were mentioned in 1 article for each of them, and third-generation Cephalosporins were found as follows: Cefixime in one article, Cefoperazone–sulbactam in 34 article, Cefotaxime in 14 articles, Ceftazidime in 61 article, Ceftriaxone in 15 article and (fourth generation) Cefepime was mentioned in 46 articles. All these antibiotics of this group used in studies were included in the research during the period from 2006 to 2021. Resistance rate percentages of A. baumannii against Cephalosporins were as follows:

Cephalothin Two articles: One is performed in 2008 and the other from 2015–2017, and the two articles referred to 100% as a resistance rate.

Cefuroxime Only one study was found performed between 2008 and 2012 and indicated 97.3% as a resistance rate against this antibiotic.

Cefoperazone–sulbactam 2007–2012: 63.9, 65, 26.7, 57, 36.6, 0, 87, 89, 79, 100, 92, 73.5, 73.6, 94.2, 77, 88.8, 45.7, 88.4, 78, 90.3, 89, 100, 21, 0, 9.1, 16.7.

2012–2016: 100, 98.15, 79.3, 77.8, 93.94, 79, 69.5, 93.6, 100, 98.3, 96.2, 69, 91.

2016–2021: no data found.

The total percentage of resistance rates frequency appears as follows: From 80–100 = 46.16%, from 50–70 = 33.33%, < 50 = 20.51%.

Ceftazidime 2007–2012: 100, 86.7, 94, 86.6, 100, 97, 80.78, 100, 94, 95, 93, 100, 76.2, 96.1, 84, 98.9, 100, 97.8, 97.9, 98.9, 94.5, 100, 89.4, 100, 92.3, 91.4, 96.3, 100.

2012–2016: 100, 100, 86.6, 89, 100, 93.4, 86.7, 96.97, 96.8, 94.9, 88.6, 78.7, 100, 94.3, 99, 98.51, 100, 98.3, 98.9, 99.4, 100, 95, 98.5, 100, 100.

2016–2021: 80.5, 71.2, 98, 96.7, 95.3, 81.6, 75, 97.1, 100, 94.2, 98.6, 95, 100, 83.3, 100.

The total percentage of resistance rates appears as follows: From 80–100 = 94.12%, from 50–70 = 5.88%, < 50 = 0%.

Ceftriaxone

2007–2012: 100, 97, 100, 100, 100, 23.9.

2012–2016: 100, 85.4, 100, 100, 100.

2016–2021: 72.8, 96.5, 100.

The total percentage of resistance rates frequency appears as follows: From 80–100 = 85.72%, from 50–70 = 7.14%, < 50 = 7.14%

Cefotaxime

2007–2012: 3.55, 97, 96, 100, 85, 98, 100, 98, 97.8, 100, 100, 100, 100.

2012–2016: 84.1, 78, 56, 98.9, 92.7, 100.

2016–2021: no data found.

The total percentage of resistance rates frequency appears as follows: From 80–100 = 89.48%, from 50–70 = 5.26%, < 50 = 5.26%.

Cefixime Only one study was found performed between 2011 and 2012 and indicated 81.13% as a resistance rate against this antibiotic.

Cefepime 2007–2012: 92, 100, 100, 97, 100, 95, 100, 95, 86, 94.8, 97.2, 95.3, 78, 100, 97.6, 100, 100, 96.8, 89.5, 100, 67.8, 100, 61.5, 80, 100, 100.

2012–2016: 82.9, 98, 100, 91.1, 82.2, 96.97, 93.7, 94.7, 32.8, 100, 96, 97.03, 100, 98.3, 99, 100, 100, 93. 2016–2021: 74.6, 97.5, 95.6, 72.7, 95.7, 100, 95.1. The total percentage of resistance rates frequency appears as follows: From 80–100 = 88.24%, from 50–70 = 9.80%, < 50 = 1.96%.

Monobactams

Aztreonam was the antibiotics of this group and mentioned in 5 articles: 2007–2012: 100, 100, 91.7. 2012–2016: 62.9, 63, 99.8. 2016–2021: 100. The total percentage of resistance rates frequency appears as follows: From 80–100 = 71.43%, from 50–70 = 28.57%, < 50 = 0%.

Penicillins

Antibiotics of this group found in research were Amoxicillin/clavulanate and Ampicillin found in 5 articles, Ampicillin/sulbactam in 42 articles, Piperacillin in 20 articles, Piperacillin/tazobactam in 59 articles, Ticarcillin and Ticarcillin/clavulanate found in 2 and 6 articles, respectively.

Amoxicillin/clavulanate 2007–2012: 100, 96.8, 70.3, 15.2.

2012–2017: 100.

2017–2021: no data found.

The total percentage of resistance rates frequency appears as follows: From 80–100 = 60%, from 50–70 = 20%, < 50 = 20%.

Ampicillin 2007–2012: 100, 100, 100, 61.8.

2012–2017: 99.5.

2017–2021: no data found.

The total percentage of resistance rates frequency appears as follows: From 80–100 = 80%, from 50–70 = 20%, < 50 = 0%.

Ampicillin/sulbactam 2007–2012: 40, 100, 53.3, 100, 97, 97.35, 100, 100, 82, 72.5, 96.8, 95.7, 97.9, 90.6, 93.5, 87.5, 11.9.

2012–2016: 100, 76.8, 100, 91.4, 88.9, 91.7, 69.6, 13.1, 100, 96.1, 94.07, 94, 98.3, 98.6, 100, 99.4, 100, 74, 100, 100, 100.

2016–2021: 62.8, 86.1, 94.5, 72.7, 95.7, 87.5, 100, 66.6, 100.

The total percentage of resistance rates frequency appears as follows: From 80–100 = 80.86%, from 50–70 = 12.76%, < 50 = 6.38%.

Piperacillin 2007–2012: 100, 100, 97, 90.03, 100, 99, 100, 69.2, 100, 100, 100, 100, 100.

2012–2016: 100, 84.1, 100, 97.4, 99.5, 100, 89.

2016–2021: 99.6, 96.2.

The total percentage of resistance rates frequency appears as follows: From 80–100 = 95.46%, from 50–70 = 4.54%, < 50 = 0%.

Piperacillin/tazobactam 2007–2012:100, 93.3, 94, 80, 0, 97, 96, 84, 97, 81.1, 90, 97.2, 96, 96, 100, 91.7, 100, 98.1, 98.9, 96, 48.6, 99, 95.5, 100, 85.7.

2012–2016: 100, 100, 81.7, 78, 100, 93.2, 82.2, 96.97, 92.8, 97.5, 75.4, 100, 92.6, 95, 97.7, 92, 100, 98.6, 98.1, 94.2, 100, 100, 93, 100, 100.

2016–2021: 82, 74, 99, 97.6, 98.9, 83.5, 72.7, 97.1, 95.7, 100, 91.6, 98.6.

The total percentage of resistance rates frequency appears as follows: From 80–100 = 91.94%, from 50–70 = 4.84%, < 50 = 3.22%.

Ticarcillin 2007–2012: 100, 100.

2012–2021: no data found.

Ticarcillin/clavulanate 2007–2012: 97.9, 100, 97.1, 98.5.

2012–2018: 99.3, 97.5

2018–2021: No data found.

The total percentage of resistance rates frequency appears as follows: From 80–100 = 100%, from 50–70 = 0%, < 50 = 0%.

Quinolones/fluoroquinolones

Antibiotics of this group found in research were Ciprofloxacin found in 68 articles, Levofloxacin in 33 articles, Ofloxacin and moxifloxacin which are found in one article for each of them.

Ciprofloxacin 2007–2012: 100, 99, 53.3, 81, 94, 87.5, 92, 76, 100, 92, 86.8, 81.1, 86, 95, 98.2, 95.7, 85, 100, 98, 100, 96.2, 97.8, 97, 100, 100, 82.9, 99, 90.47, 92.3, 91.4, 96.3, 100.

2012–2016: 100, 100, 84.1, 98, 100, 93.2, 83, 97.3, 91.7, 96.2, 77, 100, 93.4, 95, 98.51, 94, 100, 97.7, 98.8, 100, 100, 100, 100, 100, 97.7, 100, 100.

