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Analysis of antibiotic use patterns in Danish hospitals 2015–2021 using an adapted version of the who aware classification

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ABSTRACT

Background AWaRe is a tool to categorise and guide antibiotic use. Antibiotics are classified in three groups: Access, Watch and Reserve. The Access group contains first choice antibiotics for 25 of the most common infections. Antibiotics in the Watch and Reserve groups should be restricted to cases that cannot be effectively treated with drugs from the Access group.

Objectives The primary aim of this study was to evaluate and adapt the WHO 2019 AWaRe classification for use with antibiotic usage data in Danish hospitals. The secondary aim was to study the usefulness of the abxaware; software package for visualisation and analysis of temporal trends in antibiotic use patterns.

Methods We obtained data on purchases of antibiotics in Danish hospitals from January 2015 to July 2021. Sixty-seven unique drugs had been purchased. To better correspond with Danish guidelines, we moved two drugs one AWaRe level upwards. To help aggregate antibiotics according to AWaRe and visualise use patterns, we developed an R package, abxaware.

Results After adding two drugs that were not included in the original AWaRe classification nearly all antibiotics (>99%) used in Danish hospitals were covered. The abxaware software package for R is a useful tool to help aggregate, visualise and analyse antibiotic use patterns.

Conclusions With minor modifications, we adapted the AWaRe classification to cover most antibiotics used in Danish hospitals and to reflect Danish treatment guidelines. The abxaware package is a useful tool to aggregate and plot antibiotic usage data according to the AWaRe classification and to test for non-random variation in the percentage use of Access antibiotics.

INTRODUCTION

Antimicrobial resistance is a major and increasing problem worldwide. A key driver is inappropriate use of antibiotics in healthcare. This connection is important because antimicrobial resistance in turn leads to insufficient treatment options for patients with severe infections. For this reason, antimicrobial resistance is considered 'one of the biggest threats to global health, food security and development today'.[1]

From experience, we know that monitoring and reporting antibiotic use may help the implementation of treatment guidelines. Frequent reporting of antibiotic usage data to clinicians, infection control personnel, pharmacists and managers helps to discover inappropriate use of antibiotics and to document the effect of antibiotic stewardship programmes. However, little agreement exists on how to best categorise, aggregate and report antibiotic usage data for surveillance purposes.

AWaRe is a tool developed by the WHO 'to help countries improve antibiotic treatment, increase access and reduce resistance'.[2] AWaRe was introduced in 2017 as a new categorisation of antibiotics to guide prescriptions and treatment while monitoring consumption.[3] The current (as of September 2021) version was published in 2019.[4 5] The three categories are:

1. Access which indicates the antibiotic of choice for each of the 25 most common infections. These antibiotics should be available at all times, affordable and quality-assured.
2. Watch which includes most of the highest-priority critically important antimicrobials for human medicine and veterinary use. These antibiotics are recommended only for specific, limited indications.
3. Reserve antibiotics that should only be used as a last resort when all other antibiotics have failed.

It is a general recommendation to use narrow spectrum antibiotics whenever possible. WHO suggests that countries should increase the proportion of Access antibiotics to correspond to at least 60% of total national consumption (primary and secondary care).

Several studies have published AWaRe data comparing antibiotic use between and within countries.[3 6–13]

Some studies report temporal trends in AWaRe data using point-to-point comparisons or linear regression analysis.[7–9 11–14] However, these methods assume that data are trending linearly over time, which is unknowable in advance. Changing trends, cyclic patterns and transient shifts will likely be overlooked while sudden shifts risk being interpreted as gradual changes.[15] For these reasons, point-to-point comparisons and regression analysis are unsuitable for the study of temporal patterns in time series data.

Runs analysis comprise tests for non-random variation in data sequences and has been described in detail previously.[16] Runs analysis is a suitable method for detection of any type of non-random pattern in data over time.

We identified the need for simple tools to visualise not only the proportional use of antibiotics but also temporal trends in antibiotic use patterns and to help discriminate between random fluctuations and significant, non-random shifts and trends in data over time. For this purpose, we developed an R package, abxaware, to aggregate, visualise and analyse AWaRe data.[17]

The primary aim of this study was to evaluate and adapt the WHO 2019 AWaRe classification for use with antibiotic usage data in Danish hospitals.

The secondary aim was to study the usefulness of the abxaware software package for visualisation and analysis of temporal trends in antibiotic use patterns.

MATERIALS AND METHODS

Since no reliable common source for the actual use of antibiotics in Danish hospitals exists, we used data on antibiotic purchase as a proxy for use.

Data source and manipulation

Data on drugs purchased by Danish hospital pharmacies are continuously collected by Amgros I/S,[18] an organisation owned by the Danish Regions[19] and responsible for ensuring supplies of medicines to public Danish hospitals.

For the purpose of this study, Amgros supplied data on purchase of medicines with an Anatomical Therapeutic Chemical (ATC) code starting with 'J01' (antibacterials for systemic use) from somatic public hospitals in Denmark

Table 1 Hospital names, abbreviations and key characteristics of public Danish hospitals 2020

