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## Recent initiatives in the Republic of Srpska to enhance appropriate use of antibiotics in ambulatory care; their influence and implications

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### Introduction

The discovery of antibiotics is one of the greatest discoveries of modern medicine. However, since their discovery, it is acknowledged that bacteria have the ability to become resistant to antibiotics if they are not used rationally (Md Rezal et al., 2015; Godman et al 2017). Excessive and non-rational use of antibiotics have resulted in increasing rates of antimicrobial resistance (AMR) worldwide, with ongoing initiatives to address this including addressing issues of governance (WHO, 2011; Collignon et al. 2015; WHO, 2015; Shallcross et al., 2015; Jinks et al, 2016). This is essential given the low number of new antibiotics in development; although there are activities to try and improve the situation (O'Neill, 2015; Tacconelli et al., 2017). Irrational use of antibiotics includes the prescribing and dispensing of antibiotics for upper respiratory tract infections (URTIs), which are the principal infections seen in ambulatory care and are predominantly viral in origin (Llor & Bjerrum, 2014; Dyar et al, 2016; Aabenhus et al., 2017). Inappropriate prescribing, as well as dispensing without a prescription, are enhanced by patient pressure, sub-optimal knowledge about antibiotics and viral infections among key stakeholder groups and fears among physicians and pharmacists that if they do not prescribe or dispense an antibiotic patients will go elsewhere (Jorgi et al, 2014; Yu et al, 2014; Hassali et al., 2015; Bai et al., 2016; Chang et al., 2017; Eslami et al., 2016; Kibuule et al. 2016).

The costs of AMR in Europe were estimated at €1.5 billion in 2007, but now rising to €9 billion per year or higher (Oxford & Kozlov, 2013; Gandra et al., 2014). The lack of new antibiotics alongside increasing AMR rates has resulted in increasing morbidity, mortality and costs to healthcare system (Aminov, 2010; Gandra et al., 2014; O'Neill, 2015). As a result, AMR is now seen as one of the biggest public health challenges (ECDC, 2016), with deaths due to resistant strains envisaged to

reach up to 444 million by 2050 if AMR is not addressed (Taylor et al., 2014; Fitchett & Atun, 2016). This is preventable with the spread of resistant strains directly correlated with increasing and irrational use of antibiotics (Costelloe et al., 2010; Bell et al., 2014; Llor & Bjerrum, 2014). Consequently, raising awareness and knowledge about AMR and rational antibiotic use among all key stakeholder groups should result in a reduction in AMR rates (Huttner et al., 2010; Md Rezal et al., 2015; Godman et al., 2017; WHO, 2018). We are already seeing multiple activities across Europe including former Soviet Union Republics to tackle concerns with current antibiotic use and this will continue (Huttner et al., 2010; Furst et al., 2015; Abilova et al., 2018; ECDC, 2018).

The Republic of Srpska is one of the two constituent entities of Bosnia and Herzegovina, with an estimated population of approximately 1.4 million. The Republic has implemented a range of laws and other activities over the years to regulate health care activities, which includes enhancing the appropriate use of medicines through initiatives including introducing good clinical practice guidelines (MoHSW 1999, 2008, 2009, 2010; PABH 2008; Petrusic & Jakovljevic, 2015). Activities have also been ongoing in other Balkan countries; however, there are concerns with the practice of evidence based medicine, the cost consciousness of physicians even after cost containment policies as well as the principles of resource allocation among physicians, although this is changing (Jakovljevic et al., 2016a; Jakovljevic et al., 2016b). There are also concerns with the level of co-payments among patients in the Balkan countries especially with high cost medicines; although this has not prevented pharmaceutical markets growing among the Balkan countries as seen in Bulgaria, Croatia, the Republic of Srpska and Serbia in recent years, including medicines for cardiovascular and respiratory diseases, cancer and depression (Putrik et al., 2014; Jakovljevic et al., 2015; Petrusic & Jakovljevic, 2015; Jakovljevic and Souliotis, 2016; Kostic et al., 2017; Pejic & Jakovljevic, 2017).

Policies and programmes to improve the health of patients with limited resources in the Republic of Srpska include improving the availability and affordability of medicines, improving antibiotic prescribing and dispensing, and raising awareness on excessive antibiotic utilization and resistance. A summary of these initiatives are contained in Boxes 1 and 2. The various activities have increased prescribing efficiency as well as enhanced prescribing in accordance with standard treatment guidelines, positively impacting on for instance the rate of polypharmacy in practice (Markovic-Pekovic et al., 2012; Markovic-Pekovic et al., 2016).

### **Box 1. Legal framework for regulation of health care and rational medicine use in the Republic of Srpska**

- Laws, rulebooks, programs and policies for regulating the health care and rational use of medicines, including antibiotics, adopted by Ministry of Health and Social Welfare (MoHSW) of the Republic of Srpska (MoHSW, 1999, 2008; PABH, 2008; MoHSW 2009; 2010)
- Antibiotics can only be dispensed on prescription by pharmacist. There are considerable fines if this is abused (MoHSW 2008; PABH, 2008)
- The Republic of Srpska Inspectorate is the responsible institution for supervising the implementation of this legislation
- The MoHSW established the National Committee for AMR Control as a national expert body (2015) responsible for monitoring and controlling of AMR and proposing measures to improve rational antibiotic prescribing and utilization
- On the proposal of the National Committee, the MoHSW adopted the national Program to reduce AMR resistance in the Republic of Srpska from 2016 to 2020, harmonized with the WHO Global Strategy for Containment of Antimicrobial Resistance (WHO, 2001) and the Council of Europe Recommendation's on prudent use of antimicrobial agents in human medicine (EC, 2002). The aim of this program is to establish and implement high-quality and effective health care for the population ensuring good control of AMR with an emphasis on rational antibiotic use. The stated objectives are to be reached through improving the intersectoral control on AMR and antibiotic use in healthcare as well as among veterinary institutions, seeking to reduce morbidity and mortality caused by multiresistant strains of bacteria, improving education among health workers and associates in the field of AMR, raising awareness on AMR and rational antibiotic use and, also, through participation of representatives from the Republic of Srpska in international networks and research in the field of AMR

## Box 2. Activities to improve rational antibiotic use in the Republic of Srpska

### **Activities to enhance rational prescribing**

- The set of Clinical Guidelines (CG) with diagnostic and therapeutic principles have been developed for Primary Health Care physicians. These include guidelines for upper and lower acute respiratory infections in children (acute otitis media, tonsillopharyngitis, community acquired pneumonia), urinary tract infections in children, as well as urinary tract infections in adults (2004)
- The list of antibiotics funded by the Health Insurance Fund of the Republic of Srpska (HIF) are in accordance with the CG recommendations
- HIF adopted a positive list of medicines with reference prices comprised of List A and List B. List A is a basic list of medicines for which HIF covers 90% or 100% of the reference price of the medicine depending on the category of the insured person. List B is a supplementary list, which includes more expensive medicines, for which HIF covers 50% of the costs for all insured patients. For medicines not included in the positive list, the patient must pay 100% of the price. In addition, if the price of drug is higher than the reference price adopted by HIF, the patient has to pay the price difference.
- The antibiotics included in List A are: doxycycline, amoxicillin, phenoxymethylpenicillin, benzathine-phenoxymethylpenicillin, cefalexin, sulfamethoxazole with trimethoprim and erythromycin. Norfloxacin is included in List B

### **Activities to enhance rational dispensing**

- There is permanent education of pharmacists and pharmacy technicians on the appropriate management of infectious diseases to address concerns with knowledge of infectious diseases, especially viral infectious diseases, which has been a concern in other countries (Eslami et al., 2016; Saleem et al., 2016; Belkina et al., 2017; Hoxha et al., 2018)
- The Pharmaceutical Association of the Republic of Srpska launched the '*The Guideline for counselling patients in the pharmacy*' as a tool to assist pharmacy personnel to make decisions whether they can successfully treat patients with non-pharmacological measures and/or with OTC medicines, or whether to refer them to a family practitioner, in view of concerns with self-medication with antibiotics in the Republic (Markovic-Pekovic & Grubisa, 2012; Damjanović et al., 2013; Markovic-Pekovic et al., 2017)

### **Activities of professional associations and key stakeholder groups**

- Regular professional meetings, conferences and symposia in order to upgrade the knowledge, habits and attitudes of health professionals (doctors and pharmacists).
- Publishing articles on AMR and rational antibiotic use in professional journals.
- Discussions concerning current AMR surveillance in the Republic of Srpska among key stakeholder groups and agreement of specific activities to improve AMR reporting and monitoring.
- The MoHSW and the Public Health Institute (PHI) marking European Antibiotic Awareness Day and World Antibiotic Awareness Week in November each year starting from 2013 with support of European Centre for Disease Prevention and Control (ECDC)

### **Activities to enhance public awareness on AMR and rational antibiotic use**

- Campaigns are organized to raise awareness about AMR and rational antibiotic use among the general public, patient associations and health professionals.
- Promotional materials (including flyers, infographics, fact sheets, posters, and social media), recommended by ECDC, are provided to patients and health professionals.