2016–2021: 81, 73.7, 97, 95.6, 94.3, 80.5, 72.7, 97.1, 100, 95.7, 93.4, 96.6, 98.6, 95, 100, 100, 92.

The total percentage of resistance rates frequency appears as follows: From 80–100 = 93.42%, from 50–70 = 6.58%, < 50 = 0%.

Levofloxacin 2007–2012: 60, 89, 69.7, 100, 73, 94, 95.5, 81.1, 90, 100, 90.3, 95.8, 71.4.

2012–2016: 90.9, 82.2, 95.3, 89.5, 86, 74.6, 100, 97.77, 100, 97.7, 97.5, 96.9, 82, 93, 100.

2016–2021: 93, 95.5, 97.1, 60.1, 100, 91.6, 91.

The total percentage of resistance rates frequency appears as follows: From 80–100 = 82.85%, from 50–70 = 17.15%, < 50 = 0%.

Ofloxacin Only one study was found performed between 2007 and 2008 and indicated 98% as a resistance rate against this antibiotic.

Moxifloxacin Only one study was found performed between 2009 and 2010 and indicated 22.62% as a resistance rate against this antibiotic.

Sulfonamides

Trimethoprim–Sulfamethoxazole was the only antibiotic used from this group and was mentioned in 50 articles.

2007–2012: 93.3, 59, 69, 81.13, 100, 83, 64.9, 63.7, 91.9, 91, 91.7, 85.4, 73.6, 72, 67.5, 77.5, 73, 92.3, 85.7, 96.3, 71.3.

2012–2016: 100, 95, 50, 89, 77.8, 68.9, 81.2, 91.1, 72.1, 96, 100, 88.3, 80.6, 76.8, 53, 96, 73.3, 100, 79.3.

2016–2021: 61.9, 73.9, 68.9, 59, 81.8, 82.3, 100, 58.7, 75.6, 85.7, 93.2, 90, 83.8, 50, 93.8, 63.

The total percentage of resistance rates frequency appears as follows: From 80–100 = 53.57%, from 50–70 = 46.43%, < 50 = 0%.

Tetracyclines

This group included Doxycycline, Minocycline and Tetracycline. Doxycycline and Minocycline are mentioned in 2 articles, while Tetracycline in 17 articles.

Doxycycline Two articles were performed in 2015 and 2018 and referred to 100% and 91.2%, respectively, as a resistance rate.

Minocycline Two articles were performed in 2015 and 2018 and referred to 100% and 76.5%, respectively, as a resistance rate.

Tetracycline 2007–2012: 100, 70, 70.46, 55, 78, 87.8, 66.3, 72.

2012–2016: 94, 19.5, 97.7, 77.2, 76.4, 100, 93.7, 86.4, 83.

2016–2021: no data found.

The total percentage of resistance rates frequency appears as follows: From 80–100 = 47.05%, from 50–70 = 47.05%, < 50 = 5.90%.

Polypeptides

Colistin was tested in 72 articles, while Polymyxin B in one article.

Polymyxin B One article was conducted between 2009 and 2011, and the resistance rate was 0%.

Colistin 2007–2012: 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 14, 0, 0, 0, 0, 2.9, 6, 0, 0, 0, 0, 0.6, 0, 0, 0, 0,

2012–2016: 0, 0, 0, 1.4, 0.29, 0, 5.5, 0.8, 0, 5.1, 0, 0, 3.5, 0, 0, 0, 0, 100, 0, 0, 2.1, 0.3, 2.9, 0, 1.2, 0, 0, 0, 0, 100

2016–2021: 6.8, 28, 0.5, 2.5, 3, 1.8, 13.6, 17.6, 0, 12.5, 2.2, 12.8, 9.1, 1.4, 0, 10.5, 0, 9.2.

The total percentage of resistance rates frequency appears as follows: 0 = 58.66%, from 0–10 = 29.33%, from 10–20 = 8%, from 20–30 = 1.33%, from 30–90 = 0%, 100 = 2.66%.

Tigecycline

This antibiotic found to be tested in 54 articles.

2007–2012: 0, 0, 0, 29, 0, 0, 11, 0, 6.6, 0, 37.7, 25, 44.9, 12.5, 34.8, 81.3, 23, 1, 2, 5.7, 2.7, 0.

2012–2016: 0, 40.8, 6.9, 72.4, 18.2, 41.3, 5.1, 3.8, 64, 6.1, 88.9, 66.7, 10.37, 0, 26.6, 49.3, 0, 1.7, 45.8, 2, 9.3, 11.4.

2016–2021: 30, 11, 21.7, 22, 58.8, 73.9, 18.7, 5.9, 6.8, 10. The total percentage of resistance rates frequency appears as follows: 0 = 20.37%, from 0–10 = 27.77%, from 10–20 = 11.11%, from 20–40 = 14.81%, from 40–80 = 16.66%, from 80–100 = 3.70%.

Sulbactam

This antibiotic was mentioned in 5 articles.

2007–2012: 26.6, 8

2012–2016: 100, 100

2018–2021: 73.9

The total percentage of resistance rates frequency appears as follows: From 80–100 = 40%, from 50–70 = 20%, < 50 = 40%.

Others

Chloramphenicol One article was conducted between 2006 and 2010 and referred to 100% as a resistance rate.

Fosfomycin Two articles were conducted between 2008–2012 and 2012–2017 and referred to 48.6% and 100%, respectively, as a resistance rate.

Nitrofurans Nitrofurantoin was the antibiotics of this group and mentioned in two articles conducted between 2012–2014 and 2015–2017 and referred to 99.1% and 97.8%, respectively, as a resistance rate.

Rifampicin Two articles were conducted between 2009–2011 and 2009–2010 and referred to 35% and 47.62%, respectively, as a resistance rate.

Based on all previous results, we found that 15 antibiotics were tested continuously at high frequency over the study years.

Trends in antibiotic resistance that occurred most frequently over the years were represented by a graph in Fig. 1. The overall percentages of a resistance rate for these antibiotics used between 2007 and 2021 were also represented by a graph in Fig. 2.

Groups: 6 articles used the group of antibiotic to indicate the resistance rate.

Aminoglycosides 2012 (33), 2014–2015 (70.9).

b-lactams 2012 (100).

Carbapenems 2007–2010 (92), 2013–2014 (100), 2014–2015 (100), 2014–2015 (91.8), 2014–2018 (75).

Cephalosporins 2014–2015 (93.8), 2014–2018 (100).

Quinolones 2007–2010 (88), 2014–2015 (98), 2014–2018 (100).

Conclusions

Emerging of highly resistant *A. baumannii* to most available antimicrobial agents led to a high incidence of morbidity and fatality mostly for intensive care units patients (Vrancianu et al. 2020; Lee et al. 2022). A 9-year research conducted in a university hospital in Turkey revealed that 81.9% of pathogens detected in clinical specimens were Gram-negative bacteria and *A. baumannii* constituted 34.8% and was the most frequent bacteria in patients with pneumonia, catheter infections, sepsis, wound infections and meningitides. The same study found that *A. baumannii* was the most common bacteria in intensive care units with a rate of 34.8% (Yetkin et al. 2018). In our study, we found that *A. baumannii* was isolated from intensive care units patients in 72.5% of the articles. Our study also revealed that about 40 antibiotics were tested against A. baumannii from 2006 to 2021 with a different frequency and these antibiotics were Amikacin, Gentamicin, Netilmicin, Tobramycin, Doripenem, Ertapenem, Imipenem, Meropenem, Cephalothin, Cefuroxime, Cefixime, Cefoperazone–sulbactam, Cefotaxime, Ceftazidime, Ceftriaxone, Cefepime, Aztreonam, Amoxicillin/clavulanate, Ampicillin, Ampicillin/sulbactam, Piperacillin, Piperacillin/tazobactam, Ticarcillin, Ticarcillin/clavulanate, Ciprofloxacin, Levofloxacin, Ofloxacin, moxifloxacin, Trimethoprim–Sulfamethoxazole, Doxycycline, Minocycline, Tetracycline, Colistin, Polymyxin B, Tigecycline, Sulbactam, Chloramphenicol, Fosfomycin, Nitrofurantoin and Rifampicin. But the frequent antibiotics that constitute the clear map of antibiotics used by health institutions in Turkey against A. baumannii for