Region	Hospital	Abbreviation	Beds	Onkology/haematology	Notes
Hovedstaden	Amager og Hvidovre Hospital	AHH	640		
Hovedstaden	Bispebjerg og Frederiksberg Hospitaler	BFH	463		
Hovedstaden	Bornholms Hospital	BoH	89		
Hovedstaden	Herlev og Gentofte Hospital	HGH	947	X	
Hovedstaden	Hospitalerne i Nordsjælland	NoH	606	X	
Hovedstaden	Rigshospitalet	RH	1271	X	National referral hospital
Midtjylland	Aarhus Universitetshospital	AaU	855	X	Regional referral hospital
Midtjylland	Hospitalsenhed Midt	HeM	482		
Midtjylland	Hospitalsenheden Vest	HeV	393	X	
Midtjylland	Regionshospitalet Horsens	RgH	210		
Midtjylland	Regionshospitalet Randers	RgR	217		
Nordjylland	Aalborg Universitetshospital	AUH	682	X	Regional referral hospital
Nordjylland	Aalborg Universitetshospital, Thisted	AUT	65		
Nordjylland	Regionshospital Nordjylland Ven	RgN	240		
Sjælland	Region Sjællands Sygehusvæsen	SjS	2011	X	One managerial hospital unit covers all regional hospital sub-units
Syddanmark	Kolding Sygehus	KoS	312		
Syddanmark	OUH Odense Universitetshospital	OUH	972	X	Regional referral hospital
Syddanmark	Sydvestjysk Sygehus	SvJ	366	X	
Syddanmark	Sygehus Sønderjylland	Ssoe	318	X	
Syddanmark	Vejle Sygehus	VejS	274	X	

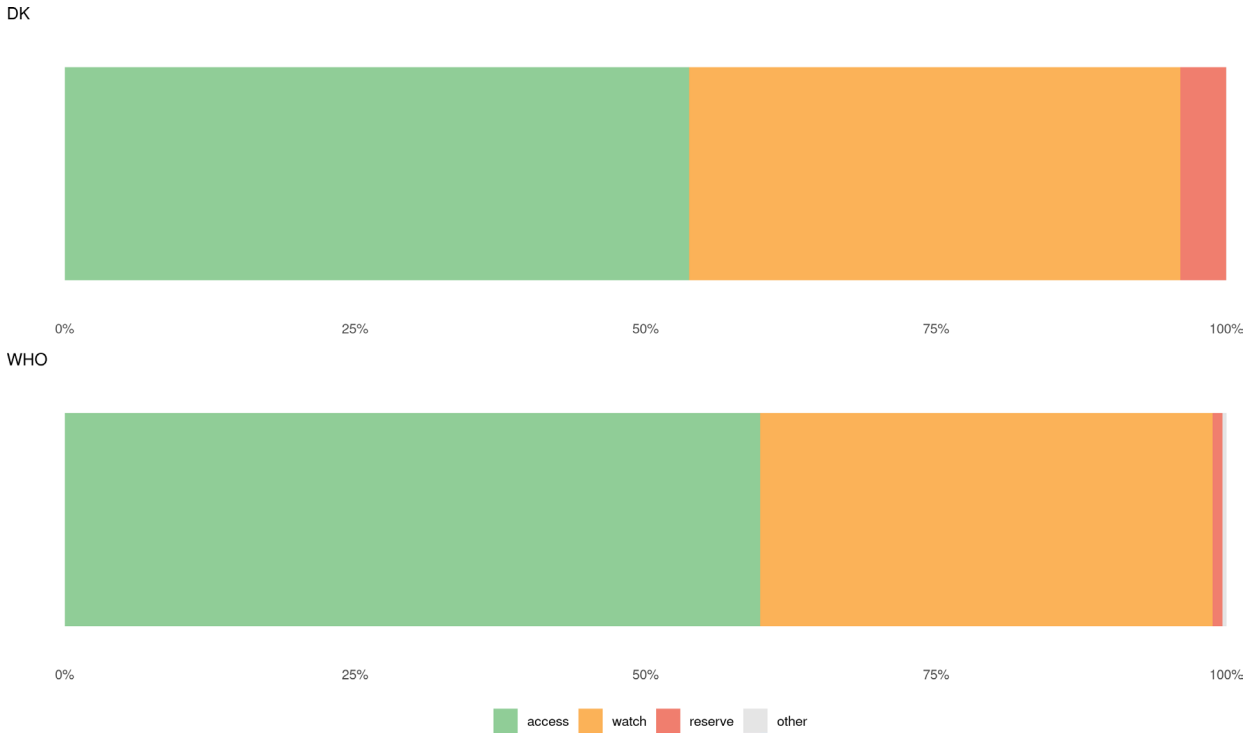

Figure 1 Relative use of antibiotics 2015–2021 in Danish hospitals by AWaRe group. DK, AWaRe adapted to Danish guidelines; WHO, original WHO AWaRe classification.

from the period January 2015 to July 2021. Somatic public hospitals account for approximately 98% of the total hospital consumption of antibiotics in Denmark.[20] Data were structured with one row per purchase with variables identifying: date, hospital/department, drug name, ATC code and amount in defined daily doses (DDD).

Data were cleaned and aggregated using the R programming language V.4.1.1[21] with functions from the add-on package dplyr V.1.0.7.[22] The resulting dataset contained monthly DDDs of 67 unique antibiotics from 20 hospitals from January 2015 to July 2021. No patient identifiable data were collected. Select information on the hospitals is presented in table 1.

The AWaRe classification

We made two adaptations to the WHO AWaRe classification to correspond better to Danish treatment guidelines:

1. Two drugs were moved up one level: amoxicillin and beta-lactamase inhibitor from Access to Watch and meropenem from Watch to Reserve.
2. We added two drugs, sulfapyridine and sulfadiazine that are unclassified by WHO to the the Access group in order to cover almost all antibiotics used in Danish hospitals.

To make data management as simple and transparent as possible, we picked the 'highest' AWaRe class (Reserve) for two drugs, minocycline and fosfomycin, where the WHO AWaRe category depends on the route of administration. A complete list of antibiotics and their corresponding AWaRe classification (including unclassified drugs) is available as online supplemental file 1.