Consequently, the aim of this study was to analyse total antibiotic utilization in the Republic of Srpska in recent years and to assess the influence of these various initiatives to improve antibiotic prescribing and dispensing in the Republic. Subsequently, compare the findings with those of other European and neighbouring countries to review potential additional measures that could be introduced in the Republic of Srpska if needed to further improve the rational use of antibiotics. As a result, seek to reduce future AMR rates.

## **Methods**

This was a retrospective observational study on outpatient antibiotic utilization in the Republic of Srpska from 2010 to 2015, based on drug utilization data obtained from the Public Health Institute (PHI). Data collection was based on quantitative and structural medicinal reports that pharmacies in

the Republic send to the PHI each year for collation (Petrusic & Jakovljevic, 2015). Consequently, includes total antibiotic utilisation in the Republic and not just prescribed antibiotics.

Drug utilization analysis of the PHI data was undertaken using the ATC (Anatomical Therapeutic Chemical classification)/DDD (Defined Daily Dose) methodology (WHO, 2017), which is the internationally accepted methodology for measuring medicine utilisation within and across populations (Godman et al., 2014; Malo et al., 2014; Versporten et al., 2014; Abilova et al., 2018). DDDs are defined as the amount of drug most commonly used in adults for the most common indication. It is a suitable measure to describe and compare drug utilization patterns between different geographical areas and health facilities. Data on outpatient antibiotic utilization are expressed in DDD/1000 inhabitants/day (DIDs) for comparative purposes (Malo et al., 2014; Versporten et al., 2014; WHO, 2017). DU 90% (drug utilization 90%) was also used as indicator for assessing the quality of antibiotic prescribing, ranking antibiotics first by volume of DIDs and then by how many antibiotics were included in DU 90% (Markovic-Pekovic et al., 2009; Malo et al., 2014).

Antibiotic utilization and associated quality indicators were used to compare the Republic of Srpska's utilisation patterns with that from other European countries, as well as former Soviet Union Republics, to place this in perspective (Adriaenssens et al., 2011a; Adriaenssens et al., 2011b; Versporten et al., 2014; de Bie et al., 2016; WHO Europe, 2017). The quality of antibiotic prescribing was assessed using the European Surveillance of Antimicrobial Consumption (ESAC), European Centre for Disease Prevention and Control (ECDC) and World Health Organisation (WHO) Europe quality indicators (Adriaenssens et al., 2011a; Adriaenssens et al., 2011b; WHO Europe, 2017; ECDC 2018). These included:

- Total utilization of antibiotics expressed as DIDs,
- Utilization of penicillins (J01C) as a % of total antibiotic use,
- Penicillins combination utilization such as amoxicillin with clavulanic acid (co-amoxiclav) as a percentage of total antibiotic use,
- Total utilization of cephalosporins expressed as DIDs,
- Percentage utilization of third- and fourth-generation of cephalosporins vs all cephalosporins,
- Total utilization of J01F group (macrolides, lincosamides and streptogramins) expressed as DIDs
- Utilization of short-acting macrolides, intermediate and long-acting macrolides (erythromycin, clarithromycin and azithromycin) as a percentage of total antibiotic use,
- Utilization of quinolones (J01M) expressed in DIDs as well as percentage of fluoroquinolones (J01MA) of total antibiotic use.

A number of these indicators are due to concerns with the over use of co-amoxiclav, macrolides, third and fourth generation cephalosporins as well as fluoroquinolones (Adriaenssens, et al., 2011a; Malo et al., 2014; WHO Europe, 2017).

Since multiple initiatives and reforms were instigated over time in the Republic of Srpska with varying intensity, coupled with the nature of reported figures, it was impossible to undertake sophisticated statistical analyses such as time series analyses. As a result, more simple statistical tests, including trend analyses, were performed to assess the level of significance, with significance seen as  $p < 0.05$ . This is similar to other health authority analyses where multiple interventions are conducted over time with no opportunity for time series analyses (Godman et al., 2010; Voncina et al., 2011; Bennie et al., 2012; Godman et al., 2014; Abilova et al., 2018).

No specific ethical approval was sought as only aggregated anonymised data was used for analysis, with Ministry of Health personnel involved in the study. This is similar to other studies of this nature (Godman et al., 2010; Bennie et al., 2012; Godman et al., 2014; Abilova et al., 2018).

## Results

The total utilization of antibiotics for systemic use (J01 group) comprised 98% of total utilization of anti-infectives (J group). Utilization of the J01 group varied between 15.6 and 18.4 DIDs during the observed period (Table 1, Table 4), lower than a number of neighbouring countries (Figure 1).

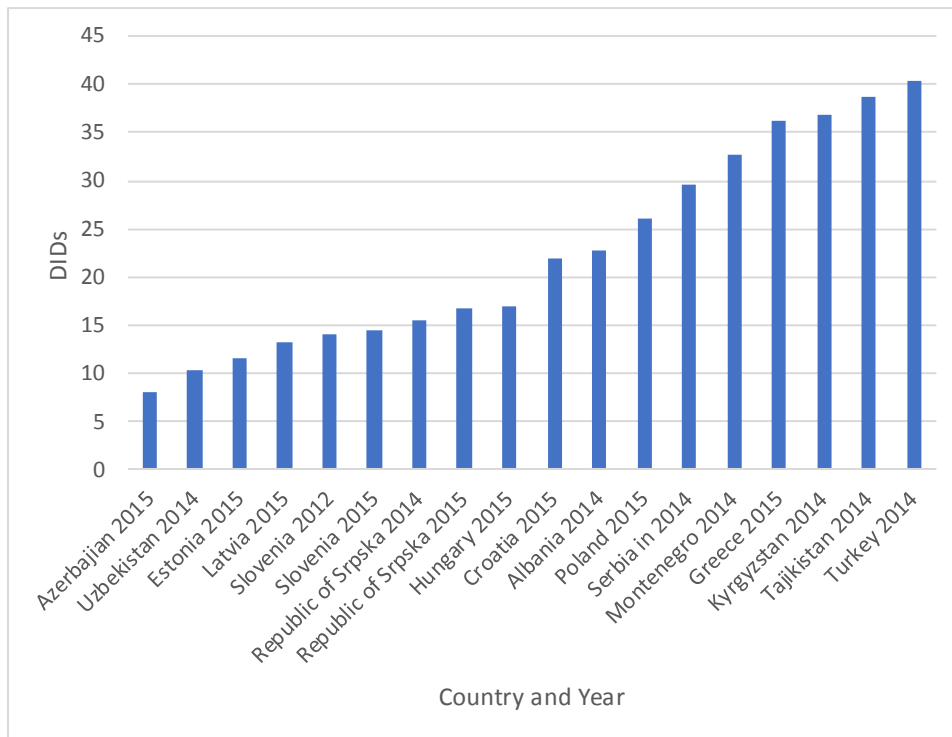
**Table 1. Total utilization of antibiotics for systemic use (J01 group) expressed in DIDs and percentages over the 2010 – 2015 period**

ATC group	2010		2011		2012		2013		2014		2015		p-values	
	DIDs	%	DIDs	%	DIDs	%	DIDs	%	DIDs	%	DIDs	%	DID	%
J01C	8.18	46.5	8.34	47.6	7.97	50.6	9.97	54.2	7.86	50.3	8.16	48.7	P=0.16	p=0.37
J01D	3.01	17.2	2.45	14.0	2.10	13.4	2.63	14.3	2.06	13.2	2.27	13.5	P=0.18	P=0.109
J01M	1.46	8.3	1.64	9.4	1.46	9.3	1.51	8.2	1.61	10.3	1.71	10.2	P=0.35	P=0.15
J01F	1.70	9.7	1.78	10.2	1.49	9.5	1.70	9.3	1.55	9.9	1.61	9.6	P=0.39	P=0.6
J01A	1.69	9.6	1.55	8.9	1.39	8.9	1.31	7.1	1.27	8.1	1.60	9.5	P=0.12	P=0.6
J01E	1.20	6.8	1.41	8.0	1.05	6.7	1.05	5.7	1.03	6.6	1.03	6.2	P=0.74	P=0.23
J01X	0.24	1.4	0.25	1.4	0.23	1.5	0.18	1.0	0.21	1.3	0.30	1.8	P=0.44	P=0.63
J01G	0.09	0.5	0.10	0.5	0.03	0.2	0.05	0.3	0.04	0.3	0.08	0.5	P=0.51	P=0.7
<b>Total J01</b>	<b>17.6</b>	<b>100</b>	<b>17.5</b>	<b>100</b>	<b>15.7</b>	<b>100</b>	<b>18.4</b>	<b>100</b>	<b>15.6</b>	<b>100</b>	<b>16.8</b>	<b>100</b>		

NB: J01A - Tetracyclines, J01C - Beta-lactam antibacterials, penicillins, J01D - Other beta-lactam antibacterials (cephalosporins), J01E - Sulfonamides and trimethoprim, J01F- Macrolides, lincosamides and streptogamins, J01G - Aminoglycoside antibacterials, J01M - Quinolone antibacterials, J01X - Other antibacterials. % = % of antibiotics in that class for the year