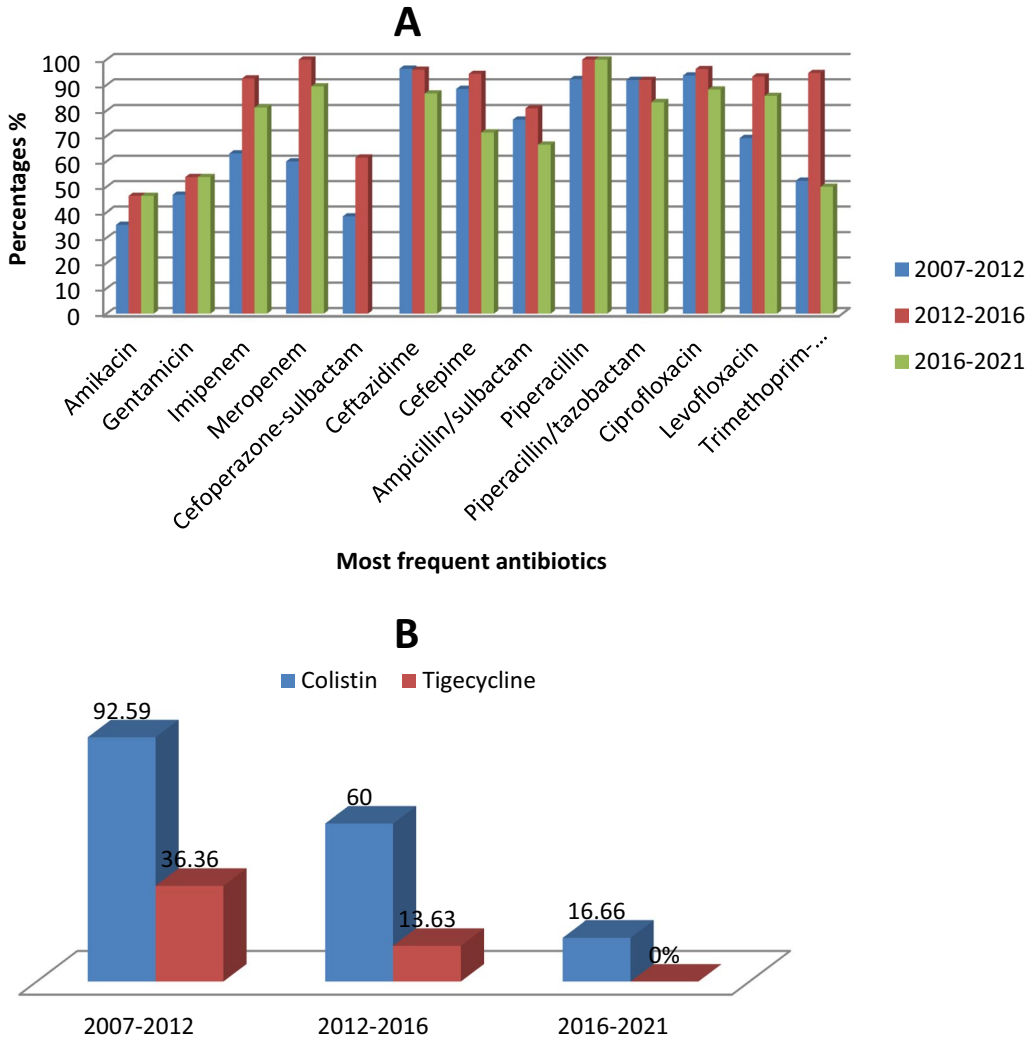

Fig. 1 Most frequent antibiotics with percentages that have shown resistance rate (80–100%) over the years (**A**). Trends of percentages of Colistin and Tigecycline sensitivity rates over the years (**B**)

the last 10 years were Amikacin, Gentamicin, Imipenem, Meropenem, Cefoperazone–sulbactam, Ceftazidime, Cefepime, Ampicillin/sulbactam, Piperacillin, Piperacillin/tazobactam, Ciprofloxacin, Levofloxacin, Trimethoprim–Sulfamethoxazole, Colistin and Tigecycline. These 15 antibiotics were tested continuously with a large frequency during the last years against *A. baumannii*. The results referred to the stability for years of the high resistance rates against some antibiotics and increase in the resistance rates against other antibiotics. We found, for example, that highly resistance rates of *A. baumannii* against Imipenem, Meropenem, Cefoperazone–sulbactam, Ceftazidime, Cefepime, Ampicillin/sulbactam, Ciprofloxacin were steadily stable for the last 10 years. This result goes with data surveillance report published by World Health Organization (WHO) which included the antimicrobial resistance surveillance in Europe 2020–2022. The report showed that resistance phenotype (%) by *Acinetobacter spp.* against Carbapenem (Imipenem/Meropenem) in Turkey from 2016–2020 was as follows: 2016 (91.6), 2017 (91.5%), 2018 (92.2%), 2019 (90.4%) and 2020 (93.1%) and for Fluoroquinolone (Ciprofloxacin/Levofloxacin) as follows: 2016 (92.1%), 2017 (92.6%), 2018 (94.4%) 2019 (90.7%) and 2020 (93.6%) (European Centre for Disease Prevention and Control World Health Organization. Regional Office for Europe. Antimicrobial resistance surveillance in Europe 2022–2020 data 2022). Similar findings for Imipenem, Meropenem, Ampicillin/sulbactam and Ciprofloxacin have been reported in a very recent article (Çiftçi et al. 2022). The analysis in our

