

Substandard and falsified antibiotics: neglected drivers of antimicrobial resistance?

Supplementary file 11. Main characteristics of equivalence studies on the quality of antibiotics

Reference / country of collection	Active pharmaceutical ingredient (s) (API)	Brand name	Outlet	Reference standard	Test(s) performed and analytical technique for API content/Impurities	Failure rate n/N (%)
Mouton, 1979[1] Netherlands	Cefadrine Cefamandole Cefalotin Cefazolin Cefotaxime Cefoxitin Cefuroxime	Unspecified	Manufacturer	Unspecified	API content - Microbiological assay	0/7 (0.0%)
Van der Bijl, 1988[2] Unknown	Ampicillin	Famicillin, Penbritin, Petercillin	Unknown	Unspecified	API identification - HPLC-MS, microbiological assay, related substances	0/10 (0.0%)
Kibwage, 1991[3] Kenya	Metronidazole	Flagyl, Unknown	Manufacturer Wholesaler	BP	API content - UV-Spectroscopy, crushing strength, disintegration, dissolution, friability, mass uniformity	6/11 (54.5%)
Sakolchai, 1991[4] Thailand	Metronidazole Ampicillin Co-trimoxazole	Unknown	Hospital/Health centre, Private pharmacy	USP	API content - HPLC, dissolution, mass uniformity	6/14 (42.9%)
Antony, 1999[5] Tanzania	Co-trimoxazole Metronidazole	Bactrim, Flagyl, Unknown	Distributor Pharmacy	BP, USP	API content – TLC and UV-Spectroscopy, disintegration, dissolution, friability	3/6 (50.0%)
Nightingale, 2000a[6] Israel, Poland, Slovakia, Slovenia	Clarithromycin	Fromilid, Karin	Unknown	USP, Manufacturer's standard	API content - HPLC, dissolution, impurity	6/11 (54.6%)

Reference / country of collection	Active pharmaceutical ingredient (s) (API)	Brand name	Outlet	Reference standard	Test(s) performed and analytical technique for API content/Impurities	Failure rate n/N (%)
Nightingale, 2000b[7] Brazil, Chile, China, Colombia, Costa Rica, El Salvador, Guatemala, India, Indonesia, Pakistan, Peru, Turkey, Uruguay	Clarithromycin	Bicrolid, Clacine, Clambiotic, Clamicin, Clamycin, Claribac, Claricide, Clarimax, Clarimicin, Clarion, Clarithro-250, Claritrobac, Claritrol, Claritromicina, Claritromicina MK, Comtro, Crixan, Dicapal, Infex, Klarid, Klarolid, Klaromin, Klax, Limaixian, Macrol, Macrolien, Mus, Pre-Clar, Synclar	Unspecified	USP	API content – HPLC, dissolution, impurity – HPLC, visual inspection	34/40 (85.0%)
Mei, 2002[8] China	Cephadrine	Unknown	Unknown	Chinese Pharmacopeia	API content – HPLC, dissolution	1/13 (7.7%)
Lambert, 2003[9] United Kingdom	Ceftriaxone	Axon, Broadced, Cefaxona, Cefaxone, Ceftriax, Ceftriaxon, Ceftriaxona GI, Ceftriaxona Sodium, Ceftriaxone Cef 3, Ceftriaxone, Cerixon, Desfin, Elpicef, Keptrix, KGE Ceftriaxone, LGP Ceftriaxone, Mercefex, Novocef, Oframax, Titan, Tpnakcoh, Triceft, Trixone, Unocef, Ventraxin, Zefrox	Unknown	European Pharmacopoeia, USP	API content - HPLC, impurity - HPLC, pH, sterility	10/34 (29.4%)
Iqbal, 2004[10] Pakistan	Ofloxacin	Albact, Avocin, Bacivid, Ciof, Curitol, Eracin, Exact, Flovix, Floxy, Geoflox, Gyrasid, Gyrex,	Unknown	National Committee for Clinical Laboratory Standards	API content - In-vitro antibacterial susceptibility	15/34 (44.1%)