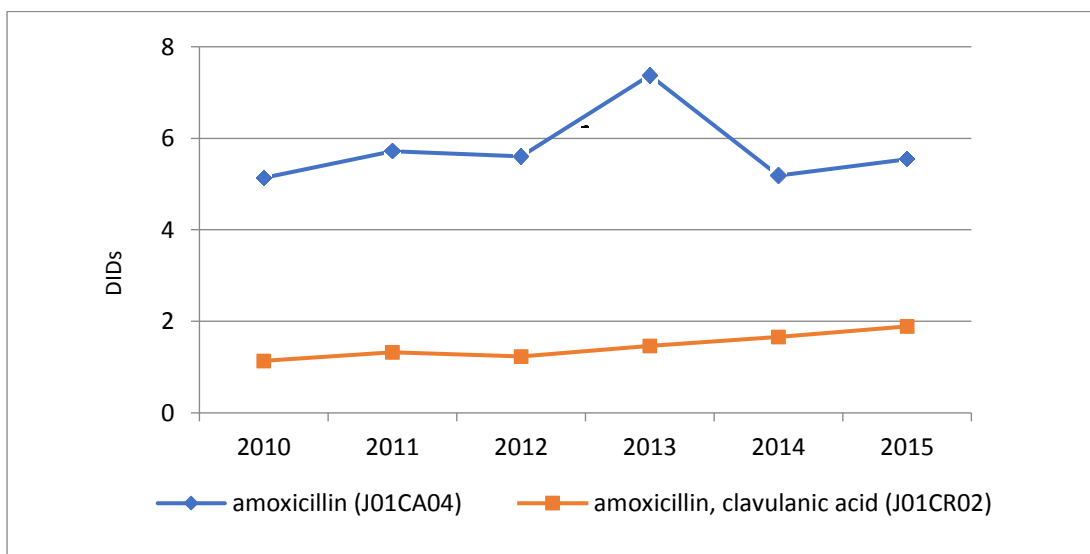
Figure 1 compares the utilisation in recent years with other neighbouring countries.

**Figure 1 – Antibiotic utilisation in the Republic of Srpska in 2014 and 2015 (in DIDs) versus neighbouring countries in similar years [Taken from Furst et al., 2015; WHO Europe, 2017; ECDC, 2018]**



The penicillins (J01C) were the most consumed antibiotics comprising 50% of total antibiotic utilization on average, followed by other beta-lactam antibiotics (14%). The highest utilization of penicillins was observed in 2013 with 10.0 DID, while the lowest (7.9 DID) observed in 2014. The utilization of broad-spectrum penicillins (J01CA) was 6.04 DID on average (Table 2). Amoxicillin constituted 95% of this group (5.76 DID) (Figure 2), followed by ampicillin (0.28 DID). Co-amoxiclav (J01CR02) ranged from 1.1 to 1.9 DID from 2010 to 2015 (Figure 2), while beta-lactamase sensitive penicillins (J01CE) comprised 5% of total antibiotic use (Table 2), with phenoxymethylpenicillin the most prescribed antibiotic of this group.

**Figure 2. Amoxicillin vs. co-amoxiclav utilization expressed in DID over the 2010-2015 period**



**Table 2. Utilization of penicillins (J01CA) expressed in DIDs over the 2010 – 2015 period**

ATC group	Pharmacological group	DIDs						P-values
		2010	2011	2012	2013	2014	2015	
J01CA	Penicillins with extended spectrum	5.62	6.10	5.88	7.56	5.38	5,72	p=0.99
J01CR	Combinations of penicillins, incl. beta-lactamase inhibitors	1.14	1.33	1.23	1.47	1.66	1.89	P=0.004
J01CE	Beta-lactamase sensitive penicillins	1.42	0.91	0.85	0.94	0.82	0.56	P=0.03
J01CF	Beta-lactamase resistant penicillins	0.01	< 0.01	< 0.01	< 0,01	< 0,01	< 0,01	P=0.918
<b>Total J01C</b>		<b>8.2</b>	<b>8.3</b>	<b>8.0</b>	<b>10.0</b>	<b>7.9</b>	<b>8.2</b>	

Utilization of cephalosporins (J01D) decreased from 3.0 DIDs in 2010 to 2.3 DIDs in 2015 (Table 1, Table 4). The first-generation cephalosporins (J01DB) were the most used within J01D group (67.6%), of which cefalexin was the only one used. Its utilization decreased from 2.0 DIDs in 2010 to 1.5 DIDs in 2015, which represents a reduction of 25%. Overall, utilization of the second and third generation of cephalosporins (J01DC and J01DD) also declined during this period. Regarding the second-generation cephalosporins, cefuroxime had very stable utilization ranging from 0.45 to 0.56 DIDs during the study period, while utilization of cefaclor decreased from 0.15 in 2010 to 0.05 DIDs in 2015 (67%). Overall, third generation cephalosporins constituted 7.9% of total cephalosporins, or 1.2% on average of total antibiotics (Table 4). After declining from 2010 to 2014, utilization of the third generation cephalosporins subsequently increased in 2015 (Table 4). The fourth generation cephalosporins, monobactams and carbapenems, were not used at all.

Erythromycin was the most used macrolide (0.68 DIDs) followed by azithromycin (0.57 DIDs) and clarithromycin (0.32DIDs). Overall, macrolides constituted 9.4% of total antibiotic utilization, which is about five times lower than the penicillins. The use of the macrolides was highest in 2011 (1.7 DIDs) and then dropped thereafter to 1.5 DIDs (Table 1).

Doxycycline was the most used tetracycline (J01A), with quinolone utilisation (J01M) ranging from 1.5 DIDs in 2010 to 1.7 DIDs in 2015 (Table 1), of which 90% were fluoroquinolones. Ciprofloxacin was the most prescribed fluoroquinolone. The only sulphonamide (J01E) was a combination of sulfamethoxazole with trimethoprim, which accounted 7% of total antibiotic utilization (Table 1). Utilization of aminoglycoside antibiotics (J01G) and other antibiotics (J01X) was negligible (Table 1).

DU90% shows the number of antibiotics included in 90% of total utilization. Over the observed period, ten antibiotics were constantly included in the DU90% profile. DU90% included ten antibiotics in 2013, eleven in 2014 and twelve during the rest of the study years. Amoxicillin, amoxicillin with clavulanic acid (co-amoxiclav), cephalexin, ciprofloxacin, doxycycline and sulfamethoxazole with trimethoprim were the most used antibiotics over the observed period (Table 3).



**Table 3. Antibiotic utilization within Drug Utilization (DU90%) profile, expressed in DIDs over the 2010-2015 period**

	2010		2011		2012		2013		2014		2015	
	DID	%	DID	%	DID	%	DID	%	DID	%	DID	%
<b>amoxi cillin</b>	5.14	29.26	5.72	32.67	5.60	35.59	7.38	40.12	5.19	33.20	5.54	33.07
<b>amoxi cillin, clavul anic acid</b>	1.14	6.49	1.33	7.60	1.23	7.82	1.47	7.99	1.66	10.62	1.89	11.28
<b>cefale xin</b>	2.05	11.67	1.58	9.02	1.31	8.32	1.93	10.49	1.44	9.21	1.53	9.13
<b>ciprof loxaci n</b>	0.96	5.46	1.13	6.45	1.04	6.61	1.11	6.03	1.20	7.68	1.23	7.34
<b>doxyc ycline</b>	1.61	9.16	1.48	8.45	1.22	7.75	1.20	6.52	1.11	7.10	1.20	7.16
<b>sulfa meth oxazo le, trimet hopri m</b>	1.20	6.83	1.41	8.05	1.05	6.67	1.05	5.71	1.03	6.59	1.03	6.15
<b>azithr omyci n</b>	0.30	1.71	0.64	3.65	0.50	3.18	0.56	3.04	0.63	4.03	0.76	4.54
<b>phen oxym ethyl- penici llin</b>	1.17	6.66	0.71	4.05	0.66	4.19	0.74	4.02	0.55	3.52	0.53	3.16
<b>cefur oxime</b>	0.49	2.79	0.56	3.20	0.51	3.24	0.54	2.94	0.48	3.07	0.45	2.69
<b>erythr omyci n</b>	1.07	6.09	0.71	4.05	0.61	3.88	0.74	4.02	0.55	3.52	0.43	2.57

<b>claritromycin</b>	-	-	0.35	2.00	0.33	2.10	-	-	0.30	1.92	0.35	2.10
<b>ampicillin</b>	0.48	2.73	0.38	2.17	0.28	1.78	-	-	-	-	-	-
<b>norfloxacin</b>	0.30	1.71	-	-	-	-	-	-	-	-	-	-
<b>amr oxol, doxycycline</b>	-	-	-	-	-	-	-	-	-	-	0.38	2.27
<b>DU90 %</b>	<b>1-12</b>	<b>1-12</b>	<b>1-12</b>	<b>1-12</b>	<b>1-10</b>	<b>1-11</b>	<b>1-12</b>					
	90.56	91.36	91.13	90.88	90.46	91.46						
<b>Others (%)</b>	<b>13-32</b>	<b>13-31</b>	<b>13-31</b>	<b>11-30</b>	<b>12-30</b>	<b>13-30</b>						
	9.44	8.64	8.87	9.12	9.54	8.54						
<b>Total (%)</b>	<b>1-32</b>	<b>1-31</b>	<b>1-31</b>	<b>1-30</b>	<b>1-30</b>	<b>1-30</b>						
	100	100	100	100	100	100						

According to the quality indicators, the total utilization of beta-lactam antibiotics (penicillins and cephalosporins), macrolides and fluoroquinolones, expressed as percentage of total antibiotic use, was very stable over the observed period (Table 4). However, the use of co-amoxiclav increased from 6.5% of total antibiotic utilization in 2010 to 11.3% in 2015, which is a concern in this trend continues. At the same time, the use of erythromycin decreased for 37.2% within the macrolide group, while azithromycin rose proportionally (Tables 3 and 4).