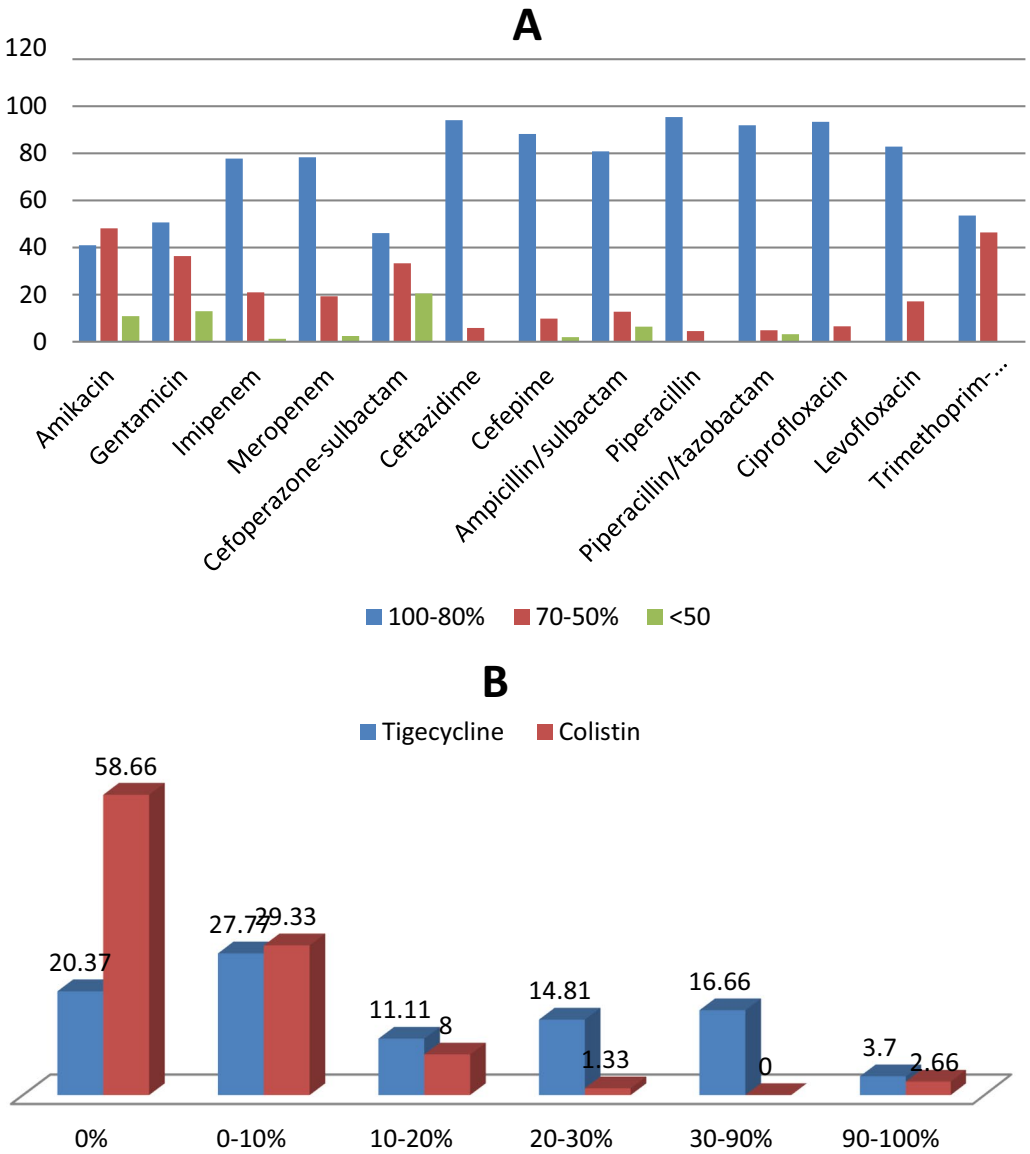

Fig. 2 The total percentages of resistance rates for the most widely used antibiotics from 2007 to 2021 (**A**). Total percentages of Colistin and Tigecycline from 2007 to 2021 based on their sensitivity rates (**B**)

study showed clearly that the increase in resistance rate against Colistin and Tigecycline was in ascending pattern for the last 5 years especially for Colistin which is considered as the last option for treatment. This result is compatible with analysis study on Colistin resistance in *A. baumannii* species in Turkey. The study which included 44 articles found a partial decrease in Colistin sensitivity in some regions over the years and more decrease in others. The study reported İzmir, Samsun, Diyarbakır, Düzce and Ankara as cities with the lowest Colistin susceptibility with rates of 81.8%, 82.4%, 94%, 94.1% and 95.8%, respectively. The study concluded that resistance development against Colistin has increased over the years (Görgün et al. 2021). According to the recent report by World Health Organization, the number of isolates of *Acinetobacter spp*. reported by laboratories in Turkey was increased from 2.463 isolates in 2016 to 3.170 in 2020. The report also indicated that percentage of isolates was higher in males and in age group 65 and over in year 2020 (European Centre for Disease Prevention and Control World Health Organization. Regional Office for Europe. Antimicrobial resistance surveillance in Europe 2022–2020 data 2022).

The continuous increase in *A. baumannii* numbers in health institutions especially in intensive care units with the high mortality caused by this pathogen needs huge studies and to be more highlighted. So we introduced in this study a detailed analysis about the picture of antibiotics profile that is used and tested against *A. baumannii* by different health institutions from different cities of Turkey from 2006 to 2021. We believe that the detailed numbers in our study can give a clear map about the types of antibiotics used continuously and the susceptibility profile regarding these antibiotics for the last 10 years. All the information in this study can be used by all health associations of Turkey including state hospitals and clinics and academic teaching hospitals to re-evaluate all the antibiotics used against *A. baumannii*. Although treatment options still very limited for *A. baumannii*, the reevaluation can answer the question about the reasonability of using the antibiotics that gave stability in high resistant rates for five years or even more. A study included four university hospitals and one state hospital in Ankara and concluded that the reduced consumption of Carbapenems was associated with decreased Carbapenems-resistant by *Acinetobacter* spp. and *Pseudomonas* spp. (Altunsoy et al. 2011). According to our results, we believe that the evaluation can also clarify that the continuous using of effective antibiotics as Colistin and Tigecycline can lead to decrease in Colistin sensitivity in few years. Therefore, reconsideration of antibiotic policies by the health institutions as well as the wise application of antibiotics in the future against *A. baumannii* is highly recommended. Precise and detailed studies regarding antibiotics used by every health setting against *A. baumannii* must be reported annually because of the rapid development in resistance by this pathogen. Long studies without annual numbers and mixed studies from different clinics or from different cities are not recommended because these studies may not give the real numbers about resistance phenotype by *A. baumannii* against antibiotics. For example, during analyzing the articles we found that a multicenter study that depended on collection of *A. baumannii* strains from hospitals located at 12 different provinces of Turkey reported a lower resistant rates against some antibiotics (Beriş et al. 2016). Therefore, we suggest that sensitivity test for *A. baumannii* strains must perform by the same clinic and in the same region of isolation. Recent study found that positive blood cultures were linked with increased odds of 90-day mortality comparing to urine cultures in patients with Carbapenem-resistant *Acinetobacter baumannii* (CRAB) and Carbapenem-resistant *Pseudomonas aeruginosa* (CRPA) (Vivo et al. 2022). Related findings were noticed during analysis of articles in our study, since we found that *A. baumannii* strains isolated from specific specimens gave a high resistance rate against some antibiotics. For example, in two studies a high resistance rate by *A. baumannii* strains most isolated from blood samples against Colistin and Tigecycline was reported with percentage of 14% for Colistin and 40.8 for Tigecycline (Bozkurt-Guzel et al. 2014; Karagöz et al. 2014). On the contrary, a different study reported a low resistance rate with (14.5%) against Tetracycline by *A. baumannii* strains isolated from blood. Another article in our study referred to clear difference in resistance rate against Colistin by *A. baumannii* strains isolated from sputum which gave 0% resistance rate and *A. baumannii* strains isolated from deep tracheal aspirate which gave 10.5%.resistance rate (Şenol et al. 2022). All these results may highlight the value of further studies to be performed regarding the relationship between the susceptibility of *A. baumannii* against antibiotics and the type of specimen that *A. baumannii* isolated from. More information in that field would improve treatment of patients infected with this pathogen in a timely manner. Combination therapy should take more attention in future studies. The use of at a minimum two active agents if possible is recommend according to the guidelines for treatment of Carbapenem-resistant *Acinetobacter baumannii* released by Infectious Disease Society of America (IDSA). The (IDSA) described the therapy of Ampicillin-sulbactam (high dose when the causative agent is indicated as resistant) combined with either Tigecycline or Minocycline as preferred choice (Tamma et al. 2022). Taking in consideration all the above issues in addition to obligatory infection control actions providing sufficient area and developing systems in intensive care units can support the aims in combating *A. baumannii* in hospitals. Therefore, efforts by all medical institutions related to critical care must be more activated and effective procedures to fight these organisms that cause high mortality should become a priority.

This study can assist in giving a precise image about antibiotics profiles used within the last years. As well, we believe that findings in our research are corresponding to the nationwide antibiotic restriction program (NARP) which is released in Turkey in 2003 and proved its effectiveness in reducing the costs and antibiotic resistance which is the same goal that we seek through work in this study. Our results may promote the development of alternative antimicrobial regimens for treatment of *A. baumannii* and may improve antibiotics regimens to be applied in the future. Further surveillance and studies on the development and epidemiological characteristic of clinical *A. baumannii* strains are required.

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SEK planned the idea for the article. ABA performed the literature search and data analysis, and SG critically revised the work. All authors read and approved the final manuscript.