Visualising AWaRe usage data and testing for non-random patterns in data over time

By default, the plot function in abxaware produces a horizontal bar chart of the proportional use of antibiotics in the three AWaRe groups (figure 1). If a time variable is supplied, a time series graph is produced (figure 2). And with a unit variable, the plot is split into facets to facilitate comparison between organisational units (figure 3).

In addition, with time series plots, the median Access group proportion is plotted as a horizontal line. The line will be dashed if non-random—variation suggesting significant changes—in the proportion of Access antibiotics over time is present. Non-random variation is identified by runs analysis.

Runs analysis checks for patterns (runs) in data that are unlikely to result from random variation alone. abxaware uses two tests for (1) unusually long runs of data points on the same side of the median and (2) unusually few crossings of the median. If either of these tests is positive, it is indicative of non-random variation. The limits for 'unusually' long and few depend on the number of available data points and can be calculated or looked up in a statistical table as explained by Anhøj and Olesen.[16]

RESULTS

After adding two drugs to the WHO AWaRe classification, all antibiotics purchased for Danish hospitals were covered except for two drugs with incomplete ATC codes

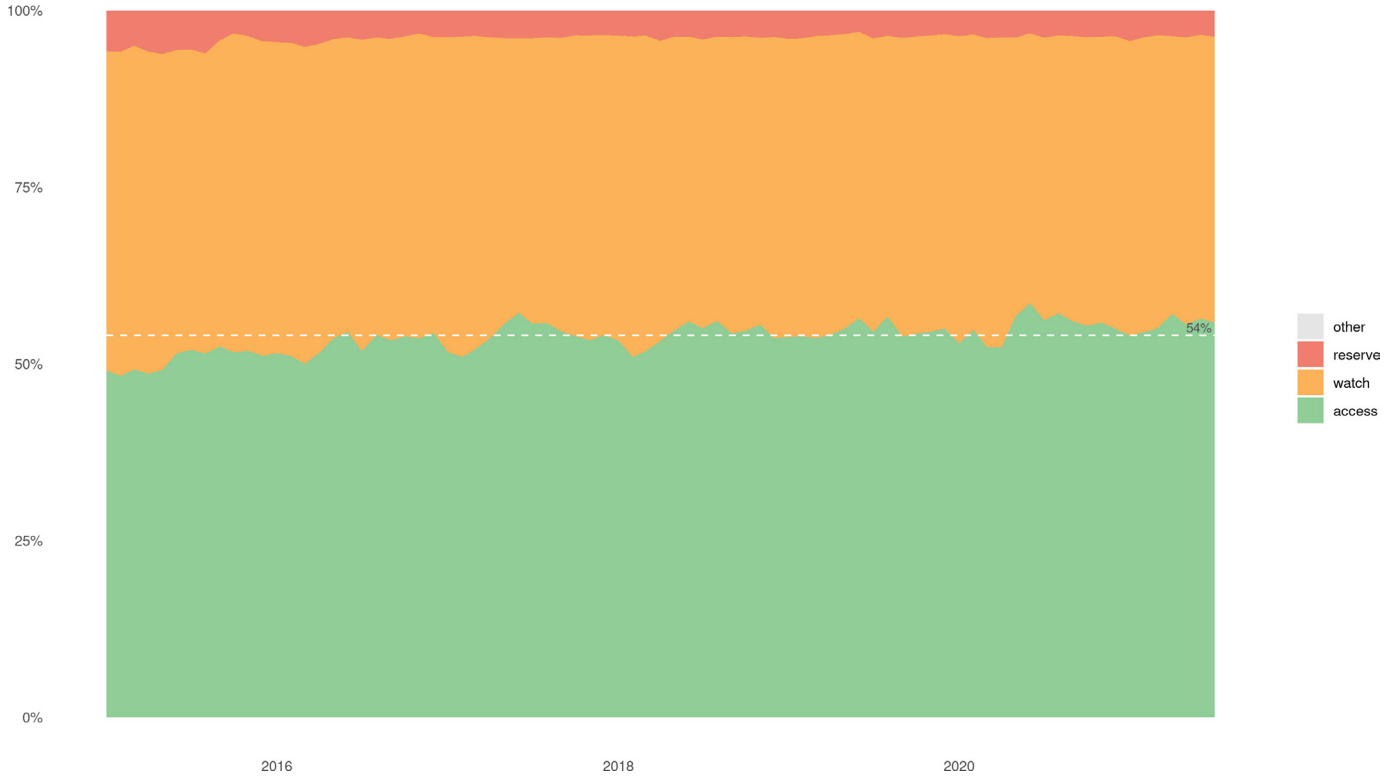

Figure 2 Antibiotic use in Danish hospitals by adapted AWaRe group and month.

(J01R: combinations of antibacterials and J01DI: other cephalosporins and penems), which had been used very little.

In total, 67 unique antibiotics had been used in Danish hospitals in the period January 2015 to July 2021 (table 2).

Figure 1 shows antibiotic use data aggregated for all public hospitals in Denmark during the period January 2015 to July 2021. The upper figure shows data aggregated by AWaRe adapted to Danish guidelines, while the lower figure shows data aggregated by the original WHO classification. As expected, our adaptation is stricter than the original having fewer drug classified in the Access group and more in the Watch and Reserve groups. Also, in our classification, fewer drugs are classified as 'other' leaving less than 0.01% in the other group.

In figure 2, a time variable, month, has been added to produce a time series plot. The white horizontal line indicates the median use of Access antibiotics over time. The line is dashed because the runs analysis suggests that there is non-random variation in data over time. As judged by eye, the Access proportion has been trending steadily over time from below 50% to around 55%. This is offset mainly by decreased use of Reserve antibiotics.

DISCUSSION

We adapted and applied the WHO AWaRe classification of antibiotics to purchase data from public Danish hospitals.