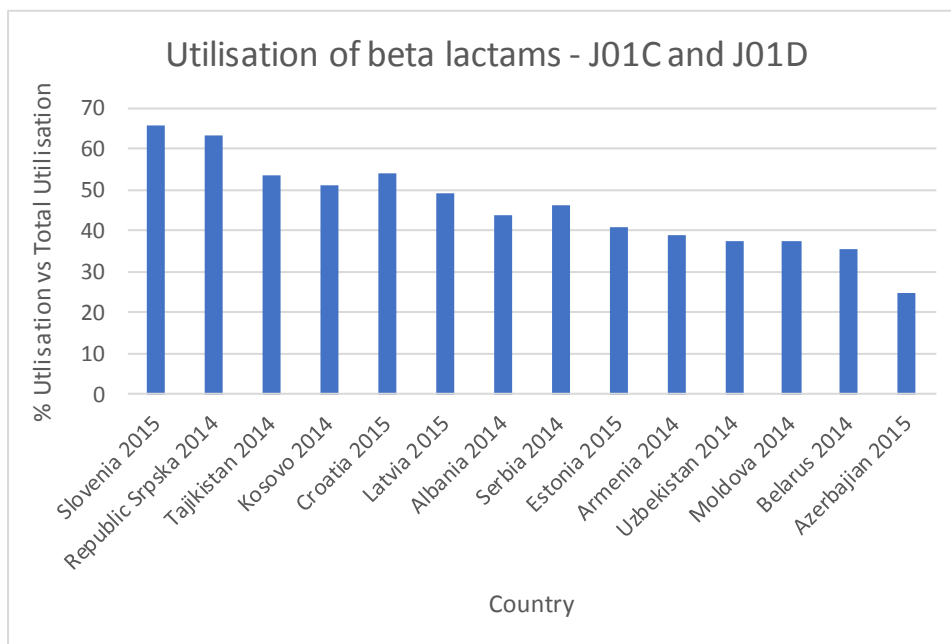
**Table 4. Quality indicators for antibiotic utilization in the Republic of Srpska over the 2010-2015 period**

<b>QUALITY INDICATOR</b>	<b>2010</b>	<b>2011</b>	<b>2012</b>	<b>2013</b>	<b>2014</b>	<b>2015</b>
Total utilization of antibiotics (J01) (DIDs)	17.6	17.5	15.7	18.4	15.6	16.8
Total utilization of beta-lactam antibiotics (penicillins – J01C and cephalosporins – J01D) as a % of total antibiotic use	63.7	61.6	64.0	68.5	63.5	62.3
Total utilization of penicillins (J01C) as a % of total antibiotic use	46.5	47.6	50.6	54.2	50.3	48.7
Utilization of combination penicillins (co-amoxiclav – J01CR02) as % of total antibiotic use	6.5	7.6	7.8	8.0	10.6	11.3
Total utilization of cephalosporins – J01D (DIDs)	3.0	2.5	2.1	2.6	2.1	2.3
Utilization of 3 <sup>rd</sup> and 4 <sup>th</sup> generation cephalosporins (J01DD and J01DE) as % of total antibiotic use	1.9	1.1	1.3	0.6	0.6	1.4
Utilization of 3 <sup>rd</sup> and 4 <sup>th</sup> generation of cephalosporins as % of total cephalosporin use	11.0	7.7	9.5	4.1	4.6	10.4

Total utilization of macrolides, lincosamides and streptogramins- J01F (DIDs)	1.7	1.8	1.5	1.7	1.6	1.6
Total utilization of erythromycin (J01FA01), clarithromycin (J01FA09) and azithromycin (J01FA10) as % of total antibiotic use	9.3	9.7	9.1	8.9	9.4	9.2
Total utilization of erythromycin as % of total macrolide use, with corresponding increase in clarithromycin and azithromycin	64.7	40.9	42.0	45.0	36.7	27.5
Total utilization of quinolones J01M – (DIDs)	1.5	1.6	1.5	1.5	1.6	1.7
Total utilization of fluoroquinolones (J01MA) as % of total antibiotic utilization	7.4	8.4	8.4	7.4	9.3	9.4

Figures 3 to 5 and Table 5 provide comparisons with similar and neighbouring countries to the Republic of Srpska in recent years.

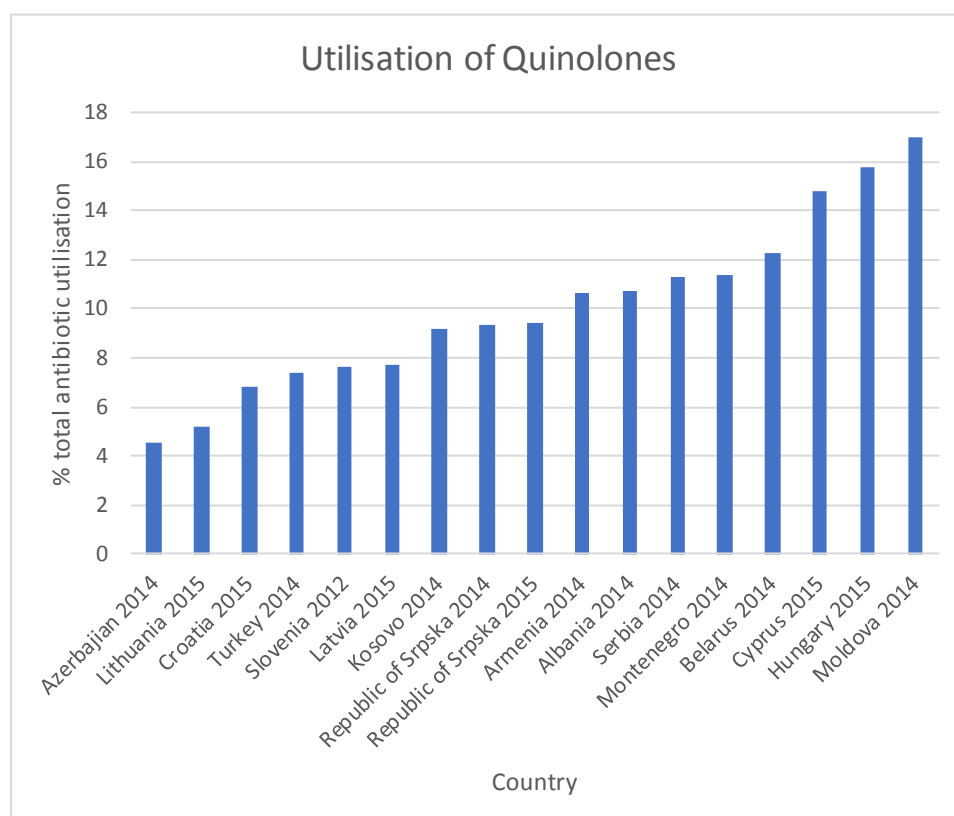
**Figure 3 - % utilisation of beta-lactams as a % of total antibiotic utilisation across countries [taken from Furst et al., 2015; WHO Europe, 2017; ECDC, 2018]**



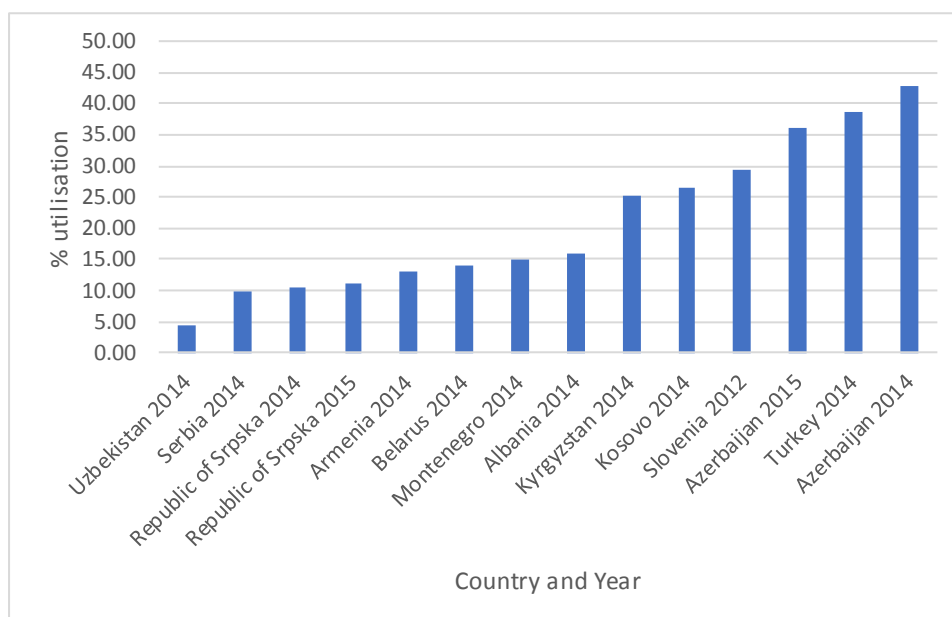
**Table 5 – Utilisation of third and fourth generation cephalosporins as a % of total cephalosporins (J01D) [taken from Furst et al., 2015; WHO Europe, 2017; ECDC, 2018]**