Reference / country of collection	Active pharmaceutical ingredient (s) (API)	Brand name	Outlet	Reference standard	Test(s) performed and analytical technique for API content/Impurities	Failure rate n/N (%)
		Kapcin, Korvid, Loxat, Ofamac, Oflobid, Oflobiotic, Ofloxin, Ofloquin, Oflox, Oftab, Oxil, Quinox, Rutix, Tabroxacin, Tariflox, Tarivid, Wiloxin				
Mei, 2004[11] China	Ceftriaxone	Unknown	Unregistered outlets	BP, European Pharmacopoeia, USP	API content - HPLC	0/17 (0%)
Nightingale, 2005[12] Argentina, Cyprus, Greece, Hong Kong, India, Indonesia, Malaysia, Mexico, Morocco, Pakistan, Palestine, Republic of Korea, Singapore, Slovenia, Spain, Uruguay	Clarithromycin	Adel, Berafen, Bicrolid, Binoclar, Clacin, Clamont, Clari, Clarion, Claripen, Claritek, Clarithro, Clarithromycin A, Claritromicina Alter, Claritromicina Bexal, Claritromicina, Geminis, Claritromicina Kern, Claromycin, Claros, Clarytas, Cleron, Crixan, E-Clar, Ezumycin, Fromilid, Hammi, Iset, Klaribact, Klaricare, Klermed, Neo-Klar, Pathocin, Ulcecure	Unspecified	USP	API content – HPLC, dissolution, impurity – HPLC, visual inspection	9/65 (13.9%)
Semde, 2005[13] Burkina Faso	Amoxicillin, Ampicillin, Metronidazole, Phenoxymethylpenicillin (Penicillin V), Sulfamethoxazole + Trimethoprim	Amoxicilline, Ampicilline, Bactrim Adultes, Clamoxyl, Co-trimoxazole, Flagyl, Metronidazole, Penicilline V, Starpen, Totapen	Wholesalers/ importer/ distributors	BP, European Pharmacopoeia, USP	API content – UV/Visible spectrophotometry, disintegration, dissolution, friability, hardness	0/20 (0%)
Adegbolagun, 2007[14] Nigeria	Ciprofloxacin	Unknown	Private pharmacy	BP, USP	API content – TLC, hardness, disintegration	4/10 (40.0%)

Reference / country of collection	Active pharmaceutical ingredient (s) (API)	Brand name	Outlet	Reference standard	Test(s) performed and analytical technique for API content/Impurities	Failure rate n/N (%)
Bamiro, 2007[15] Nigeria	Metronidazole	Unknown	Retail outlets - undefined	BP	API content – Titrimetry, disintegration, dissolution, friability, tablet hardness, mass uniformity	2/7 (28.6%)
Ibezim, 2008[16] Nigeria	Metronidazole	Unknown	Unregistered outlet, patent medicine vendor, hospital, private pharmacy	BP, USP	API content – UV/Visible spectrophotometry	9/10 (90.0%)
Mu'az, 2009[17] Nigeria	Ciprofloxacin	Unknown	Manufacturer	BP, USP	API content - LC, disintegration, dissolution, friability, hardness	0/7 (0%)
Nazir Mughal, 2009[18] Pakistan	Ciprofloxacin	Axcin, Ciproxin, Cyrocip, Mercip	Unknown	Unknown/Not specified.	API content - In-vitro antibacterial susceptibility	0/8 (0%)
Ngwuluka, 2009[19] Nigeria	Ciprofloxacin	Cipro-J, Ciprobon, Ciprogem, Ciproval, Ivacip, Vitapro	Private pharmacy	BP, USP	API content - UV-visible spectrophotometry, disintegration, dissolution, friability test, tablet hardness, mass uniformity	3/6 (50.0%)
Shahnaz, 2009[20] Pakistan	Cefixime	Unknown	Private pharmacy	BP, USP	API content – HPLC and microbiological assay, disintegration, dissolution, mass uniformity	0/6 (0%)
Wei, 2009[21] China	Cefteram	Unknown	Unknown	Unknown/Not specified	API content - HPLC	0/2 (0%)
Awofisayo, 2010[22] Nigeria	Ofloxacin	Asflovid, Drovid, Floxan, Floxavid, Gaxin, Ofloved, Tarivid, Traflox, Zanocin	Private pharmacy	USP	API content – UV-Spectroscopy, disintegration, dissolution, friability, tablet hardness, mass uniformity	9/9 (100.0%)
Nayak, 2010[23] India	Ciprofloxacin	Unknown	Private pharmacy	Indian Pharmacopeia, USP	API content – UV-spectrophotometry, disintegration, dissolution, friability, tablet hardness, mass uniformity	0/7 (0%)