After adding two drugs that are missing from the current WHO classification, our classification covered all antibiotics used in Danish hospitals in the period January 2015 to July 2021 (except drugs with incomplete ATC codes).

To better reflect Danish treatment guidelines, we moved two drugs up one level, which resulted in a more 'stricter' classification with less use of Access antibiotics compared with the WHO classification.

Overall, at the national level, we found a steady increase in use of Access antibiotics over time. The same pattern was present in hospital data, although more variation in use patterns was observed at the hospital level (figure 3).

In addition, we found that the abxaware package for R is a useful tool to aggregate and plot antibiotic usage data according to the AWaRe classification and to test for non-random variation in the percentage use of Access antibiotics. We refer to the abxaware package vignette for detailed instructions and examples of its use.[23]

It is outside the scope of this study to try to explain and interpret the observed trends in antibiotic use patterns at the national and hospital level. But we consider the overall increased use of Access antibiotics a positive thing and a deliberate result of many national and regional initiatives to optimise antibiotic use patterns in Danish hospitals over the years.[24]

Our study has several strengths:

First, data from hospitals and departments across Denmark had been collected by the same automated processes over many years, which ensured a high degree of completeness, comparability and reproducibility.

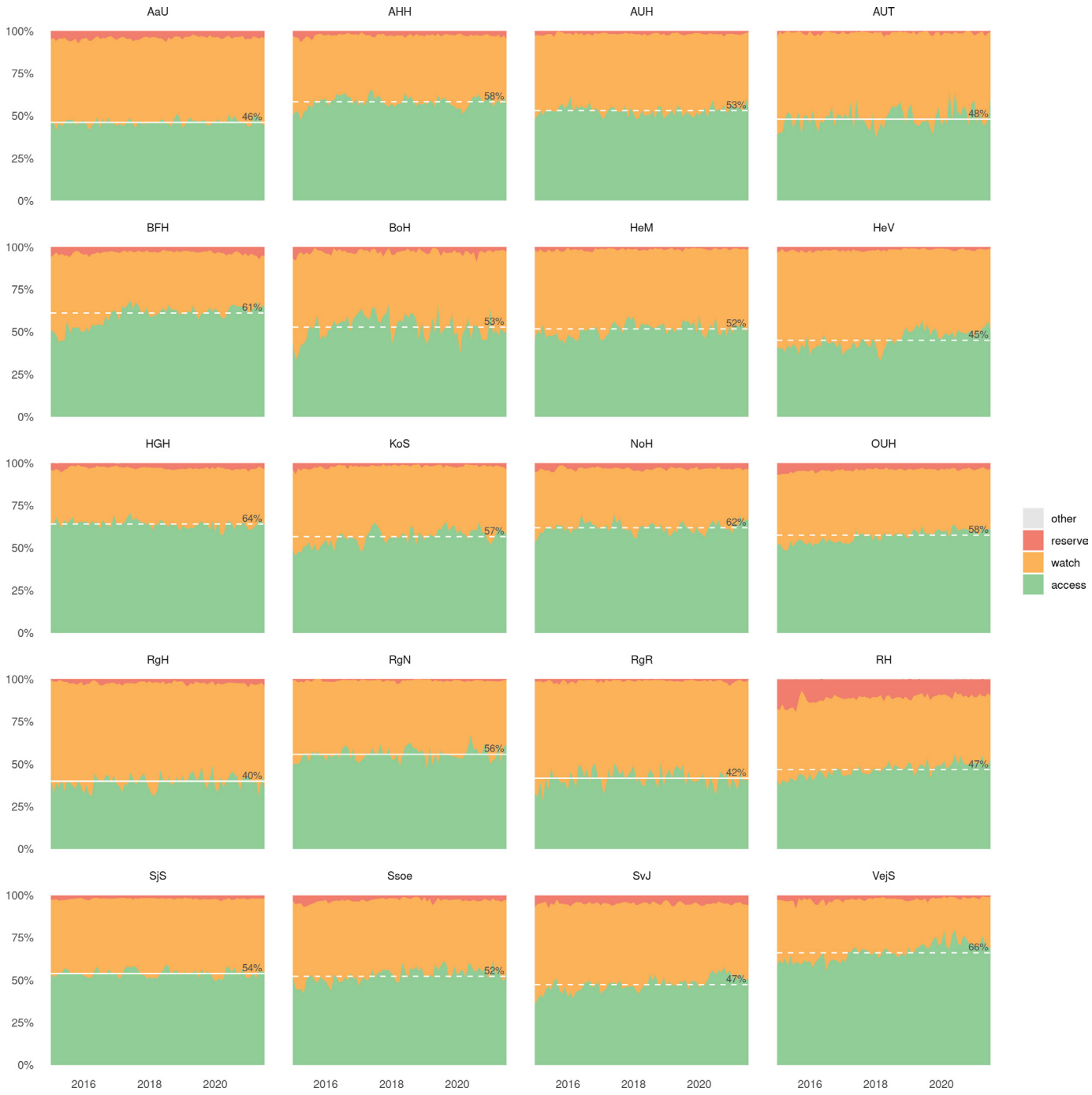

Figure 3 Shows data over time split by hospital. See table 1 for hospital characteristics and abbreviations. In most hospitals, there is non-random variation in the Access proportion mostly in the form of a relatively steady upwards trend. But in some hospitals (eg, VejS) data seem to shift in a stepwise fashion. In a few hospitals (eg, BoH) data seem to exhibit a cyclic pattern. BoH, Bornholms Hospital; VejS, Vejle Sygehus.