Country and year	%
Republic of Srpska 2014	4.6%
Republic of Srpska 2015	10.4%
Serbia 2014	16%
Albania 2014	30%
Turkey 2014	38%
Montenegro 2014	40%
Moldova 2014	46%
Uzbekistan 2014	63%
Azerbaijan 2014	76%
Belarus 2014	79%
Kyrgyzstan 2014	81%
Azerbaijan 2015	82%

**Figure 4 – Utilisation of quinolones as a % of total antibiotic utilisation across countries [taken from Furst et al., 2015; WHO Europe, 2017; ECDC, 2018]**



**Figure 5 - % Combination penicillins (co-amoxiclav J01CR02) as a % of total antibiotic utilisation [taken from Furst et al., 2015; WHO Europe, 2017; ECDC, 2018]**



## Discussion

Total antibiotic utilisation was relatively constant during the study period in the Republic of Srpska (Table 1), with minor fluctuations, and an overall a decline in total utilization of 5% between 2010 and 2015, with a corresponding reduction in expenditure on antibiotics (J01) in 2013 versus 2009 (Petrusic & Jakovljevic, 2015). In addition, antibiotic utilisation in the Republic was lower than a number of neighbouring countries and former Soviet Union Republics in recent years (Figure 1). This is in direct contrast with total worldwide antibiotic utilisation, which rose by 36% during the past decade (Laxminarayan et al., 2016). There appears to be several reasons for this in the Republic of Srpska. Firstly, health care in the Republic is well regulated by a number of policies, strategies, guidelines and normatives (Boxes 1 and 2), despite limited available resources for such initiatives. The Law on health care and the Law of health insurance enables all patients to have adequate health care access in the Republic, including medicines and other types of treatment (MoHSW, 1999; MoHSW 2009). Standard treatment guidelines for the most common clinical problems in ambulatory care were developed by family physician associations and adopted by Ministry of Health and Social Welfare (MoHSW) in 2004 in order to improve the quality and rationality of physician prescribing. Based on these guidelines, only recommended and essential antibiotics were included in the HIF positive list of medicines to emphasize rational prescribing and reduce unnecessary expenditure to help ensure cost-efficient antibiotics are available for all citizens in the Republic. This approach is similar to the situation seen in some European countries and regions with multiple initiatives to enhance the quality and efficiency of prescribing (Gustafsson et al., 2011; Bjorkhem-Bergman et al., 2013). However, we are aware that there is variable implementation of guidelines among a number of European countries in practice (Francke et al., 2008; Sermet et al., 2010; van Dijk et al., 2011; Brusamento et al., 2012; Fitzgerald et al., 2014; Baker et al., 2015). In addition, as mentioned, there are concerns with issues of evidence based medicine among physicians in the Balkan countries (Jakovljevic et al., 2016a; Jakovljevic et al., 2016b); however, this appears not to be the case in the Republic of Srpska certainly with respect to antibiotic prescribing.

Secondly, a number of initiatives and activities have been implemented in the Republic in order to improve knowledge, attitudes and practices of pharmacists to reduce antibiotic self-medication and improve appropriate management of patients with URTIs (Boxes 1 and 2), especially as pharmacists are often the first health professional patients see with their URTI (Markovic-Pekovic et al, 2017). This includes the tightening of self-medication regulations, with self-medication known to appreciably increase antibiotic utilisation in URTIs and similar conditions (Kalaba et al., 2011; Kibuule et al., 2016; Markovic-Pekovic et al., 2017). This is different to Albania where self-medication is common particularly for URTIs, and there are considerable concerns with pharmacy knowledge regarding

antibiotics and viruses ( Jorgji et al., 2014; Hoxha et al., 2015; Hoxha et al., 2018). There are also concerns with continuing self-medication in Serbia (Kalaba et al., 2011). Education among pharmacists also reduced the extent of self-medication with antibiotics in Kenya especially for URTIs (Mukokinya et al., 2018).

These combined initiatives also appeared to result in high use of beta-lactam antibiotics and limited use of third and fourth generation cephalosporins and fluoroquinolones in the Republic in recent years in accordance with agreed quality indicators (Table 4), comparable or improved prescribing versus neighbouring countries (Figures 3 and 4, Table 5). We have also seen reduced expenditure on first and second generation cephalosporins in Serbia between 2007 and 2012, although also reduced prescribing on combinations of penicillins (J01CR) and penicillins with extended spectrums (J01CA) (Jakovljevic and Souliotis, 2016). The DU90% profile (Table 3) shows that first and second generation antibiotics were mainly used, reflecting the antibiotics reimbursed by HIF and contained in current clinical guidelines (Box 2). This is similar to the situation with other medicines when prescribing is restricted and/ or where there are high co-payments to rationalize pharmacotherapy (Sakshaug et al., 2007; Martikainen et al. 2010; Wettermark et al., 2010; Kalaba et al., 2012; Markovic-Pekovic et al., 2012; Moon et al., 2014). In Slovenia, prescribing restrictions for co-amoxiclav, the cephalosporins, macrolides, and fluoroquinolones, also significantly reduced their use (Furst et al., 2015). These findings support other published studies which suggest that multiple initiatives are typically needed to positively influence prescribing (Bero et al., 1998; Barton, 2001; Francke et al., 2008; Godman et al., 2013; Godman et al., 2014; Moon et al., 2014).

Amoxicillin, which is included in the HIF positive A list, was the most utilised penicillin in the Republic of Srpska, with utilization of co-amoxiclav approximately 4 times lower than amoxicillin. The low utilisation of co-amoxiclav in the Republic compares favourably with neighbouring countries (Figure 5). However, there are concerns with the rise in its utilization in recent years (Tables 2 and 4 and Figure 2). This is due to concerns with increasing side-effects and resistance leading to co-amoxiclav now being recommended as a second line antibiotic after amoxicillin in a number of guidelines (Andrade & Tulkens, 2011; Desrosiers et al., 2011; NHS Scotland, 2014; GGC Prescribing, 2017; ECDC, 2018). There are also concerns with currently limited prescribing of phenoxymethyl penicillin in the Republic (Table 3) as it is likely that a high proportion of infections seen in ambulatory care are likely to be URTIs (Llor & Bjerrum, 2014; Rezal et al., 2015; Dyar et al., 2016). These will be areas to address if these trends (Figure 2) continue.

Encouragingly, given concerns with the development and spread of resistant strains of *C. difficile* (Dancer, 2001; Batzing-Feigenbaum et al., 2016), there were low rates of cephalosporin utilisation, with rates remaining relatively constant over the study period (Tables 1 and 4). In addition, as mentioned, the Republic of Srpska had low utilization of third and fourth generation of cephalosporins in recent years (Table 4), comparing favourably with neighbouring countries (Table 5). There was also relatively low utilization of macrolides (J01F), with rates decreasing in recent years but not reaching statistical significance (Tables 1 and 4). This is similar to Serbia with expenditure on macrolides falling in recent years (Jakovljevic and Souliotis, 2016). However, the prescribing of azithromycin is increasing, with a simultaneous decrease in utilization of erythromycin (Tables 3 and 4), resulting in the utilization of azithromycin exceeding erythromycin in 2014 and 2015. This is causing concern with increasing resistance rates as well as side-effects with the macrolides (Albert & Schuller, 2014; ECDC, 2018).

Concerns with the recent increased utilisation of co-amoxiclav and azithromycin, as well as higher use of fluoroquinolones than some neighbouring countries (Table 1), has already resulted in planned activities, with their implementation and impact being monitored. These ongoing and planned activities (Box 2) should further help with enhancing appropriate antibiotic use in the Republic of Srpska. Planned activities also include programmes to improve inter-sectoral control over antibiotic utilisation, including both health and veterinary sectors, as well as improved undergraduate and postgraduate education regarding antibiotics and AMR. The development of specific indicators for monitoring antibiotic utilization is also planned, building on existing quality indicators for NCDs, as well as monitoring hospital resistance patterns. These data will be used to revise and update the clinical guidelines for rational antibiotic use in the Republic. Planned activities also include improving the information technology for monitoring of AMR and antibiotic consumption. The findings will subsequently be shown to health professionals to emphasize what has been done so far and to discuss further activities. This is similar to activities in for instance in Sweden with its monitoring of

prescribing in the regions together with the development of quality indicators to improve physician prescribing practices (Godman et al., 2009; Wettermark et al., 2009; Gustafsson et al., 2011; Eriksen et al., 2017).

Alongside this, pharmacists and family physicians will be encouraged to communicate more to their patients about rational antibiotic use and AMR, building on current initiatives. This will be combined with planned activities to further raise public awareness regarding the potential harmful effects of excessive, inappropriate, and unnecessary use of antibiotics. These programmes will also be the subject of future research projects.

We believe this study clearly shows that even lower income countries such as the Republic of Srpska can appreciably improve rational medicine utilization by introducing multiple interventions and initiatives, acting as an exemplar to other European countries and wider.