Reference / country of collection	Active pharmaceutical ingredient (s) (API)	Brand name	Outlet	Reference standard	Test(s) performed and analytical technique for API content/Impurities	Failure rate n/N (%)
Silva, 2010[24] Colombia	Meropenem, Piperacillin-tazobactam	Unknown	Hospital/Health centres	Colombia National Formulary, United States Pharmacopeia	API content – microbiological assay	0/39 (0%)
Arshad, 2011[25] Pakistan	Gatifloxacin	Unknown	Private pharmacy	BP, USP	API content - HPLC-UV, disintegration, dissolution, tablet hardness, size variability, thickness, mass uniformity	0/5 (0%)
Bano, 2011[26] Pakistan	Levofloxacin	Unknown	Private pharmacy	BP, USP	API content - UV-visible spectrophotometry and In-vitro antibacterial susceptibility, disintegration, dissolution, friability, tablet hardness, thickness, mass uniformity	0/6 (0%)
Diaz, 2011[27] Colombia	Vancomycin	Unknown	Hospital/Health centres	USP	API content - In-vitro antibacterial susceptibility and microbiological assay	0/23 (0%)
Hailu, 2011[28] Ethiopia	Sulfamethoxazole-Trimethoprim	Bactrim, Bisepton, Cotreich, Cotri, Cotrimoxazole, Deprim	Manufacturer	BP, USP	API content – HPLC, disintegration, dissolution, friability, tablet hardness, thickness, mass uniformity	0/6 (0%)
Singal, 2011[29] India	Ciprofloxacin	Ciprobid	Private pharmacy	Indian Pharmacopeia	API content – HPLC and UV-Spectroscopy, API identification – IR spectroscopy, dissolution, mass uniformity	0/20 (0%)
Akpabio, 2011[30] Nigeria	Ciprofloxacin	Cefroden, Cipox, Ciprocure, Cipronol	Manufacturer	USP	API content – Titrimetry, disintegration, dissolution, friability, mass uniformity	1/4 (25.0%)
Mikre, 2011[31] Ethiopia	Amoxicillin	Unknown	Private pharmacy	BP, USP	API content- UV-visible spectrophotometry, API identification-TLC, dissolution, pH, mass uniformity, water content-Karl-Fischer titration	2/13 (15.4%)