Second, the abxaware package makes data aggregation and visualisation easy, provided structured data are available. And the visualisation includes visual clues to the presence or absence of non-random variation in Access proportion over time, which helps to avoid overinterpretation of insignificant fluctuations in data when only random variation is present or overlooking non-random variation caused by significant trends or shifts in data over time.

Finally, data keep coming, which makes establishing continuous, real-time surveillance feasible, should someone want this. Source data are updated at the beginning of each month, and data cleaning, aggregation and visualisation can be automated using R (or any other programming language) and the abxaware package.

Some limitations should be noted:

First, we used purchase data as a proxy for antibiotic consumption. Two problems may arise from purchase

Table 2 Total use of antibiotics in public Danish hospitals August 2020–July 2021 and the corresponding WHO and DK AWaRe classification

ATC	Drug	DDD	WHO	DK
J01AA02	Doxycycline	85 844	Access	Access
J01AA04	Lymecycline	395	Watch	Watch
J01AA07	Tetracycline	6210	Access	Access
J01AA08	Minocycline	700	Reserve	Reserve
J01AA12	Tigecycline	928	Reserve	Reserve
J01CA01	Ampicillin	37 742	Access	Access
J01CA02	Pivampicillin	9855	Access	Access
J01CA04	Amoxicillin	99 582	Access	Access
J01CA08	Pivmecillinam	483 330	Access	Access
J01CA11	Mecillinam	16 910	Access	Access
J01CE01	Benzylpenicillin	148 482	Access	Access
J01CE02	Phenoxymethylpenicillin	195 004	Access	Access
J01CE08	Benzathine benzylpenicillin	569	Access	Access
J01CF01	Dicloxacillin	207 289	Access	Access
J01CF02	Cloxacillin	232 923	Access	Access
J01CF05	Flucloxacillin	3168	Access	Access
J01CR02	Amoxicillin and beta-lactamase inhibitor	238 147	Access	Watch
J01CR05	Piperacillin and beta-lactamase inhibitor	466 319	Watch	Watch
J01DB01	Cefalexin	1230	Access	Access
J01DB04	Cefazolin	73	Access	Access
J01DC01	Cefoxitin	276	Watch	Watch
J01DC02	Cefuroxime	279 656	Watch	Watch
J01DD01	Cefotaxime	3664	Watch	Watch
J01DD02	Ceftazidime	5171	Watch	Watch
J01DD04	Ceftriaxone	33 713	Watch	Watch
J01DD52	Ceftazidime and beta-lactamase inhibitor	956	Reserve	Reserve
J01DE01	Cefepime	552	Watch	Watch
J01DF01	Aztreonam	240	Reserve	Reserve
J01DH02	Meropenem	104 524	Watch	Reserve
J01DH03	Ertapenem	2285	Watch	Watch
J01DH51	Imipenem and cilastatin	1027	Watch	Watch
J01DI	Other cephalosporins and penems in atc	63		
J01DI54	Ceftolozane and beta-lactamase inhibitor	509	Reserve	Reserve
J01EA01	Trimethoprim	16 528	Access	Access
J01EB02	Sulfamethizole	2373	Access	Access
J01EB04	Sulfapyridine	18		Access
J01EC02	Sulfadiazine	12 292		Access
J01EE01	Sulfamethoxazole and trimethoprim	268 430	Access	Access
J01FA01	Erythromycin	12 237	Watch	Watch
J01FA02	Spiramycin	50	Watch	Watch
J01FA06	Roxithromycin	13 200	Watch	Watch
J01FA09	Clarithromycin	94 990	Watch	Watch
J01FA10	Azithromycin	52 113	Watch	Watch
J01FF01	Clindamycin	23 576	Access	Access

Continued

Table 2 Continued

ATC	Drug	DDD	WHO	DK
J01FG01	Pristinamycin	345	Watch	Watch
J01GB01	Tobramycin	13359	Watch	Watch
J01GB03	Gentamicin	73477	Access	Access
J01GB06	Amikacin	2084	Access	Access
J01MA02	Ciprofloxacin	169410	Watch	Watch
J01MA12	Levofloxacin	39746	Watch	Watch
J01MA14	Moxifloxacin	42318	Watch	Watch
J01R	Combinations of antibacterials	185		
J01XA01	Vancomycin	51385	Watch	Watch
J01XA02	Teicoplanin	1127	Watch	Watch
J01XA04	Dalbavancin	33	Reserve	Reserve
J01XB01	Colistin	7719	Reserve	Reserve
J01XC01	Fusidic acid	1370	Watch	Watch
J01XD01	Metronidazole	144814	Access	Access
J01XE01	Nitrofurantoin	12249	Access	Access
J01X×01	Fosfomycin	148	Reserve	Reserve
J01X×08	Linezolid	17340	Reserve	Reserve
J01X×09	Daptomycin	4655	Reserve	Reserve

ATC, Anatomical Therapeutic Chemical; DDD, defined daily doses.

data: First, data may be 'chunky'. If, for example, one buys a large amount of a specific drug, this may last for longer than the inventory period creating peaks and valleys in time series plots that are not related to actual consumption. Second, the amount purchased will, due to spillage and partial use of packages, inevitably be larger than what is actually used.

However, from experience and previous studies,[25] we knew that as long as the organisational units of interest are big enough and the inventory periods long enough, purchase and consumption are tightly coupled, and since we did not aggregate below hospital and AWaRe level, chunky data were not a concern. Also, since we were only looking at the proportional use of antibiotics, accurate consumption data were not important as long as use patterns were preserved.

Second, our modifications to the AWaRe classification are entirely our own and should be considered suggestions for future discussion between subject matter experts in Danish healthcare.