We are aware of a number of limitations of this study. These include no access to prescribing data to be able to assess the quality of antibiotic prescribing against standard treatment guidelines. However, we believe our methodology, including the use of total antibiotic utilisation via the PHI datasets, as well as comparisons with neighbouring countries, adds robustness to our findings and conclusions.

In conclusion, without looking specifically at prescribing indications, we believe there appears to be rational antibiotic utilization in the Republic of Srpska in recent years compared to neighbouring countries, with favourable use of penicillins combined with moderate or low use of co-amoxiclav, cephalosporins including third and fourth generation cephalosporins, macrolides and quinolones. This again demonstrates that multiple interventions with key stakeholder groups can favourably improve medicine utilisation patterns.

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Vanda Marković-Peković is employed by the Ministry of Health and Social Welfare in the Republic of Srpska and Ljubica Bojanić, Mirjana Đermanović and Janja Bojanić are employed by the Public Health Institute. The authors have no other conflicts of interest to declare.

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#### **References**

- Aabenhus, R., Hansen, M. P., Saust, L. T., & Bjerrum, L. (2017). Characterisation of antibiotic prescriptions for acute respiratory tract infections in Danish general practice: a retrospective registry based cohort study. *NPJ Prim Care Respir Med*, *27*(1), 37.
- Abilova, V., Kurdi, A., & Godman, B. (2018). Ongoing initiatives in Azerbaijan to improve the use of antibiotics; findings and implications. *Expert Rev Anti Infect Ther*, *16*(1), 77-84.
- Adriaenssens, N., Coenen, S., Tonkin-Crine, S., Verheij, T. J., Little, P., & Goossens, H. (2011a). European Surveillance of Antimicrobial Consumption (ESAC): disease-specific quality indicators for outpatient antibiotic prescribing. *BMJ Qual Saf*, *20*(9), 764-772. d
- Adriaenssens, N., Coenen, S., Versporten, A., Muller, A., Vankerckhoven, V., & Goossens, H. (2011b). European Surveillance of Antimicrobial Consumption (ESAC): quality appraisal of antibiotic use in Europe. *J Antimicrob Chemother*, *66* Suppl 6, vi71-77.
- Albert, R. K., & Schuller, J. L. (2014). Macrolide antibiotics and the risk of cardiac arrhythmias. *Am J Respir Crit Care Med*, *189*(10), 1173-1180. doi:10.1164/rccm.201402-0385CI
- Aminov, R. I. (2010). A brief history of the antibiotic era: lessons learned and challenges for the future. *Front Microbiol*, *1*, 134.
- Andrade, R. J., & Tulkens, P. M. (2011). Hepatic safety of antibiotics used in primary care. *J Antimicrob Chemother*, *66*(7), 1431-1446.

- Bai, Y., Wang, S., Yin, X., Bai, J., Gong, Y., & Lu, Z. (2016). Factors associated with doctors' knowledge on antibiotic use in China. *Sci Rep*, *6*, 23429.
- Baker, A., Chen, L. C., Elliott, R. A., & Godman, B. (2015). The impact of the 'Better Care Better Value' prescribing policy on the utilisation of angiotensin-converting enzyme inhibitors and angiotensin receptor blockers for treating hypertension in the UK primary care setting: longitudinal quasi-experimental design. *BMC Health Serv Res*, *15*, 367.
- Barton, S. (2001). Using clinical evidence. *BMJ*, *322*(7285), 503-504.
- Batzing-Feigenbaum, J., Schulz, M., Schulz, M., Hering, R., & Kern, W. V. (2016). Outpatient Antibiotic Prescription. *Dtsch Arztebl Int*, *113*(26), 454-459.
- Bell, B. G., Schellevis, F., Stobberingh, E., Goossens, H., & Pringle, M. (2014). A systematic review and meta-analysis of the effects of antibiotic consumption on antibiotic resistance. *BMC Infectious Diseases*, *14*, 13-13.
- Belkina, T., Duvanova, N., Karbovskaia, J., Tebbens, J. D., & Vlcek, J. (2017). Antibiotic use practices of pharmacy staff: a cross-sectional study in Saint Petersburg, the Russian Federation. *BMC Pharmacology & Toxicology*, *18*, 11. doi:10.1186/s40360-017-0116-y
- Bennie, M., Godman, B., Bishop, I., & Campbell, S. (2012). Multiple initiatives continue to enhance the prescribing efficiency for the proton pump inhibitors and statins in Scotland. *Expert Rev Pharmacoecon Outcomes Res*, *12*(1), 125-130.
- Bero, L. A., Grilli, R., Grimshaw, J. M., Harvey, E., Oxman, A. D., & Thomson, M. A. (1998). Closing the gap between research and practice: an overview of systematic reviews of interventions to promote the implementation of research findings. The Cochrane Effective Practice and Organization of Care Review Group. *BMJ*, *317*(7156), 465-468.
- Bjorkhem-Bergman, L., Andersen-Karlsson, E., Laing, R., Diogene, E., Melien, O., Jirlow, M., . . . Gustafsson, L. L. (2013). Interface management of pharmacotherapy. Joint hospital and primary care drug recommendations. *Eur J Clin Pharmacol*, *69 Suppl 1*, 73-78.
- Brusamento, S., Legido-Quigley, H., Panteli, D., Turk, E., Knai, C., Saliba, V., et al. (2012). Assessing the effectiveness of strategies to implement clinical guidelines for the management of chronic diseases at primary care level in EU Member States: a systematic review. *Health Policy*, *107*(2-3), 168-183.
- Chang, J., Ye, D., Lv, B., Jiang, M., Zhu, S., Yan, K., et al. (2017). Sale of antibiotics without a prescription at community pharmacies in urban China: a multicentre cross-sectional survey. *J Antimicrob Chemother*, *72*(4), 1235-1242.
- Collignon, P., Athukorala, P. C., Senanayake, S., & Khan, F. (2015). Antimicrobial resistance: the major contribution of poor governance and corruption to this growing problem. *PLoS One*, *10*(3), e0116746.
- Costelloe, C., Metcalfe, C., Lovering, A., Mant, D., & Hay, A. D. (2010). Effect of antibiotic prescribing in primary care on antimicrobial resistance in individual patients: systematic review and meta-analysis. *BMJ*, *340*, c2096.
- Dancer, S. J. (2001). The problem with cephalosporins. *J Antimicrob Chemother*, *48*(4), 463-478.
- Damjanović A, Š. A., Bajraktarević A, Božović T. (2013). The Guideline for counselling patients in the pharmacy. Pharmaceutical Association of the Republic of Srpska, Banja Luka
- de Bie, S., Kaguelidou, F., Verhamme, K. M., De Ridder, M., Picelli, G., Straus, S. M., et al. (2016). Using Prescription Patterns in Primary Care to Derive New Quality Indicators for Childhood Community Antibiotic Prescribing. *Pediatr Infect Dis J*, *35*(12), 1317-1323.



- Desrosiers, M., Evans, G. A., Keith, P. K., Wright, E. D., Kaplan, A., Bouchard, J., et al. (2011). Canadian clinical practice guidelines for acute and chronic rhinosinusitis. *J Otolaryngol Head Neck Surg*, 40 Suppl 2, S99-193.
- Dyar, O. J., Beovic, B., Vlahovic-Palcevski, V., Verheij, T., & Pulcini, C. (2016). How can we improve antibiotic prescribing in primary care? *Expert Rev Anti Infect Ther*, 14(4), 403-413.
- EC Council Recommendation (EC) 2002/77 of 15 November 2001 on the prudent use of antimicrobial agents in human medicine (2002) OJ L34/13. Available at URL: <http://eur-lex.europa.eu/legal-content/EN/TXT/HTML/?uri=URISERV:c11569&from=EN>
- ECDC. (2016). EARS-Net surveillance data. Summary of the latest data on antibiotic resistance in the European Union. Available at URL: <http://ecdc.europa.eu/en/eaad/antibiotics-get-informed/antibiotics-resistance-consumption/Documents/antibiotics-EARS-Net-summary-2016.pdf>
- ECDC. (2018) Quality indicators for antibiotic consumption in the community in Europe. Available at URL: <http://ecdc.europa.eu/en/healthtopics/antimicrobial-resistance-and-consumption/antimicrobial-consumption/esac-net-database/Pages/quality-indicators-primary-care.aspx>.
- Eriksen, J., Gustafsson, L. L., Ateva, K., Bastholm-Rahmner, P., Ovesjo, M. L., Jirlow, M., et al. (2017). High adherence to the 'Wise List' treatment recommendations in Stockholm: a 15-year retrospective review of a multifaceted approach promoting rational use of medicines. *BMJ Open*, 7(4), e014345.
- Eslami, N., Eshraghi, A., Vaseghi, G., Mehdizadeh, M., Masjedi, M., & Mehrpooya, M. (2016). Pharmacists' Knowledge and Attitudes Towards Upper Respiratory Infections (URI) in Iran: A Cross Sectional Study. *Rev Recent Clin Trials*, 11(4), 342-345.
- Fitchett, J. R., & Atun, R. (2016). Antimicrobial resistance: opportunity for Europe to establish global leadership. *Lancet Infect Dis*, 16(4), 388-389.
- Fitzgerald, A., Lethaby, A., Cikalo, M., Glanville, J., Wood, H. (2014) Review of Systematic Reviews Exploring the Implementation/Uptake of Guidelines. Yorh Health Economics Consortium. Available at URL: <https://www.nice.org.uk/guidance/ph56/evidence/evidence-review-2-431762366>.
- Francke, A. L., Smit, M. C., de Veer, A. J. E., & Mistiaen, P. (2008). Factors influencing the implementation of clinical guidelines for health care professionals: A systematic meta-review. *BMC Medical Informatics and Decision Making*, 8, 38-38.
- Furst, J., Cizman, M., Mrak, J., Kos, D., Campbell, S., Coenen, S., et al. (2015). The influence of a sustained multifaceted approach to improve antibiotic prescribing in Slovenia during the past decade: findings and implications. *Expert Rev Anti Infect Ther*, 13(2), 279-289.
- Gandra, S., Barter, D. M., & Laxminarayan, R. (2014). Economic burden of antibiotic resistance: how much do we really know? *Clin Microbiol Infect*, 20(10), 973-980.
- Godman, B., Wettermark, B., Hoffmann, M., Andersson, K., Haycox, A., & Gustafsson, L. L. (2009). Multifaceted national and regional drug reforms and initiatives in ambulatory care in Sweden: global relevance. *Expert Rev Pharmacoecon Outcomes Res*, 9(1), 65-83. doi:10.1586/14737167.9.1.65
- Godman, B., Shrank, W., Andersen, M., Berg, C., Bishop, I., Burkhardt, T., et al. (2010). Comparing policies to enhance prescribing efficiency in Europe through increasing generic utilization: changes seen and global implications. *Expert Rev Pharmacoecon Outcomes Res*, 10(6), 707-722.
- Godman, B., Bishop, I., Finlayson, A. E., Campbell, S., Kwon, H. Y., & Bennie, M. (2013). Reforms and initiatives in Scotland in recent years to encourage the prescribing of generic drugs, their influence and implications for other countries. *Expert Rev Pharmacoecon Outcomes Res*, 13(4), 469-482.