Reference / country of collection	Active pharmaceutical ingredient (s) (API)	Brand name	Outlet	Reference standard	Test(s) performed and analytical technique for API content/Impurities	Failure rate n/N (%)
Musa, 2011[32] Nigeria	Metronidazole	Unknown	Hospital, Patent medicine vendor, Private pharmacy	BP	API content – unknown, dissolution, friability, tablet hardness, mass uniformity	10/15 (66.7%)
Omari, 2011[33] Jordan	Ciprofloxacin	Unknown	Manufacturer	US FDA, USP	API content - HPLC	0/2 (0%)
Singhal, 2011[34] India	Ciprofloxacin	Ciprobid, Ciproral	Private and public outlet - undefined	Indian Pharmacopeia	API content and identification – HPLC, content uniformity, mass uniformity	0/2 (0%)
Ashrafu Islam, 2012[35] Bangladesh	Ciprofloxacin	Unknown	Private pharmacy	USP	API content – HPLC, disintegration, dissolution, friability, tablet hardness, mass uniformity	0/6 (0%)
Olanrewaju, 2012[36] Nigeria	Amoxicillin plus Clavulanic acid	Unknown	Private pharmacy	BP, USP	API content – HPLC, disintegration, dissolution, friability, tablet hardness, mass uniformity	3/6 (50.0%)
Onanuga, 2012[37] Nigeria	Ciprofloxacin, Gentamicin	Cenox, Cifran, Cipro-J, Ciprotab, Ciproxamed, Cyplox, Depmax, Elcees, Gentamicin Sulphate, Gentaven, Glogent, Paulio, Siprosan, Taman, Tivagenta, Unknown, Vitrapro	Combination of outlets, Private pharmacy	Unknown/Not specified	API content-in-vitro antibacterial susceptibility	11/17 (64.7%)
Nambiar, 2012[38] USA	Vancomycin	Unknown	Wholesaler/ Importer/ distributors	BP	API content and impurity – HPLC	0/6 (0%)
Hadwiger, 2012[39] United States of America	Vancomycin	Unknown	Manufacturer	BP, USP	API content - UHPLC, impurity - UV-MS	0/6 (0%)

Reference / country of collection	Active pharmaceutical ingredient (s) (API)	Brand name	Outlet	Reference standard	Test(s) performed and analytical technique for API content/Impurities	Failure rate n/N (%)
Qureshi, 2012[40] Pakistan	Ciprofloxacin	Unknown	Unknown	Unknown/Not specified	API content- HPLC	1/11 (9.1%)
Kahaliw, 2013[41] Ethiopia	Metronidazole	Amrizole, Camezol, Giardyl-125, Metazole, Metrogyl, Metrolag, Metronidazole	Private pharmacy	BP, Indian Pharmacopeia, USP	API content – HPLC, disintegration, dissolution, friability, tablet hardness, mass uniformity, sedimentation, viscometer	1/10 (10.0%)
Rahim, 2013[42] Pakistan	Cefadroxil	Unknown	Retail – undefined, Wholesaler	USP	API content – HPLC, disintegration, dissolution, tablet hardness, mass uniformity, tablet thickness	0/7 (0%)
Hussain, 2013[43] Pakistan	Ciprofloxacin	Unknown	Private pharmacy	USP	API content – UV spectroscopy, disintegration, dissolution, tablet hardness, mass uniformity	1/12 (8.3%)
Birhanu, 2013[44] Ethiopia	Erythromycin	Erycin, Erythromycin, Etocin, Rythro	Drug retail outlets – undefined	BP, USP	API content – unknown, disintegration, dissolution, tablet hardness, identity, mass uniformity	1/4 (25.0%)
Akhtar, 2013[45] Pakistan	Levofloxacin	Cravit, Farleo, Feelix, Lecord, Levodin, Levofin, Levoflox, Levosafe, Qevo	Unknown	BP, USP	Disintegration, dissolution, friability, tablet hardness, mass uniformity	8/9 (88.9%)
Kassaye, 2013[46] Ethiopia	Amoxicillin	Unknown	Unknown	USP	Dissolution	0/8 (0%)
Pais, 2013[47] India	Amoxicillin	Unknown	Government outlets	USP	API content-alkalimetry test and in-vitro antibacterial susceptibility, moisture content-drying oven method, pH, sedimentation test	4/12(33.3%)
Naveed, 2014[48] Pakistan	Doxycycline	Doxycycline, Doxyn, Vibramycin	Unknown	BP, USP	Disintegration, dissolution, mass uniformity	0/3 (0%)
Khamis, 2014[49] Gulf region	Metronidazole	Amrizole, Metrolags, Negazole, Nidazol	Private pharmacy	USP	API content – UV-spectroscopy, disintegration, friability, tablet hardness, mass uniformity	0/4 (0%)