It should also be noted that runs analysis for detection of non-random variation in time series data is a wast area and several approaches exist. They are, however, all based on the same core principles for the detection of non-random patterns in data sequences. We chose to apply the tests suggested by Anhøj and Olesen,[16] which have proven reliable and robust over many years of use and have recently been thoroughly validated.[26 27]

It is also important to stress that runs analysis in itself is unable to determine the causes, direction and significance of non-random variation. The presence of non-random variation is simply a signal that the process in question is changing over time—for better or worse—and that further analysis including visual inspection and interpretation by subject matter experts is needed.

Finally, one should keep in mind that while the AWaRe classification is well suited for high-level aggregation and surveillance of antibiotic usage data it does not suffice as a basis for targeted interventions at the local level. For this purpose, one must apply a much more detailed look at specific antibiotic use patterns (preferably consumption) at the site of intervention. However, this is not a limitation of our study in particular but applies to the AWaRe principle in general.

It is also important to stress that while surveillance of antibiotic use is an important prerequisite for antibiotic stewardship, surveillance in itself does not ensure optimal use of antibiotics. The optimal antibiotic use pattern depends on local context and must be tailored to the patient casemix and microbial environment.

In conclusion, we have demonstrated that, with minor modifications, the WHO AWaRe classification of antibiotics is useful for monitoring antibiotic use patterns in Danish hospitals and that runs analysis of Access proportion is useful for detection of non-random variation in use patterns over time.

In addition, we developed and tested a freely available open source software package that makes aggregating, plotting and analysing antibiotic usage data easy and reproducible.

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Contributors JA designed the study, wrote the draft manuscript, performed the statistitical analyses, and contributed to the development of the software package. JB contributed to the writing of the manuscript and contributed to the development of the software package. All other authors contributed to the writing of the manuscript.

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Antibiotics classified according to AWaRe

atc	generic_name	aware_who	aware_dk
J01	ANTIBACTERIALS FOR SYSTEMIC USE		
J01A	TETRACYCLINE ANTIBIOTICS		
J01AA	Tetracyclines		
J01AA01	demeclocycline		
J01AA02	doxycycline	access	access
J01AA03	chlortetracycline	watch	watch
J01AA04	lymecycline	watch	watch
J01AA05	metacycline	watch	watch
J01AA06	oxytetracycline	watch	watch
J01AA07	tetracycline	access	access
J01AA08	minocycline	reserve	reserve
J01AA09	rolitetracycline		
J01AA10	penimepicycline		
J01AA11	clomocycline		
J01AA12	tigecycline	reserve	reserve
J01AA13	eravacycline	reserve	reserve
J01AA14	sarecycline		
J01AA15	omadacycline		
J01AA20	combinations of tetracyclines		
J01AA56	oxytetracycline, combinations		
J01B	AMPHENICOLS		
J01BA	Amphenicol antibacterials, systemic		
J01BA01	chloramphenicol	access	access
J01BA02	thiamphenicol	access	access
J01BA52	thiamphenicol, combinations		
J01C	BETA-LACTAM ANTIBACTERIALS, PENICILLINS		
J01CA	Penicillins with extended spectrum		
J01CA01	ampicillin	access	access
J01CA02	pivampicillin	access	access
J01CA03	carbenicillin	watch	watch
J01CA04	amoxicillin	access	access
J01CA05	carindacillin		
J01CA06	bacampicillin	access	access
J01CA07	epicillin		
J01CA08	pivmecillinam	access	access
J01CA09	azlocillin	watch	watch
J01CA10	mezlocillin	watch	watch
J01CA11	mecillinam	access	access
J01CA12	piperacillin	watch	watch
J01CA13	ticarcillin	watch	watch
J01CA14	metampicillin		
J01CA15	talampicillin		
J01CA16	sulbenicillin	watch	watch
J01CA17	temocillin	watch	watch
J01CA18	hetacillin		
J01CA19	aspoxicillin		
J01CA20	penicillins with extended spectrum combinations		
J01CA51	ampicillin, combinations		
J01CE	Beta-lactamase sensitive penicillins		
J01CE01	benzylpenicillin	access	access
J01CE02	phenoxymethylpenicillin	access	access
J01CE03	propicillin		
J01CE04	azidocillin		
J01CE05	pheneticillin	watch	watch
J01CE06	penamecillin	access	access
J01CE07	clometocillin	access	access
J01CE08	benzathine benzylpenicillin	access	access
J01CE09	procaine benzylpenicillin	access	access
J01CE10	benzathine phenoxymethylpenicillin		

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Antibiotics classified according to AWaRe