Godman, B., Wettermark, B., van Woerkom, M., Fraeyman, J., Alvarez-Madrado, S., Berg, C., et al. (2014). Multiple policies to enhance prescribing efficiency for established medicines in Europe with a particular focus on demand-side measures: findings and future implications. *Front Pharmacol*, 5, 106.

Godman, B., Fadare, J., Kibuule, D., Irawati, L., Mubita, M., Ogunleye, O., et al. (2017) Initiatives across countries to reduce antibiotic utilization and resistance patterns; impact and implications. Ps 539-576 in *Drug Resistance in Bacteria, Fungi, Malaria, and Cancer - Arora, Sajid, & Kalia Eds. Publisher Springer Nature. ISBN 978-3-319-48682-6*. Available at URL: <https://link.springer.com/content/pdf/bfm%3A978-3-319-48683-3%2F1.pdf>

Greater Glasgow and Clyde Prescribing. (2017) Co-Amoxiclav. Available at URL: <http://www.ggcprescribing.org.uk/formulary/infections/antibacterial-drugs/>

Gustafsson, L. L., Wettermark, B., Godman, B., Andersen-Karlsson, E., Bergman, U., Hasselstrom, J., et al. (2011). The 'wise list'- a comprehensive concept to select, communicate and achieve adherence to recommendations of essential drugs in ambulatory care in Stockholm. *Basic Clin Pharmacol Toxicol*, 108(4), 224-233.

Hassali, M. A., Kamil, T. K., Md Yusof, F. A., Alrasheedy, A. A., Yusoff, Z. M., Saleem, F., et al. (2015). General practitioners' knowledge, attitude and prescribing of antibiotics for upper respiratory tract infections in Selangor, Malaysia: findings and implications. *Expert Rev Anti Infect Ther*, 13(4), 511-520.

Hoxha, I., Malaj, A., Kraja, B., Bino, S., Oluka, M., Marković-Peković, V., Godman, B. Are pharmacists' good knowledge and awareness on antibiotics taken for granted? The situation in Albania and future implications across countries. *Journal of Global Antimicrobial Resistance* (In Press)

HOXHA, I., Malaj A., TAKO, R., MALAJ, L. (2015). Survey on how antibiotics are dispensed in community pharmacies in Albania. *International Journal of Pharmacy and Pharmaceutical Sciences*, 7(7), 449-450.

Huttner, B., Goossens, H., Verheij, T., & Harbarth, S. (2010). Characteristics and outcomes of public campaigns aimed at improving the use of antibiotics in outpatients in high-income countries. *Lancet Infect Dis*, 10(1), 17-31.

Jakovljevic, M. B., Djordjevic, N., Jurisevic, M., & Jankovic, S. (2015). Evolution of the Serbian pharmaceutical market alongside socioeconomic transition. *Expert Rev Pharmacoecon Outcomes Res*, 15(3), 521-530.

Jakovljevic, M.B, Vukovic M., Chen Ching, C., Antunovic, M., Simic Dragojevic, V., Radovanovic Velickovic, R., et al. (2016a). Do Health Reforms Impact Cost Consciousness of Health Care Professionals? Results from a Nation-Wide Survey in the Balkans. *Balkan Med Jn*, 33, 8-

Jakovljevic, M., Lazarevic, M., Milovanovic, O., & Kanjevac, T. (2016b). The New and Old Europe: East-West Split in Pharmaceutical Spending. *Front Pharmacol*, 7, 18.

Jakovljevic, M., Souliotis, K. (2016). Pharmaceutical expenditure changes in Serbia and Greece during the global economic recession *SEEJPH*, 1-17. Available at URL: <file:///C:/Users/mail/Downloads/document.pdf>.

Jinks, T., Lee, N., Sharland, M., Rex, J., Gertler, N., Diver, M., et al. (2016). A time for action: antimicrobial resistance needs global response. *Bull World Health Organ*, 94(8), 558-558a. doi:10.2471/blt.16.181743

Jorgji, K., Bebeci, E., Apostoli, P., & Apostoli, A. (2014). Evaluation of use of antibiotics without prescription among young adults in Albania case study: Tirana and Fier District. *Hippokratia*, 18(3), 217-220.

Kalaba, M., Bajcetic, M., Sipetic, T., Godman, B., Coenen, S., Goossens, H. (2011). High rate of self purchasing of oral antibiotics in Serbia: implications for future policies. PPRI Conference. Vienna 2011. Available at URL:

[http://whocc.goeg.at/Downloads/Conference2011/PraesentationenPPRIKonferenz/general\\_PPRI%20conference%202011%20Abstract%20book.pdf](http://whocc.goeg.at/Downloads/Conference2011/PraesentationenPPRIKonferenz/general_PPRI%20conference%202011%20Abstract%20book.pdf).

Kalaba, M., Godman, B., Vuksanovic, A., Bennie, M., & Malmstrom, R. E. (2012). Possible ways to enhance renin-angiotensin prescribing efficiency: Republic of Serbia as a case history? *J Comp Eff Res*, 1(6), 539-549.

Kibuule, D., Kagoya, H. R., & Godman, B. (2016). Antibiotic use in acute respiratory infections in under-fives in Uganda: findings and implications. *Expert Rev Anti Infect Ther*, 14(9), 863-872

Kostic, M., Djakovic, L., Sujic, R., Godman, B., & Jankovic, S. M. (2017). Inflammatory Bowel Diseases (Crohn s Disease and Ulcerative Colitis): Cost of Treatment in Serbia and the Implications. *Appl Health Econ Health Policy*, 15(1), 85-93.

Laxminarayan, R., Matsoso, P., Pant, S., Brower, C., Rottingen, J. A., Klugman, K., & Davies, S. (2016). Access to effective antimicrobials: a worldwide challenge. *Lancet*, 387(10014), 168-175.

Llor, C., & Bjerrum, L. (2014). Antimicrobial resistance: risk associated with antibiotic overuse and initiatives to reduce the problem. *Ther Adv Drug Saf*, 5(6), 229-241.

Malo, S., Bjerrum, L., Feja, C., Lallana, M. J., Abad, J. M., & Rabanaque-Hernandez, M. J. (2014). The quality of outpatient antimicrobial prescribing: a comparison between two areas of northern and southern Europe. *Eur J Clin Pharmacol*, 70(3), 347-353.

Markovic-Pekovic, V., Stoisavljevic-Satara, S., & Skrbic, R. (2009). Utilisation of cardiovascular medicines in Republic of Srpska, Bosnia and Herzegovina, 5 years study. *Pharmacoepidemiol Drug Saf*, 18(4), 320-326

Markovic-Pekovic, V., Skrbic, R., Godman, B., & Gustafsson, L. L. (2012). Ongoing initiatives in the Republic of Srpska to enhance prescribing efficiency: influence and future directions. *Expert Rev Pharmacoecon Outcomes Res*, 12(5), 661-671.

Markovic-Pekovic, V., & Grubisa, N. (2012). Self-medication with antibiotics in the Republic of Srpska community pharmacies: pharmacy staff behavior. *Pharmacoepidemiol Drug Saf*, 21(10), 1130-1133. doi:10.1002/pds.3218

Markovic-Pekovic, V., Skrbic, R., Petrovic, A., Vlahovic-Palcevski, V., Mrak, J., Bennie, M., et al. (2016). Polypharmacy among the elderly in the Republic of Srpska: extent and implications for the future. *Expert Rev Pharmacoecon Outcomes Res*, 16(5), 609-618.