Reference / country of collection	Active pharmaceutical ingredient (s) (API)	Brand name	Outlet	Reference standard	Test(s) performed and analytical technique for API content/Impurities	Failure rate n/N (%)
Al-Tahami, 2014[50] Yemen	Amoxicillin plus Clavulanic acid	Unknown	Private pharmacy	USP	API content – HPLC, pH	0/4 (0%)
Arnet, 2014[51] China, Myanmar	Ceftriaxone	Becef, Cefaxone, Cefin, Ceftriaxon, Incept, Oframax, Triacef	Wholesalers/ importer/ distributors	Manufacturer	API content – HPLC, API identification – NIR, impurity – HPLC, pH, physical appearance, sterility	8/8 (100.0%)
Aliyu, 2014[52] Nigeria	Metronidazole	Bonagyl, Emgyl, Jugyl, Lemetro, Loxagyl, Metrotab, Metrozam, Metrozo, Palagyl, Stargyl, Unigyl, Vamis	Private pharmacy	BP	API content – UV-spectroscopy, disintegration, dissolution, friability, tablet hardness, mass uniformity	7/12 (58.3%)
Humayoon, 2014[53] Pakistan	Doxycycline	Generic	Private pharmacy	BP	API content- UV-visible spectrophotometry, disintegration, dissolution, mass uniformity	0/6 (0%)
Idries, 2014[54] Sudan	Ceftriaxone	Unknown	Unknown	Unknown	API content - microbiological assay	1/2 (50.0%)
Fahmy, 2014[55] United Arab Emirates	Ciprofloxacin	Unknown	Private pharmacy	USP	Bioavailability, dissolution	0/6 (0%)
Fayyaz, 2014[56] Pakistan	Levofloxacin	Unknown	Unknown	USP	API content – HPLC, disintegration, dissolution, tablet hardness, mass uniformity	1/6 (16.7%)
Hamam, 2014[57] Sudan	Ciprofloxacin	Unknown	Unknown	USP	API content – HPLC, disintegration, friability, mass uniformity, tablet thickness	0/4 (0%)
Malele, 2014[58] Tanzania	Ciprofloxacin	Unknown	Combination of outlets	Unknown/Not specified	API content - In-vitro antibacterial susceptibility	4/9 (44.4%)
Nettey, 2014[59] Ghana	Amoxicillin-Clavulanic acid	Unknown	Private pharmacy	BP	API content – HPLC and in-vitro antibacterial susceptibility, disintegration, dissolution	29/38 (76.3%)

Reference / country of collection	Active pharmaceutical ingredient (s) (API)	Brand name	Outlet	Reference standard	Test(s) performed and analytical technique for API content/Impurities	Failure rate n/N (%)
Jaman, 2015[60] Bangladesh	Ciprofloxacin	Unknown	Unknown	USP	API content – UV spectroscopy, disintegration, dissolution, tablet hardness, mass uniformity, tablet thickness	0/5 (0%)
Aljohani, 2015[61] Egypt, India, Jordan, Morocco, United Kingdom, United States	Azithromycin	Unknown, Zithromax	Hospital/health centres, private pharmacy	US FDA, USP	API content - HPLC	5/19 (26.3%)
Bashir, 2015[62] Pakistan	Levofloxacin	Bexus, Cravit, Dynaquin, Effiflox, Floxolev, Glit, Lazer, L-cyn, Lecin, Leflox, Levo, Levocil, Levocure, Levoday, Levomerc, Levoscot, Levotar, Levotas, Levovis, Locus, Mclevo, Protektin, Qumic, Spectrix, Tavanic, Vizor, Voksec, Voxiquin, Xeflox	Unknown	National Committee for Clinical Laboratory Standards	In-vitro antibacterial susceptibility	0/29 (0%)
Bendari, 2015[63] Oman	Metronidazole	Flazole, Klont, Metrolag, Negazole, Nidazole, Suprazole	Unknown	USP	Disintegration, dissolution- UV-visible spectrophotometer, friability, tablet hardness, mass uniformity	2/6 (33.3%)
El Attug, 2015[64] Libya	Amoxicillin-clavulanic acid	Unknown	Unknown	USP	API content – LC and in-vitro antibacterial susceptibility, API ID – LC and FTIR, disintegration, dissolution, tablet hardness, tablet thickness, mass uniformity	0/5 (0%)
Alzomor, 2016[65] Yemen	Sulfamethoxazole plus trimethoprim	Amirtrim, Balkatrim, Batrim, Cotrix, Farcotrim, Omtran, Septram, Septrim, Shatrim, Sinotrim	Unregistered	BP, USP	API content – HPLC, disintegration, dissolution, friability, tablet hardness	2/10 (20.0%)