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References

Ababneh Q, Abulaila S, Jaradat Z (2022) Isolation of extensively drug resistant *Acinetobacter baumannii* from environmental surfaces inside intensive care units. Am J Infect Control 50(2):159–165. https://doi.org/10.1016/j.ajic.2021.09.001

Ak O, Haciseyitoglu D, Cag Y, Gencer S, Biteker F, Ozer S (2016) In vitro activities of colistin combined with imipenem, tigecycline or cefoperazone-sulbactam against multidrug-resistant *Acinetobacter baumannii* bloodstream isolates. Dis Mol Med 4(4):51. https://doi.org/10.5455/dmm.20160830024755

Albayrak H, Bayraktar MT, Yıldız ZF (2021) Antibiotic resistance profile of *Acinetobacter* species isolated from blood cultures of inpatients in Harran University Hospital. Harran Üniversitesi Tıp Fakültesi Dergisi (j Harran Univ Med Fac) 18(2):165–169. https://doi.org/10.35440/hutfd.889541

Alp E, Eren E, Elay G, Cevahir F, Esmaoğlu A, Rello J (2017) Efficacy of loading dose of colistin in *Acinetobacter baumannii* ventilator-associated pneumonia. Infez Med 25(4):311–319

Altun HU, Yagci S, Bulut C et al (2014) Antimicrobial susceptibilities of clinical *Acinetobacter baumannii* isolates with different genotypes. Jundishapur J Microbiol 7(12):e13347. https://doi.org/10.5812/jjm.13347

Altun Ş, Koçak Tufan Z, Altun B, Önde U, Kınıklı S, Demiröz AP (2016) Growing OXA-23 type strains among carbapenem-resistant *Acinetobacter baumannii* and tigecycline as an alternate combination therapy. Turk J Med Sci 46(6):1894–1899. https://doi.org/10.3906/sag-1508-20

Altunsoy A, Aypak C, Azap A, Ergönül Ö, Balık I (2011) The impact of a nationwide antibiotic restriction program on antibiotic usage and resistance against nosocomial pathogens in Turkey. Int J Med Sci 8(4):339–344. https://doi.org/10.7150/ijms.8.339

Arabaci C, Karabulut N (2020) *Acinetobacter* species and their antibiotic resistance profiles isolated from various clinical specimens between 2014 and 2018. Ann Med Res 27(2):476–483. https://doi.org/10.5455/annalsmedres.2019.12.911

Asgin N, Otlu B, Cakmakliogullari EK, Celik B (2019) High prevalence of TEM, VIM, and OXA-2 beta-lactamases and clonal diversity among *Acinetobacter baumannii* isolates in Turkey. J Infect Dev Ctries 13(9):794–801. https://doi.org/10.3855/jidc.11684

Aşik G, Özdemir M, Kurtoğlu MG et al (2014) Detection of the frequency of PER-1 type extended-spectrum β-lactamase-producing *Acinetobacter baumannii* clinical isolates in Turkey: a multicenter study. Turk J Med Sci 44(6):1041–1046. https://doi.org/10.3906/sag-1309-126

Atasoy AR, Ciftci IH, Petek M (2015) Modifying enzymes related aminoglycoside: analyses of resistant *Acinetobacter* isolates. Int J Clin Exp Med 8(2):2874–2880

Atik TK, Atik B, Kilinç O et al (2018) Epidemiological evaluation of an *Acinetobacter baumannii* outbreak observed at an intensive care unit. Saudi Med J 39(8):767–772. https://doi.org/10.15537/smj.2018.8.22431

Atik TK, Çetinkaya RA, Özyurt M et al (2019) Identification of oxa-gene in *Acinetobacter baumannii* isolates obtained from clinical specimens and the clonality between these isolates. Nobel Medicus 15(3):44–51

Aydın M, Ergönül Ö, Azap A et al (2018) Rapid emergence of colistin resistance and its impact on fatality among healthcare-associated infections. J Hosp Infect 98(3):260–263. https://doi.org/10.1016/j.jhin.2017.11.014

Aye GL, Emel SC, Buket CA, Levent OZ (2012) In vitro synergistic activity of carbapenems in combination with other antimicrobial agents against multidrug-resistant *Acinetobacter baumannii*. Afr J Microbiol Res 6(12):2985–2992

Ayhan M, Kalem AK, Hasanoglu I et al (2021) Intrathecal and intraventricular administration of antibiotics in gram-negative nosocomial meningitis in a research hospital in Turkey. Turk Neurosurg 31(3):348–354. https://doi.org/10.5137/1019-5149.JTN.29844-20.2

Barış A, Bulut ME, Öncül A, Bayraktar B (2017) Distribution of Clinical Isolates at Species Level and Their Antibiotic Susceptibilities in Intensive Care Units Patients. Türk Yoğun Bakım Derneği Dergisi 15(1):21–27. https://doi.org/10.4274/tybdd.55707

Bayram Y, Parlak M, Aypak C, Bayram I (2013) Three-year review of bacteriological profile and antibiogram of burn wound isolates in Van. Turkey Int J Med Sci 10(1):19–23. https://doi.org/10.7150/ijms.4723

Bayram Y, Gultepe B, Bektas A, Parlak M, Guducuoglu H (2015) Evaluation of antibiotic resistance in *Acinetobacter baumannii* strains isolated from various clinical samples. Klimik Dergisi 26(2):49–53. https://doi.org/10.5152/kd.2013.17

Bayramoglu G, Kaya S, Besli Y et al (2012) Molecular epidemiology and the clinical significance of *Acinetobacter baumannii* complex isolated from cerebrospinal fluid in neurosurgical intensive care unit patients. Infection 40(2):163–172. https://doi.org/10.1007/s15010-011-0215-4

Beriş FŞ, Budak EE, Gülek D et al (2016) Investigation of the frequency and distribution of beta-lactamase genes in the clinical isolates of *Acinetobacter baumannii* collected from different regions of Turkey: a multicenter study. Mikrobiyol Bul 50(4):511–521. https://doi.org/10.5578/mb.2917

Boral B, Unaldi Ö, Ergin A, Durmaz R, Eser ÖK (2019) Acinetobacter Study Group. A prospective multicenter study on the evaluation of antimicrobial resistance and molecular epidemiology of multidrug-resistant *Acinetobacter baumannii* infections in intensive care units with clinical and environmental features. Ann Clin Microbiol Antimicrob 18(1):19. https://doi.org/10.1186/s12941-019-0319-8

Bozkurt-Guzel C, Savage PB, Akcali A, Ozbek-Celik B (2014) Potential synergy activity of the novel Ceragenin, CSA-13, against Carbapenem-resistant *Acinetobacter baumannii* strains isolated from bacteremia patients. Biomed Res Int 2014:1–5. https://doi.org/10.1155/2014/710273

Büyük A, Yilmaz FF, Gül Yurtsever S, Hoşgör LM (2017) Antibiotic Resistance Profiles and Genotypes of *Acinetobacter baumannii* Isolates and *In Vitro* Interactions of Various Antibiotics in Combination with Tigecycline and Colistin. Turk J Pharm Sci 14(1):13–18. https://doi.org/10.4274/tjps.44127

Çağlan E, Nigiz Ş, Sancak B, Gür D (2019) Resistance and heteroresistance to colistin among clinical isolates of *Acinetobacter baumannii*. Acta Microbiol Immunol Hung 67(2):1–5. https://doi.org/10.1556/030.66.2019.021

Cakirlar FK, Gonullu N (2014) The susceptibility to colistin and tigecycline of carbapenem-resistant *Acinetobacter baumannii* isolates in Turkey. Int J Infect Dis 21:85. https://doi.org/10.1016/j.ijid.2014.03.605

Cetin ES, Tekeli A, Ozseven AG, Us E, Aridogan BC (2013) Determination of in vitro activities of polymyxin B and rifampin in combination with ampicillin/sulbactam or cefoperazone/sulbactam against multidrug-resistant *Acinetobacter baumannii* by the E-test and checkerboard methods. Jpn J Infect Dis 66(6):463–468. https://doi.org/10.7883/yoken.66.463

Çetinkol Y, Telli M, Altunçekiç Yıldırım A, Çalgın MK (2016) Evaluation of the efficacy of colistin/sulbactam combination on carbapenem-resistant *Acinetobacter baumannii* strains. Mikrobiyol Bul 50(3):460–465. https://doi.org/10.5578/mb.26289