Markovic-Pekovic, V., Grubisa, N., Burger, J., Bojanic, L., & Godman, B. (2017). Initiatives to Reduce Nonprescription Sales and Dispensing of Antibiotics: Findings and Implications. *J Res Pharm Pract*, 6(2), 120-125.

Martikainen, J. E., Saastamoinen, L. K., Korhonen, M. J., Enlund, H., & Helin-Salmivaara, A. (2010). Impact of restricted reimbursement on the use of statins in Finland: a register-based study. *Med Care*, 48(9), 761-766.

Md Rezal, R. S., Hassali, M. A., Alrasheedy, A. A., Saleem, F., Md Yusof, F. A., & Godman, B. (2015). Physicians' knowledge, perceptions and behaviour towards antibiotic prescribing: a systematic review of the literature. *Expert Rev Anti Infect Ther*, 13(5), 665-680.

Ministry of Health and Social Welfare (MoHSW). (1998). Law on Health Insurance [in Serbian]. The Republic of Srpska Official Gazzette 1999, No 18.

Ministry of Health and Social Welfare. (2008) Pharmacy Practice Law [in Serbian]. The Republic of Srpska Official Gazzette 2008, No 119

Ministry of Health and Social Welfare. (2009) Law on Health Care [in Serbian]. The Republic of Srpska Official Gazette, No 106.

Ministry of Health and Social Welfare. (2010). Law on Protection of Population from Infectious Diseases [in Serbian]. The Republic of Srpska Official Gazette 2010, No 14.

Moon, J. C., Godman, B., Petzold, M., Alvarez-Madrazo, S., Bennett, K., Bishop, I., et al. E. (2014). Different initiatives across Europe to enhance losartan utilization post generics: impact and implications. *Front Pharmacol*, 5, 219.

Mukokinya, M.M., Opanga, S., Oluka, M., Godman, B. (2018) Dispensing of antimicrobials in Kenya; a cross sectional pilot study and its implications. *Journal of Research in Pharmacy Practice* (In Press)

NHS Scotland. (2014) National Therapeutic Indicators 2014/ 2015. Available at URL: <http://www.sehd.scot.nhs.uk/publications/DC20141201nti.pdf>

O'Neill, J. (2015). Securing new drugs for future generations: the pipeline of antibiotics. The review of antimicrobial resistance. Available at URL: [https://amr-review.org/sites/default/files/SECURING%20NEW%20DRUGS%20FOR%20FUTURE%20GENERATIONS%20FINAL%20WEB\\_0.pdf](https://amr-review.org/sites/default/files/SECURING%20NEW%20DRUGS%20FOR%20FUTURE%20GENERATIONS%20FINAL%20WEB_0.pdf).

Oxford, J., & Kozlov, R. (2013). Antibiotic resistance--a call to arms for primary healthcare providers. *Int J Clin Pract Suppl*(180), 1-3.

Parliamentary assembly of Bosnia and Herzegovina. (2008) Law on Medicines and Medical Devices [in Serbian, Croatian, Bosnian]. Bosnia and Herzegovina Official Gazette 2008, No 58.

Pejcic, A. V., & Jakovljevic, M. (2017). Pharmaceutical expenditure dynamics in the Balkan countries. *J Med Econ*, 20(10), 1013-1017.

Petrusic, T., & Jakovljevic, M. (2015). Budget Impact of Publicly Reimbursed Prescription Medicines in the Republic of Srpska. *Front Public Health*, 3, 213.

Putrik, P., Ramiro, S., Kvien, T. K., Sokka, T., Pavlova, M., Uhlig, T., & Boonen, A. (2014). Inequities in access to biologic and synthetic DMARDs across 46 European countries. *Ann Rheum Dis*, 73(1), 198-206.

Rezal, R. S., Hassali, M. A., Alrasheedy, A. A., Saleem, F., Yusof, F. A., Kamal, M., et al. (2015). Prescribing patterns for upper respiratory tract infections: a prescription-review of primary care practice in Kedah, Malaysia, and the implications. *Expert Rev Anti Infect Ther*, 13(12), 1547-1556.

Saleem, Z., Saeed, H., Ahmad, M., Yousaf, M., Hassan, H. B., Javed, A., et al. (2016). Antibiotic Self-Prescribing Trends, Experiences and Attitudes in Upper Respiratory Tract Infection among Pharmacy and Non-Pharmacy Students: A Study from Lahore. *PLoS One*, 11(2), e0149929.

Sakshaug, S., Furu, K., Karlstad, O., Ronning, M., & Skurtveit, S. (2007). Switching statins in Norway after new reimbursement policy: a nationwide prescription study. *Br J Clin Pharmacol*, 64(4), 476-481.

Sermet, C., Andrieu, V., Godman, B., Van Ganse, E., Haycox, A., & Reynier, J. P. (2010). Ongoing pharmaceutical reforms in France: implications for key stakeholder groups. *Appl Health Econ Health Policy*, 8(1), 7-24.

Shallcross, L. J., Howard, S. J., Fowler, T., & Davies, S. C. (2015). Tackling the threat of antimicrobial resistance: from policy to sustainable action. *Philosophical Transactions of the Royal Society B: Biological Sciences*, 370(1670), 20140082.

Tacconelli, E., Carrara, E., Savoldi, A., Harbarth, S., Mendelson, M., Monnet, D. L., et al. (2017). Discovery, research, and development of new antibiotics: the WHO priority list of antibiotic-resistant bacteria and tuberculosis. *Lancet Infect Dis*.

Taylor J, H. M., Yerushalmi E, Smith R, Bellasio J, Vardavas R, et al. (2014). Estimating the economic costs of antimicrobial resistance: model and results. Available at URL: [http://www.rand.org/content/dam/rand/pubs/research\\_reports/RR900/RR911/RAND\\_RR911.pdf](http://www.rand.org/content/dam/rand/pubs/research_reports/RR900/RR911/RAND_RR911.pdf).

van Dijk, L., de Jong, J. D., Westert, G. P., & de Bakker, D. H. (2011). Variation in formulary adherence in general practice over time (2003-2007). *Fam Pract*, 28(6), 624-631.

Versporten, A., Bolokhovets, G., Ghazaryan, L., Abilova, V., Pyshnik, G., Spasojevic, T., et al. (2014). Antibiotic use in eastern Europe: a cross-national database study in coordination with the WHO Regional Office for Europe. *Lancet Infect Dis*, 14(5), 381-387. doi:10.1016/s1473-3099(14)70071-4

Voncina, L., Strizrep, T., Godman, B., Bennie, M., Bishop, I., Campbell, S., et al. (2011). Influence of demand-side measures to enhance renin-angiotensin prescribing efficiency in Europe: implications for the future. *Expert Rev Pharmacoecon Outcomes Res*, 11(4), 469-479. doi:10.1586/erp.11.42

Wettermark, B., Godman, B., Neovius, M., Hedberg, N., Mellgren, T. O., & Kahan, T. (2010). Initial effects of a reimbursement restriction to improve the cost-effectiveness of antihypertensive treatment. *Health Policy*, 94(3), 221-229. doi:10.1016/j.healthpol.2009.09.014

Wettermark, B., Pehrsson, A., Juhasz-Haverinen, M., Veg, A., Edlert, M., Tornwall-Bergendahl, G., et al (2009). Financial incentives linked to self-assessment of prescribing patterns: a new approach for quality improvement of drug prescribing in primary care. *Qual Prim Care*, 17(3), 179-189.

WHO. (2001). Global Strategy for Containment of Antimicrobial Resistance. Geneva, 2001. Available at URL: [http://www.who.int/drugresistance/WHO\\_Global\\_Strategy\\_English.pdf](http://www.who.int/drugresistance/WHO_Global_Strategy_English.pdf)

WHO. (2011). European strategic action plan on antibiotic resistance. Available at URL: [http://www.euro.who.int/data/assets/pdf\\_file/0008/147734/wd14E\\_AntibioticResistance\\_111380.pdf](http://www.euro.who.int/data/assets/pdf_file/0008/147734/wd14E_AntibioticResistance_111380.pdf)

WHO. (2015) Global action plan on antimicrobial resistance. Available at URL: <http://www.who.int/antimicrobial-resistance/publications/global-action-plan/en/>.

WHO. (2017) WHO Collaborating Centre for Drug Statistics Methodology. ATC/ DDD Index. Available at URL: <https://www.whocc.no/>.

WHO Europe. (2017) Antimicrobial Medicines Consumption (AMC) Network. Available at URL: <http://www.euro.who.int/en/publications/abstracts/antimicrobial-medicines-consumption-amc-network.-amc-data-20112014-2017>.

WHO. (2018). Antimicrobial resistance. Fact Sheet. 2018. Available at URL: <http://www.who.int/mediacentre/factsheets/fs194/en/>.

Yu, M., Zhao, G., Stålsby Lundborg, C., Zhu, Y., Zhao, Q., & Xu, B. (2014). Knowledge, attitudes, and practices of parents in rural China on the use of antibiotics in children: a cross-sectional study. *BMC Infectious Diseases*, 14, 112-112.