Reference / country of collection	Active pharmaceutical ingredient (s) (API)	Brand name	Outlet	Reference standard	Test(s) performed and analytical technique for API content/Impurities	Failure rate n/N (%)
Shraim, 2016[66] State of Palestine	Cefuroxime	Unknown	Unregistered	USP	API content – HPLC, dissolution, mass uniformity	0/3 (0%)
Idrees, 2016[67] Pakistan	Amoxicillin	Acamoxil, Amoxascot, Amoxicillin, Effimox, Glomox, HMC, Lapmox, Maxil, Medimox, Namoxil, Werrimox	Unknown	Unspecified	API content – HPLC and capillary electrophoresis	1/11 (9.1%)
Israr, 2016[68] Pakistan	Cefuroxime	Unknown	Manufacturer	USP	API content – HPLC, disintegration, dissolution, mass uniformity, thickness	0/4 (0%)
Osonwa, 2016[69] Nigeria	Ciprofloxacin	Unknown	Private pharmacy	BP	API content - UV-visible spectrophotometry, disintegration, friability, Monsanto tablet hardness, mass uniformity	1/15 (6.7%)
Pathak, 2016[70] India	Amoxicillin-clavulanic acid	Unknown	Private pharmacy	Unknown/Not specified	API content - In-vitro antibacterial susceptibility	2/6 (33.3%)
Adeniyi, 2017[71] Nigeria	Ciprofloxacin	Unknown	Private pharmacy	BP	API content - In-vitro antibacterial susceptibility, mass uniformity	0/5 (0%)
Al-Tabakha, 2017[72] United Arab Emirates	Amoxycillin plus Clavulanic acid	Unknown	Private pharmacy	USP	API content – HPLC, dissolution, friability, mass uniformity	0/5 (0%)
Uddin, 2017[73] Bangladesh	Ciprofloxacin	Unknown	Private pharmacy	BP, USP	API content – UV spectroscopy, disintegration, dissolution, friability, tablet hardness, mass uniformity	4/10 (40.0%)
Manani, 2017[74] Kenya	Clarithromycin	Unknown	Private pharmacy	USP	API content – HPLC, dissolution	0/16 (0%)