atc	generic_name	aware_who	aware_dk
J01CE30	beta-lactamase sensitive penicillin combinations		
J01CF	Beta-lactamase resistant penicillins		
J01CF01	dicloxacillin	access	access
J01CF02	cloxacillin	access	access
J01CF03	meticillin		
J01CF04	oxacillin	access	access
J01CF05	flucloxacillin	access	access
J01CF06	nafcillin	access	access
J01CG	Beta-lactamase inhibitors, systemic penicillins		
J01CG01	sulbactam		
J01CG02	tazobactam		
J01CR	Combinations of penicillins, incl. beta-lactamase inhibitors		
J01CR01	ampicillin and beta-lactamase inhibitor	access	access
J01CR02	amoxicillin and beta-lactamase inhibitor	access	watch
J01CR03	ticarcillin and beta-lactamase inhibitor		
J01CR04	sultamicillin	access	access
J01CR05	piperacillin and beta-lactamase inhibitor	watch	watch
J01CR50	combinations of penicillins		
J01D	OTHER BETA-LACTAM ANTIBACTERIALS IN ATC		
J01DB	First-generation cephalosporins		
J01DB01	cefalexin	access	access
J01DB02	cefaloridine		
J01DB03	cefalotin	access	access
J01DB04	cefazolin	access	access
J01DB05	cefadroxil	access	access
J01DB06	cefazedone	access	access
J01DB07	cefatrizine	access	access
J01DB08	cefapirin	access	access
J01DB09	cefradine	access	access
J01DB10	cefacetrile	access	access
J01DB11	cefroxadine	access	access
J01DB12	ceftezole	access	access
J01DC	Second-generation cephalosporins		
J01DC01	cefoxitin	watch	watch
J01DC02	cefuroxime	watch	watch
J01DC03	cefamandole	watch	watch
J01DC04	cefaclor	watch	watch
J01DC05	cefotetan	watch	watch
J01DC06	cefonicid	watch	watch
J01DC07	cefotiam	watch	watch
J01DC08	loracarbef		
J01DC09	cefmetazole	watch	watch
J01DC10	cefprozil	watch	watch
J01DC11	ceforanide	watch	watch
J01DC12	cefminox	watch	watch
J01DC13	cefbuperazone	watch	watch
J01DC14	flomoxef	watch	watch
J01DD	Third-generation cephalosporins		
J01DD01	cefotaxime	watch	watch
J01DD02	ceftazidime	watch	watch
J01DD03	cefsulodin		
J01DD04	ceftriaxone	watch	watch
J01DD05	cefmenoxime	watch	watch
J01DD06	latamoxef	watch	watch
J01DD07	ceftizoxime	watch	watch
J01DD08	cefixime	watch	watch
J01DD09	cefodizime	watch	watch
J01DD10	cefetamet	watch	watch
J01DD11	cefpiramide	watch	watch

Antibiotics classified according to AWaRe

atc	generic_name	aware_who	aware_dk
J01DD12	cefoperazone	watch	watch
J01DD13	cefpodoxime	watch	watch
J01DD14	ceftibuten	watch	watch
J01DD15	cefdinir	watch	watch
J01DD16	cefditoren	watch	watch
J01DD17	cefcapene	watch	watch
J01DD18	cefteram	watch	watch
J01DD51	cefotaxime and beta-lactamase inhibitor		
J01DD52	ceftazidime and beta-lactamase inhibitor	reserve	reserve
J01DD54	ceftriaxone, combinations		
J01DD62	cefoperazone and beta-lactamase inhibitor		
J01DD63	ceftriaxone and beta-lactamase inhibitor		
J01DD64	cefpodoxime and beta-lactamase inhibitor		
J01DE	Fourth-generation cephalosporins		
J01DE01	cefepime	watch	watch
J01DE02	cefpirome	watch	watch
J01DE03	cefozopran	watch	watch
J01DF	Monobactams		
J01DF01	aztreonam	reserve	reserve
J01DF02	carumonam		
J01DH	Carbapenems		
J01DH02	meropenem	watch	reserve
J01DH03	ertapenem	watch	watch
J01DH04	doripenem	watch	watch
J01DH05	biapenem	watch	watch
J01DH06	tebipenem pivoxil	watch	watch
J01DH51	imipenem and cilastatin	watch	watch
J01DH52	meropenem and vaborbactam	reserve	reserve
J01DH55	panipenem and betamipron		
J01DH56	imipenem, cilastatin and relebactam		
J01DI	Other cephalosporins and penems in atc		
J01DI01	ceftobiprole medocaril	reserve	reserve
J01DI02	ceftaroline fosamil	reserve	reserve
J01DI03	faropenem	reserve	reserve
J01DI04	cefiderocol		
J01DI54	ceftolozane and beta-lactamase inhibitor	reserve	reserve
J01E	SULFONAMIDES AND TRIMETHOPRIM ANTIBACTERIALS FOR SYSTEMIC USE		
J01EA	Trimethoprim and derivatives, systemic antibacterials		
J01EA01	trimethoprim	access	access
J01EA02	brodimoprim		
J01EA03	iclaprim		
J01EB	Short-acting sulfonamides		
J01EB01	sulfaisodimidine		
J01EB02	sulfamethizole	access	access
J01EB03	sulfadimidine		
J01EB04	sulfapyridine	access	
J01EB05	sulfafurazole		
J01EB06	sulfanilamide		
J01EB07	sulfathiazole		
J01EB08	sulfathiourea		
J01EB20	short-acting sulfonamide combinations		
J01EC	Intermediate-acting sulfonamides		
J01EC01	sulfamethoxazole		
J01EC02	sulfadiazine	access	
J01EC03	sulfamoxole		
J01EC20	intermediate-acting sulfonamide combinations		
J01ED	Long-acting sulfonamides		
J01ED01	sulfadimethoxine		
J01ED02	sulfalene		