Ceyhan-Guüvensen N, Keskin D, Sankur F (2017) Antibiotic resistance ratio of *Acinetobacter baumannii* against to ten antibiotics and multidrug resistance index. Fresenius Environ Bull 25:8316–8320
Cicek AC, Karagoz A, Koksal E et al (2013) A single clone *Acinetobacter baumannii* outbreak in a state hospital in Turkey. Jpn J Infect Dis 66(3):245–248. https://doi.org/10.7883/yoken.66.245
Cicek AC, Saral A, Iraz M et al (2014) OXA- and GES-type β-lactamases predominate in extensively drug-resistant *Acinetobacter baumannii* isolates from a Turkish University Hospital. Clin Microbiol Infect 20(5):410–415. https://doi.org/10.1111/1469-0691.12338
Çıçek AÇ, Düzgün AÖ, Saral A et al (2013) Detection of class 1 integron in *Acinetobacter baumannii* isolates collected from nine hospitals in Turkey. Asian Pac J Trop Biomed 3(9):743–747. https://doi.org/10.1016/S2221-1691(13)60149-5
Çiftci İH, Aşik G, Karakeçe E et al (2013) Distribution of blaOXA genes in *Acinetobacter baumannii* strains: a multicenter study. Mikrobiyol Bul 47(4):592–602. https://doi.org/10.5578/mb.6388
Çiftçi İH, Kılbaş İ, Kahraman Kılbaş EP (2022) The war against the resistance of *Acinetobacter Baumannii*: a meta-analysis of findings in Türkiye. Erciyes Med J 44(5):447–454. https://doi.org/10.14744/etd.2022.94770
Çil B, Kütük E, Kabak M, Yıldız T, Hocanlı İ (2022) *Acinetobacteria baumannıı* infection in the intensive care unit-risk factors and antibiotic resistance. New Trends Med Sci 3(1):55–60
Çolakoğlu Ş, Alişkan H, Göçmen J (2014) Kan Kültürlerinden İzole Edilen *Acinetobacter baumannii* ve *Pseudomonas aeruginosa* Suşlarının Antibiyotik Duyarlılık Profilleri (2012–2014). Türk Mikrobiyoloji Cemiyeti Dergisi 44(4):132–138. https://doi.org/10.5222/TMCD.2014.132
Dede B, Kadanalı A, Karagöz G, Çomoğlu Ş, Bektaşoğlu MF, Yücel FM (2013) Investigation of antibiotic resistance of *Acinetobacter baumannii* strains isolated from various clinical samples in intensive care unit. Bakırköy Tıp Dergisi Bakirkoy. https://doi.org/10.5350/BTDMJB201309105
Demir T, Buyukguclu T (2013) Evaluation of the in vitro activity of fosfomycin tromethamine against Gram-negative bacterial strains recovered from community- and hospital-acquired urinary tract infections in Turkey. Int J Infect Dis 17(11):e966–e970. https://doi.org/10.1016/j.ijid.2013.04.005
Deveci Ö, Dal T, Tekin R, Bozkurt F, Tekin A, Dayan S (2013) Carbapenem resistance in *Acinetobacter baumannii*: where is it heading? Infez Med 21(3):211–215
Direkel Ş, Uzunoğlu-Karagöz E, Keleş S, Yapar K (2015) Antibiotic resistance rates of *Acinetobacter baumannii* strains isolated from various clinical samples in Giresun Prof. Dr. Atilla ilhan Ozdemir State Hospital. Gazi Med J 26(3):92–96
Direkel Ş, Çopur Çiçek A, Karagöz A et al (2016) Antimicrobial susceptibility and molecular characterization of multidrug-resistant *Acinetobacter baumannii* isolated in an university hospital. Mikrobiyol Bul 50(4):522–534. https://doi.org/10.5578/mb.34158
Doğan A, Gezer Y (2021) Treatment combinations and prognosis in multiple resistant *Acinetobacter baumannii* and Carbapenem resistant *Klebsiella pneumonıae*/oxytoca isolates. J Immunol Clin Microbiol 6(3):121–128
Doğan M, Taşbent FE, Feyzioğlu B, Baykan M (2014) Investigation of colistin, tigecycline and other antibiotic resistance profiles of *Acinetobacter* species isolated from several clinical specimens. ANKEM Dergisi 28(4):138–143. https://doi.org/10.5222/ankem.2014.138
Durdu B, Kritsotakis EI, Lee ACK et al (2018) Temporal trends and patterns in antimicrobial-resistant Gram-negative bacteria implicated in intensive care unit-acquired infections: A cohort-based surveillance study in Istanbul, Turkey. J Glob Antimicrob Resist 14:190–196. https://doi.org/10.1016/j.jgar.2018.04.015
Ece G, Samlioglu P, Atalay S, Kose S (2014) Evaluation of the in vitro colistin susceptibility of *Pseudomonas aeruginosa* and *Acinetobacter baumannii* strains at a tertiary care centre in Western Turkey. Infez Med 22(1):36–40
Ece G, Erac B, Yurday Cetin H, Ece C, Baysak A (2015) Antimicrobial susceptibility and clonal relation between *Acinetobacter baumannii* Strains at a Tertiary Care Center in Turkey. Jundishapur J Microbiol 8(2):e15612. https://doi.org/10.5812/jjm.15612
Ertugrul G, Hayriye G, Mustafa Z (2013) Effectiveness of menthol and folium menthae piperitae against *Acinetobacter baumannii*. Afr J Microbiol Res 7(23):2870–2874. https://doi.org/10.5897/AJMR12.1166
Ertürk A, Çiçek AÇ, Gümüş A et al (2014) Molecular characterisation and control of *Acinetobacter baumannii* isolates resistant to multi-drugs emerging in inter-intensive care units. Ann Clin Microbiol Antimicrob 13:36. https://doi.org/10.1186/s12941-014-0036-2
European Centre for Disease Prevention and Control & World Health Organization. Regional Office for Europe. Antimicrobial resistance surveillance in Europe 2022–2020 data. (2022). World Health Organization. Regional Office for Europe. https://apps.who.int/iris/handle/10665/351141. License: CC BY-NC-SA 3.0 IGO
Falcone M, Tiseo G, Nicastro M et al (2021) Cefiderocol as rescue therapy for *Acinetobacter baumannii* and other Carbapenem-resistant Gram-negative Infections in intensive care unit patients. Clin Infect Dis 72(11):2021–2024. https://doi.org/10.1093/cid/ciaa1410
Falcone M, Tiseo G, Leonildi A et al (2022) Cefiderocol-compared to colistin-based regimens for the treatment of severe infections caused by carbapenem-resistant *Acinetobacter baumannii*. Antimicrob Agents Chemother 66(5):e0214221. https://doi.org/10.1128/aac.02142-21
Gedefie A, Demsis W, Ashagrie M et al (2021) *Acinetobacter baumannii* biofilm formation and its role in disease pathogenesis: a review. Infect Drug Resist 14:3711–3719. https://doi.org/10.2147/IDR.S332051
Giamarellou H, Karaiskos I (2022) Current and potential therapeutic options for infections caused by difficult-to-treat and pandrug resistant gram-negative bacteria in critically ill patients. Antibiotics (basel) 11(8):1009. https://doi.org/10.3390/antibiotics11081009
Gorgun S, Guzel M, Gunal O, Kılıc SS (2020) The efficiency of Colistin, Minocycline, Tigecycline, and Doxycycline against multidrug-resistant *Acinetobacter* strains. Ann Clin Anal Med. https://doi.org/10.4328/ACAM.20207
Görgün S, Usanmaz M, Odabaşı H (2021) A meta-analysis study on colistin resistance in *Acinetobacter baumannii* species in Turkey. World J Adv Res Rev 10(2):090–097
Gozalan A, Ünaldı Ö, Kıırca F et al (2020) Molecular characterisation of Carbapenem-resistant *Acinetobacter baumannii* bloodstream infections in intensive care units. Türk Hijyen Ve Deneysel Biyoloji Dergisi 77(1):15–24. https://doi.org/10.5505/TurkHijyen.2019.53323
Gozutok F, Mutlu Sariguzel F, Celik I, Berk E, Aydin B, Guzel D (2013) Investigation of antimicrobial resistance rates of *Acinetobacter baumannii* strains from nosocomial infections. ANKEM Dergisi 27(1):7–12. https://doi.org/10.5222/ankem.2013.007
Guckan R, Kilinc C, Demir AD, Capraz A, Yanik K (2017) Antimicrobial susceptibility of *Acinetobacter baumannii* complex isolated from different clinical samples in a tertiary care hospital. J Antibiotics Res. https://doi.org/10.15744/2574-5980.1.103
Güdül Havuz S (2022) Acinetobacter baumannii strains grown in endotracheal aspirate culture in Samsun Bafra State Hospital intensive care units and the effect of COVID-19 on Acinetobacter baumannii strains (2019–2020). Türk Hijyen Ve Deneysel Biyoloji Dergisi 79(2):229–242. https://doi.org/10.5505/TurkHijyen.2022.48753
Güler E, Hürdoğanoğlu U, Farhan Almasoodi LH, Çakır N, Süer K (2022) Distribution of microorganisms and antibiotic resistance rates isolated from blood cultures: 5-year evaluation in a University Hospital in Northern Cyprus. Konuralp Medical Journal 14(1):13–22
Gultekin E, Uyanik MH, Hanci H, Erdil Z, Gelen FN, Celebi S (2014) Antimicrobial susceptibility of nonfermentative gram negative bacteria isolated from blood cultures. ANKEM Dergisi 28(3):79–85. https://doi.org/10.5222/ankem.2014.079
Gür H, Hazırolan G (2019) Detection of distribution and antibiotic susceptibility profiles of nonfermentative gram negative bacteria isolated from blood cultures. ANKEM Dergisi 33(2):49–57. https://doi.org/10.5222/ankem.2019.1915
Gür Vural D, Durupinar B (2016) Araştırılması§ Karbapenem Dirençli *Acinetobacter baumannii* Klinik İzolatlarında Sınıf D Beta Laktamaz Varlığının Araştırılması. Türk Mikrobiyoloji Cemiyeti Dergisi 46(4):181–187. https://doi.org/10.5222/TMCD.2016.181
Güven T, Yilmaz G, Güner HR, Kaya Kalem A, Eser F, Taşyaran MA (2014) Increasing resistance of nosocomial *Acinetobacter baumannii*: are we going to be defeated? Turk J Med Sci 44(1):73–78. https://doi.org/10.3906/sag-1211-21
Guven Gokmen T, Akcimen B, Kayar B, Marzi M, Koksal F (2016) The outbreak of *Acinetobacter baumannii* producing OXA-23 and OXA-51 type carbapenemases in a state hospital. J Exp Clin Med 33(3):157–161. https://doi.org/10.5835/jecm.omu.33.03.006