Reference / country of collection	Active pharmaceutical ingredient (s) (API)	Brand name	Outlet	Reference standard	Test(s) performed and analytical technique for API content/Impurities	Failure rate n/N (%)
Noor, 2017[75] Bangladesh	Metronidazole	Unknown	Private pharmacy	BP, USP	API content – UV/Visible spectrophotometry, disintegration, dissolution, friability, tablet hardness, mass uniformity, tablet thickness and diameter	0/9 (0%)
Gberindyer, 2017[76] Nigeria	Gentamicin	Unknown	Private pharmacy	USP	API content – HPLC-UV	0/14 (0%)
Fatima, 2017[77] Pakistan	Metronidazole	Unknown	Unknown	USP	Disintegration, dissolution, tablet hardness, mass uniformity, tablet thickness and diameter	2/3 (66.7%)
Alyahawi, 2018[78] Yemen	Ciprofloxacin	Unknown	Private pharmacy	BP, USP	API content - UV spectrophotometry, disintegration, dissolution, friability Roche friabilator, tablet hardness, mass uniformity	0/5 (0%)
Hasin, 2018[79] Bangladesh	Cefuroxime	Unknown	Private pharmacy	BP	API content – HPLC, disintegration, dissolution, friability, tablet hardness, mass uniformity, tablet thickness and diameter	0/3 (0%)
Gogoi, 2018[80] India	Ciprofloxacin	Unknown	Private pharmacy	Indian Pharmacopeia	API content and identification – HPLC, dissolution, mass uniformity	0/2 (0%)
Shaibu, 2018[81] Nigeria	Ciprofloxacin	Unknown	Private pharmacy	BP	API content – UV/Visible - Spectrophotometry, disintegration, friability, impurity, mass uniformity	3/20 (15.0%)
Thamer, 2018[82] Iraq	Cefotaxime	Cefotaxime LDP, Cefotaxime LG, Fortax, Kon-SEFATAX, Loraxime 1000	Private pharmacy	USP	API content – HPLC, API identification – NIR, impurity, pH, physical appearance	0/5 (0%)
Obarisiagbon, 2018[83] Nigeria	Erythromycin	Althrocin-S 500, Donythrocin-500, Enthrox-500, Erotab-500, Eryfast-500 Erythromycin, Erymycin,	Unknown	USP	Disintegration, dissolution, friability, tablet hardness, mass uniformity	5/12 (41.7%)

Reference / country of collection	Active pharmaceutical ingredient (s) (API)	Brand name	Outlet	Reference standard	Test(s) performed and analytical technique for API content/Impurities	Failure rate n/N (%)
		Erythrocin-500, Erythromycin, Erythromycin 500mg, Icethrocin, Labcin-500, Rycin Erythromycin, Zin zine				
Thambavita, 2018[84] Sri Lanka	Metronidazole	Flagyl, Metrogyl	Private pharmacy	BP, USP	API content and Identification- UV-Vis Spectrophotometry disintegration, dissolution, tablet hardness, mass uniformity	0/2 (0%)
Ukwueze, 2018[85] Nigeria	Azithromycin	Unknown	Private pharmacy	BP, USP	API content – UV/Visible spectrophotometry, disintegration, dissolution, friability, tablet hardness, mass uniformity	1/9 (11.1%)
Igboasoiiyi, 2018[86] Nigeria	Ciprofloxacin	Unknown	Private pharmacy	BP USP	API content – Titrimetry and UV/Visible spectrophotometry, disintegration, dissolution, friability, tablet hardness, mass uniformity	3/10 (30.0%)
Rafiq, 2018[87] Pakistan	Ofloxacin, Ciprofloxacin	Unknown	Government outlet, Private pharmacy	BP, USP	Disintegration, dissolution-UV/Visible spectrophotometer, friability, tablet hardness, thickness, mass uniformity	0/4 (0%)
Ogochukwu, 2018[88] Nigeria	Azithromycin Clarithromycin	Klabax, Zithromax, Unknown	Private pharmacy	USP	API content – microbiological assay and UV Spectrophotometry, disintegration, dissolution, friability, tablet hardness	0/9 (0%)
Bagbi, 2018[89] Nigeria	Cefuroxime	Axacef, Donacef-500, Kadnat, Microcef-500, Sefzital, Spizef, Zinnat	Private pharmacy	BP USP	API content – UV/Visible spectrophotometry, disintegration, dissolution, friability, tablet hardness, mass uniformity	3/7 (42.9%)
Anah, 2019[90] Nigeria	Ciprofloxacin	Unknown	Private pharmacy	BP USP	API content – Titrimetry and UV spectrophotometry, disintegration, dissolution, friability, tablet hardness, mass uniformity	11/15 (73.3%)