Antibiotics classified according to AWaRe

atc	generic_name	aware_who	aware_dk
J01ED03	sulfametomidine		
J01ED04	sulfametoxydiazine		
J01ED05	sulfamethoxypyridazine		
J01ED06	sulfaperin		
J01ED07	sulfamerazine		
J01ED08	sulfaphenazole		
J01ED09	sulfamazone		
J01ED20	long-acting sulfonamide combinations		
J01EE	Combinations of sulfonamides and trimethoprim, incl. derivatives		
J01EE01	sulfamethoxazole and trimethoprim	access	access
J01EE02	sulfadiazine and trimethoprim	access	access
J01EE03	sulfametrole and trimethoprim	access	access
J01EE04	sulfamoxole and trimethoprim	access	access
J01EE05	sulfadimidine and trimethoprim		
J01EE06	sulfadiazine and tetroxoprim		
J01EE07	sulfamerazine and trimethoprim		
J01F	MACROLIDES, LINCOSAMIDES AND STREPTOGRAMINS		
J01FA	Macrolides		
J01FA01	erythromycin	watch	watch
J01FA02	spiramycin	watch	watch
J01FA03	midecamycin	watch	watch
J01FA05	oleandomycin	watch	watch
J01FA06	roxithromycin	watch	watch
J01FA07	josamycin	watch	watch
J01FA08	troleandomycin		
J01FA09	clarithromycin	watch	watch
J01FA10	azithromycin	watch	watch
J01FA11	miocamycin		
J01FA12	rokitamycin		
J01FA13	dirithromycin	watch	watch
J01FA14	flurithromycin		
J01FA15	telithromycin	watch	watch
J01FA16	solithromycin		
J01FF	Lincosamides		
J01FF01	clindamycin	access	access
J01FF02	lincomycin	watch	watch
J01FG	Streptogramins		
J01FG01	pristinamycin	watch	watch
J01FG02	quinupristin/dalfopristin	reserve	reserve
J01G	AMINOGLYCOSIDE ANTIBACTERIALS		
J01GA	Streptomycins		
J01GA01	streptomycin	watch	watch
J01GA02	streptoduocin		
J01GB	Other aminoglycosides in atc		
J01GB01	tobramycin	watch	watch
J01GB03	gentamicin	access	access
J01GB04	kanamycin	watch	watch
J01GB05	neomycin	watch	watch
J01GB06	amikacin	access	access
J01GB07	netilmicin	watch	watch
J01GB08	sisomicin	watch	watch
J01GB09	dibekacin	watch	watch
J01GB10	ribostamycin	watch	watch
J01GB11	isepamicin	watch	watch
J01GB12	arbekacin	watch	watch
J01GB13	bekanamycin		
J01GB14	plazomicin		
J01M	QUINOLONE ANTIBACTERIALS		
J01MA	Fluoroquinolone antibacterials, systemic		

Antibiotics classified according to AWaRe

atc	generic_name	aware_who	aware_dk
J01MA01	ofloxacin	watch	watch
J01MA02	ciprofloxacin	watch	watch
J01MA03	pefloxacin	watch	watch
J01MA04	enoxacin	watch	watch
J01MA05	temafloxacin		
J01MA06	norfloxacin	watch	watch
J01MA07	lomefloxacin	watch	watch
J01MA08	fleroxacin	watch	watch
J01MA09	sparfloxacin	watch	watch
J01MA10	rufloxacin	watch	watch
J01MA11	grepafloxacin		
J01MA12	levofloxacin	watch	watch
J01MA13	trovafloxacin		
J01MA14	moxifloxacin	watch	watch
J01MA15	gemifloxacin	watch	watch
J01MA16	gatifloxacin	watch	watch
J01MA17	prulifloxacin	watch	watch
J01MA18	pazufloxacin	watch	watch
J01MA19	garenoxacin	watch	watch
J01MA21	sitafloxacin	watch	watch
J01MA22	tosufloxacin	watch	watch
J01MA23	delafloxacin	watch	watch
J01MA24	levonadifloxacin		
J01MA25	lascufloxacin		
J01MB	Other quinolones in atc		
J01MB01	rosoxacin		
J01MB02	nalidixic acid		
J01MB03	piromidic acid		
J01MB04	pipemidic acid		
J01MB05	oxolinic acid		
J01MB06	cinoxacin		
J01MB07	flumequine	watch	watch
J01MB08	nemonoxacin		
J01R	COMBINATIONS OF ANTIBACTERIALS		
J01RA	Combinations of antibacterials		
J01RA01	penicillins, combinations with other antibacterials		
J01RA02	sulfonamides, combinations with other antibacterials (excl. trimethoprim)		
J01RA03	cefuroxime and metronidazole		
J01RA04	spiramycin and metronidazole	watch	watch
J01RA05	levofloxacin and ornidazole		
J01RA06	cefepime and amikacin		
J01RA07	azithromycin, fluconazole and secnidazole		
J01RA08	tetracycline and oleandomycin		
J01RA09	ofloxacin and ornidazole		
J01RA10	ciprofloxacin and metronidazole		
J01RA11	ciprofloxacin and tinidazole		
J01RA12	ciprofloxacin and ornidazole		
J01RA13	norfloxacin and tinidazole		
J01X	OTHER ANTIBACTERIALS IN ATC		
J01XA	Glycopeptide antibacterials		
J01XA01	vancomycin	watch	watch
J01XA02	teicoplanin	watch	watch
J01XA03	telavancin	reserve	reserve
J01XA04	dalbavancin	reserve	reserve
J01XA05	oritavancin	reserve	reserve
J01XB	Polymyxins		
J01XB01	colistin	reserve	reserve
J01XB02	polymyxin b	reserve	reserve
J01XC	Steroid antibacterials		

Antibiotics classified according to AWaRe

atc	generic_name	aware_who	aware_dk
J01XC01	fusidic acid	watch	watch
J01XD	Imidazole derivatives, antibacterial for systemic use		
J01XD01	metronidazole	access	access
J01XD02	tinidazole		
J01XD03	ornidazole		
J01XE	Nitrofuran derivatives, antibacterials for systemic use		
J01XE01	nitrofurantoin	access	access
J01XE02	nifurtoinol		
J01XE03	furazidin		
J01XE51	nitrofurantoin, combinations		
J01XX	Other antibacterials in atc		
J01XX01	fosfomycin	reserve	reserve
J01XX02	xibornol		
J01XX03	clofoctol	watch	watch
J01XX04	spectinomycin	access	access
J01XX05	methenamine		
J01XX06	mandelic acid		
J01XX07	nitroxoline		
J01XX08	linezolid	reserve	reserve
J01XX09	daptomycin	reserve	reserve
J01XX10	bacitracin		
J01XX11	tedizolid	reserve	reserve
J01XX12	lefamulin		

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