Hosoglu S, Hascuhadar M, Yasar E, Uslu S, Aldudak B (2012) Control of an *Acinetobacter* [corrected] *baumannii* outbreak in a neonatal ICU without suspension of service: a devastating outbreak in Diyarbakir, Turkey [published correction appears in Infection. 2012 Feb;40(1):107]. Infection 40(1):11–18. https://doi.org/10.1007/s15010-011-0180-y

Ibrahim S, Al-Saryi N, Al-Kadmy IMS, Aziz SN (2021) Multidrug-resistant *Acinetobacter baumannii* as an emerging concern in hospitals. Mol Biol Rep 48(10):6987–6998. https://doi.org/10.1007/s11033-021-06690-6

Kalin G, Alp E, Akin A, Coskun R, Doganay M (2014) Comparison of colistin and colistin/sulbactam for the treatment of multidrug resistant *Acinetobacter baumannii* ventilator-associated pneumonia. Infection 42(1):37–42. https://doi.org/10.1007/s15010-013-0495-y

Karadag Gecgel S, Demir C (2017) Increased colistin resistance of *Acinetobacter* species in intensive care unit-acquired infections in a tertiary care hospital. Int Arabic J Antimicrob Agents. https://doi.org/10.3823/815

Karagöz A, Baran I, Aksu N, Acar S, Durmaz R (2014) Characterization and determination of antibiotic resistance profiles of a single clone *Acinetobacter baumannii* strains isolated from blood cultures. Mikrobiyol Bul 48(4):566–576. https://doi.org/10.5578/mb.8276

Keskin H, Tekeli A, Dolapci İ, Öcal D (2014) Klinik örneklerden izole edilen *Acinetobacter baumannii* suşlarında beta-laktamaz kaynaklı direncin moleküler karakterizasyonu [Molecular characterization of beta-lactamase-associated resistance in *Acinetobacter baumannii* strains isolated from clinical samples]. Mikrobiyol Bul 48(3):365–376

Konca C, Tekin M, Geyik M (2021) Susceptibility patterns of multidrug-resistant *Acinetobacter baumannii*. Indian J Pediatr 88(2):120–126. https://doi.org/10.1007/s12098-020-03346-4

Kostakoğlu U, Ertürk A, Yildiz İE et al (2020) Antibiotic resistance and integron gene cassettes in *Acinetobacter baumannii* isolates produced in lower respiratory tract samples taken from the intensive care unit. Kırıkkale Üniversitesi Tıp Fakültesi Dergisi 22(3):450–546. https://doi.org/10.24938/kutfd.789547

Lee CM, Kim CJ, Kim SE et al (2022) Risk factors for early mortality in patients with carbapenem-resistant *Acinetobacter baumannii* bacteraemia. J Glob Antimicrob Resist 31:45–51. https://doi.org/10.1016/j.jgar.2022.08.010

Metan G, Sariguzel F, Sumerkan B, Tv R, Dijkshoorn L (2013) Clonal diversity and high prevalence of OXA-58 among *Acinetobacter baumannii* isolates from blood cultures in a tertiary care centre in Turkey [published correction appears in Infect Genet Evol. 2013 Jun;16:447–8]. J Mol Epidemiol Evolut Genet Infect Dis 2013(14):92–97. https://doi.org/10.1016/j.meegid.2012.11.003

Metan G, Pala Ç, Kaynar L, Cevahir F, Alp E (2014) A nightmare for haematology clinics: extensively drug-resistant (XDR) *Acinetobacter baumannnii*. Infez Med 22(4):277–282

Mohd Sazlly Lim S, Zainal Abidin A, Liew SM, Roberts JA, Sime FB (2019) The global prevalence of multidrug-resistance among *Acinetobacter baumannii* causing hospital-acquired and ventilator-associated pneumonia and its associated mortality: a systematic review and meta-analysis. J Infect 79(6):593–600. https://doi.org/10.1016/j.jinf.2019.09.012

Nemli A, Demirdal T (2016) Impact of appropriate empirical antibiotic therapy on clinical outcome in patients with *Acinetobacter baumannii* bacteremia. Open Forum Infect Dis. https://doi.org/10.1093/ofid/ofw172.805

Nguyen M, Joshi SG (2021) Carbapenem resistance in *Acinetobacter baumannii*, and their importance in hospital-acquired infections: a scientific review. J Appl Microbiol 131(6):2715–2738. https://doi.org/10.1111/jam.15130

Özcan N, Dal T, Can Ş, Tekin A, Gül K (2015) OXA Carbapenemase genes in multidrug-resistant *A. baumannii* strains in Southeast of Turkey. SMU Med J 2(2):21–32

Ozdemir H, Kendirli T, Ergün H et al (2011) Nosocomial infections due to *Acinetobacter baumannii* in a pediatric intensive care unit in Turkey. Turk J Pediatr 53(3):255–260

Ozekinci T, Habip Z, Onder N, Koçoglu ME (2020) Antibiotic resistance of *Acinetobacter baumannii* strains isolated in 2015–2018 years. Van Med J 27(3):340–344. https://doi.org/10.5505/vtd.2020.73384

Özkul C, Hazırolan G (2020) Oxacillinase gene distribution, antibiotic resistance, and their correlation with biofilm formation in *Acinetobacter baumannii* bloodstream isolates. Microb Drug Resist 27(5):637–646. https://doi.org/10.1089/mdr.2020.0130

Ozyurt S, Kostakoglu U, Yildiz IE et al (2020) Investigation of the clonal associations in *Acinetobacter Baumannii* strains isolated from the respiratory samples of patients in a tertiary research hospital. Niger J Clin Pract 23(8):1155–1162. https://doi.org/10.4103/njcp.njcp_549_18