Reference / country of collection	Active pharmaceutical ingredient (s) (API)	Brand name	Outlet	Reference standard	Test(s) performed and analytical technique for API content/Impurities	Failure rate n/N (%)
Avianto, 2019[91] Indonesia	Amoxicillin	Unknown	Hospital/Health centres	Indonesia Pharmacopoeia (Farmakope Indonesia)	API content - microbiological assay	0/5 (0%)
Pereira dos Anjos, 2019[92] Brazil	Amoxicillin, Azithromycin	Unknown	Government outlets - others	Unknown/Not specified	Impurities - LC-MS	1/2 (50.0%)
Rahman, 2019[93] Bangladesh	Ciprofloxacin	Unknown	Private pharmacy	BP, USP	API content - UV spectrophotometry, disintegration, dissolution, tablet hardness, mass uniformity	0/5 (0%)
Shah, 2019[94] Pakistan	Moxifloxacin	Unknown	Private pharmacy	BP, USP	API content – HPLC, disintegration, dissolution, friability, tablet hardness, mass uniformity	0/5 (0%)
Sharif, 2019[95] Pakistan	Azithromycin	Azomin, Ery-Pack, Unknown	Unknown	Unknown/Not specified	API content - Ouchterlony Double Immune Diffusion Technique	1/3 (33.3%)
Uwambajineza, 2019[96] Rwanda	Amoxicillin, Metronidazole	Unknown	Unknown	USP	Disintegration, dissolution, friability, HPLC-DAD, visual inspection, mass uniformity	1/14 (7.1%)
Hambisa, 2019[97] Ethiopia	Norfloxacin	Asnor, GyraBlock, Negaflox, Norbek, Norcin, Norfen, Norflox, Trizolin, Uriflox	Hospital/ Health centres, Private pharmacy	USP	API content – HPLC, dissolution, friability, tablet hardness, mass uniformity	2/9 (22.2%)
Agudelo, 2019[98] Columbia	Imipenem plus cilastatin	Inem, Tienam	Private pharmacy	USP	API content – HPLC-UV and microbiological assay	1/2 (50.0%)
Badulla, 2020[99] Yemen	Ciprofloxacin	Unknown	Unknown	BP	API content - Spectrophotometry-no detail	0/9 (0%)
Desta, 2020[100] Ethiopia	Ciprofloxacin	Unknown	Private pharmacy	USP	API content – HPLC, disintegration, dissolution - UV-visible spectrophotometer, mass uniformity	0/6 (0%)

Reference / country of collection	Active pharmaceutical ingredient (s) (API)	Brand name	Outlet	Reference standard	Test(s) performed and analytical technique for API content/Impurities	Failure rate n/N (%)
Hobeika, 2020[101] Lebanon	Amoxicillin, Amoxicillin-Clavulanic acid, Ciprofloxacin	Unknown	Private Pharmacy	USP	API content - HPLC	6/13 (46.2%)
Leficho, 2020[102] Ethiopia	Doxycycline	Doxy denk, Doxycad, Doxycap, Doxylagap, Doxyleb, Epadoxine, Medomycin, Miraclin, Remycin 100, Teradoxin	Private pharmacy	USP	API content and identification - HPLC, dissolution, friability, tablet hardness, visual inspection, mass uniformity	3/10 (30.0%)
Oli, 2020[103] Nigeria	Ciprofloxacin, Metronidazole	Unknown	Private pharmacy	BP	API content - UV-visible spectrophotometry, particulate matter, pH, sterility	12/16 (75.0%)
Rahman, 2020[104] Bangladesh	Metronidazole	Antipro, D-Metro, Filmet, Flagyl, Metryl	Combination of outlets	USP	API content - UV-visible spectrophotometry, disintegration, dissolution, friability, mass uniformity, size variability, tablet hardness, tablet thickness	0/5 (0%)
Tolentino-Hernandez, 2020[105] Mexico	Ciprofloxacin	Cipro XR, Ciproflox DM	Unknown	European Medicines Agency	API content - HPLC	0/2 (0%)
Note: FTIR - Fourier Transform Infrared Spectrometry, HPLC – High performance liquid chromatography, IR – infrared spectroscopy, LC – DAD - Liquid chromatography-diode array detection, NIR – near-infrared spectroscopy, TLC – Thin liquid chromatography, UHPLC – Ultra high-performance liquid chromatography, UV-MS – UV mass spectrometry						

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