Roy S, Chowdhury G, Mukhopadhyay AK, Dutta S, Basu S (2022) Convergence of biofilm formation and antibiotic resistance in *Acinetobacter baumannii* infection. Front Med (lausanne) 9:793615. https://doi.org/10.3389/fmed.2022.793615

Ruh E, Gazi U, Güvenir M, Süer K, Çakır N (2016) Antibiotic resistance rates of *Pseudomonas aeruginosa*, *Acinetobacter baumannii* and *Klebsiella pneumoniae* isolated from a university-affiliated hospital in North Cyprus. Türk Hijyen Ve Deneysel Biyoloji Dergisi 73(4):333–344

Şafak B, Kilinç O, Tunç N (2016) Klinik Örneklerden İzole Edilen Acinetobacter baumannii Suşlarının Antibiyotik Duyarlılık Oranlarının İncelenmesi. Investigation of antibiotic susceptibility of *Acinetobacter baumannii* isolated from clinical specimens (2010–2016). Flora İnfeksiyon Hastalıkları Ve Klinik Mikrobiyoloji Dergisi 21(2):77–81

Şahin AR, Doğruer D, Nazik S et al (2019) Hastane Kökenli Patojenlerde Artan Antimikrobiyal Direnç Sorunu: *Acinetobacter baumannii*. Online Türk Sağlık Bilimleri Dergisi 4(2):156–169. https://doi.org/10.26453/otjhs.462304

Saral A, Cinemre S, Okumus F et al (2021) Investigation of class 1 integrons with antibiotic resistance genes in multidrug-resistant *Acinetobacter baumannii* strains and determination of plant extract effects on multidrug-resistant isolates. Farmacia 69(5):914–918. https://doi.org/10.31925/farmacia.2021.5.13

Sargin Altunok E, Koc MM (2014) Comparison of antibiotic resistance rates in *Acinetobacter* strains isolated from intensive care units by year. ANKEM Dergisi 28(1):1–7. https://doi.org/10.5222/ankem.2014.001

Sarı AN, Biçmen M, Gülay Z (2013) The first report on the outbreak of OXA-24/40-like carbapenemase-producing *Acinetobacter baumannii* in Turkey. Jpn J Infect Dis 66(5):439–442

Say Coskun US, Caliskan E, Copur Cicek A, Turumtay H, Sandalli C (2019) β-lactamase genes in carbapenem resistance *Acinetobacter baumannii* isolates from a Turkish university hospital. J Infect Dev Ctries 13(1):50–55. https://doi.org/10.3855/jidc.10556

Şenol FF, Bahçeci İ, Arslan N et al (2022) Comparison of respiratory tract pathogens and antibiotic susceptibility profiles of patients diagnosed with COVID-19 with pre-COVID-19. J Health Sci Med 5(2):510–516. https://doi.org/10.32322/jhsm.1010249

Şimşek M, Demir C (2020) Determination of colistin and tigecycline resistance profile of *Acinetobacter baumannii* strains from different clinical samples in a territory hospital in Turkey. J Health Sci Med Res 38(2):81–91. https://doi.org/10.31584/jhsmr.2020727

Tacconelli E, Carrara E, Savoldi A, Harbarth S, Mendelson M, Monnet DL et al (2018) WHO pathogens priority list working group. Discovery, research, and development of new antibiotics: the WHO priority list of antibiotic-resistant bacteria and tuberculosis. Lancet Infect Dis 18(3):318–327. https://doi.org/10.1016/S1473-3099(17)30753-3

Tamma PD, Aitken SL, Bonomo RA et al (2022) Infectious diseases society of america guidance on the treatment of AmpC β-lactamase-producing enterobacterales, carbapenem-resistant *Acinetobacter baumannii*, and *Stenotrophomonas maltophilia* infections. Clin Infect Dis 74(12):2089–2114. https://doi.org/10.1093/cid/ciab1013

Tasbakan MS, Pullukcu H, Sipahi OR, Tasbakan MI, Aydemir S, Bacakoglu F (2011) Is tigecyclin a good choice in the treatment of multidrug-resistant *Acinetobacter baumannii* pneumonia? J Chemother 23(6):345–349. https://doi.org/10.1179/joc.2011.23.6.3455

Tasdogan A (2020) Risk factors of mortality from *Acinetobacter Baumannii* infection in intensive care units. Eurasian J Med Investig 4(1):55–60. https://doi.org/10.14744/ejmi.2019.24282

Temocin F, Erdinc FS, Tulek N et al (2015) Synergistic effects of sulbactam in multi-drug-resistant *Acinetobacter baumannii*. Braz J Microbiol 46(4):1119–1124. https://doi.org/10.1590/S1517-838246420140101

Turkoglu M, Mirza E, Tunçcan ÖG et al (2011) *Acinetobacter baumannii* infection in patients with hematologic malignancies in intensive care unit: risk factors and impact on mortality. J Crit Care 26(5):460–467. https://doi.org/10.1016/j.jcrc.2011.04.007

Uğur M, Genç S (2019) Three year resistance profile of *Acinetobacter baumannii* and *Pseudomonas aeruginosa* strains isolated from intensive care units.

Turk J Intensive Care 17(3):130–137. https://doi.org/10.4274/tybd.galenos.2018.94103
Uskudar-Guclu A, Altay-Kocak A, Akcil Ok M, Tutluoglu B, Basustaoglu AC (2021) Respiratory Study Group. Antibacterial resistance in lower respiratory tract bacterial pathogens: a multicenter analysis from Turkey. J Infect Dev Ctries 15(2):254–262. https://doi.org/10.3855/jidc.12599
Uzun B, Gungor S, Yurtsever SG, Afsar İ, Demirci M (2012) Evalution of resistance to various antibiotics in *Pseudomonas aeruginosa* and *Acinetobacter baumannii* strains isolated from blood cultures of intensive care patients. ANKEM Dergisi 26(2):55–60. https://doi.org/10.5222/ankem.2012.055
Uzunoglu E, Direkel S et al (2017) Co-existance of isaba1/blaoxa-51/23 is increasing in carbapenem rersistant *Acinetobacter baumannii* isolates in Turkey. Acta Med Mediterr 33(6):1001. https://doi.org/10.19193/0393-6384_2017_6_159
Vivo A, Fitzpatrick MA, Suda KJ et al (2022) Epidemiology and outcomes associated with carbapenem-resistant *Acinetobacter baumannii* and carbapenem-resistant *Pseudomonas aeruginosa*: a retrospective cohort study. BMC Infect Dis 22(1):491. https://doi.org/10.1186/s12879-022-07436-w
Vrancianu CO, Gheorghe I, Czobor IB, Chifiriuc MC (2020) Antibiotic resistance profiles, molecular mechanisms and innovative treatment strategies of *Acinetobacter baumannii*. Microorganisms 8(6):935. https://doi.org/10.3390/microorganisms8060935
Yavaş S, Yetkin MA, Kayaaslan B et al (2016) Investigating the in vitro synergistic activities of several antibiotic combinations against carbapenem-resistant *Acinetobacter baumannii* isolates. Turk J Med Sci 46(3):892–896. https://doi.org/10.3906/sag-1408-14
Yetkin F, Yakupogullari Y, Kuzucu C et al (2018) Pathogens of intensive care unit-acquired infections and their antimicrobial resistance: a 9-year analysis of data from a University Hospital. Jundishapur J Microbiol 11(10):e67716. https://doi.org/10.5812/jjm.67716
Yilmaz Ş, Hasdemir U, Aksu B, Altınkanat Gelmez G, Söyletir G (2020) Alterations in AdeS and AdeR regulatory proteins in 1-(1-naphthylmethyl)-piperazine responsive colistin resistance of *Acinetobacter baumannii*. J Chemother 32(6):286–293. https://doi.org/10.1080/1120009X.2020.1735118
Zeka AN, Poirel L, Sipahi OR et al (2014) GES-type and OXA-23 carbapenemase-producing *Acinetobacter baumannii* in Turkey. J Antimicrob Chemother 69(4):1145–1146. https://doi.org/10.1093/jac/dkt465

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