Doping Practices in International Weightlifting: Analysis of sanctioned athletes/support personnel from 2008-2019 and retesting of samples from the 2008 and 2012 Olympic Games

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Abstract

Background The pervasiveness of doping and findings of anti-doping corruption threaten weightlifting's position at the 2024 Olympics. Analysing the practices of doping weightlifters could identify patterns in doping that assist in future detection.

Methods We analysed publicly available data on sanctioned athletes/support personnel from the International Weightlifting Federation (IWF) between 2008–2019 and retrospective Anti-Doping Rule Violations (ADRVs) from the 2008 and 2012 Olympics.

Results There were 565 sanctions between 2008–2019 of which 82% related to exogenous and endogenous Anabolic Androgenic Steroids (AAS). The distribution of exogenous AAS, endogenous AAS and other detected substances varied by IWF Continental Federation ($p \leq 0.05$) with Europe (74%, 11%, 15%) and Asia (70%, 15%, 15%) showing a higher detection of exogenous AAS compared to Pan America (37%, 30%, 33%) and Africa (50%, 17%, 33%). When looking at the 10 most detected substances, the nations with the highest number of sanctions (range 17–35) all had at least one overrepresented substance that accounted for 38–60% of all detected substances. The targeted re-analysis of samples from the 2008 and 2012 Olympics due to the discovery of long-term metabolites for exogenous AAS has to date produced 61 retrospective ADRVs in weightlifting. Of these, 34 were original medallists (9 Gold, 10 Silver and 15 Bronze), the highest of any sport. The exogenous AAS Dehydrochloromethyltestosterone and Stanozolol accounted for 83% of detected substances and were present in 95% of these samples.

Conclusion Based on these findings of regional differences in doping practices, weightlifting would benefit from the targeted testing of certain regions and continuing investment in long-term sample storage as the sensitivity and specificity of detection continues to improve.

Key Points

- The nations with the highest number of sanctioned weightlifters between 2008–2019 (the worst period for doping in weightlifting's history) all had at least one overrepresented detected substance that accounted for 38–60% of all detected substances.
- Improvements in the detection window for exogenous anabolic steroids resulted in samples from the 2008 and 2012 Olympic Games being re-analysed and to date weightlifting has produced 61 retrospective Anti-Doping Rule Violations (ADRVs) with the highest number of medallists (34) across all sports.
- These findings suggest that weightlifting would benefit from the targeted testing of certain regions and further invest in long-term sample storage at other major competitions (i.e. World and Continental Companionships).

1 Introduction

By June 2017 a targeted re-analysis of samples collected from the Beijing 2008 and London 2012 Olympic Games had resulted in thirty weightlifters having their medals rescinded as they had retrospectively been identified to have committed an anti-doping rule violation (ADRV) (1, 2). At this time Thomas Bach the International Olympic Committee (IOC) President said weightlifting had “a massive doping problem” (3) and the IOC Executive Board instructed the International Weightlifting Federation (IWF) to demonstrate by December 2017 that it had addressed, or had put in place plans to address, the serious incidence of doping if the sport was to be considered for inclusion in the 2024 Olympic Games (4). This targeted reanalysis took advantage of improvements in the detection window of Exogenous Anabolic Androgenic Steroids (AAS) via the discovery of the long-term metabolites (LTMs) for compounds such as Metandienone, Dehydrochloromethyltestosterone and Stanozolol (5).

In response, the IWF created two new independent commissions to advise on anti-doping policy changes which eventually became the Clean Sport and Sport Programme Commissions (6, 7). Additionally, the IWF started a series of actions to combat doping and in 2017 announced one-year suspensions for nine Member Federations (MFs) found to have had three or more ADRVs from the retesting of samples taken at the 2008 and 2012 Olympic Games (8). The IWF also enforced a new qualification system for the Tokyo 2020 Olympic Games (9) and each athlete must compete in a minimum of six eligible events that occur within defined time frames to increase the likelihood of being tested in-competition prior to the Games. This will include at least one event between 1 October 2020 and 30 April 2021 to account for the coronavirus pandemic delaying the Games (9, 10). The IWF also announced limitations on MFs for participants per country for the 2020 Games based on the MFs doping record since the start date of the 2008 Games and the end of the 2020 qualification period (9). MFs that had 20 or more ADRVs would be able to send only one male and one female athlete in total; MFs that recorded 10–19 ADRVs would be eligible to send two male and two female athletes; and MFs with less than ten ADRVs would be eligible to send four male and four female athletes (9). The IWF also signed an agreement with the International Testing Agency (ITA) to take responsibility for key areas of its anti-doping programme and once this partnership was finalised the IOC lifted the conditional status of weightlifting for the 2024 Games, citing the positive steps taken by the IWF to combat doping (11, 12). However, the IOC still reserves it’s right to review weightlifting’s place on the 2024 Olympic Programme, due to the recent revelations of anti-doping corruption in the sport (13).

The Hungarian Anti-Doping Group (HUNADO), who carried out a large proportion of the anti-doping tests requested by the IWF in the last decade, and both the IWF and ex-President Tamás Aján, who’s tenure started in 2000, have had recent accusations of anti-doping corruption with irregularities in Out of Competition (OOC) testing, urine sample manipulation and the disappearance of positive doping results (14) which eventually resulted in Aján’s resignation in April 2020 (15). An independent report concluded that HUNADO had acted in accordance with World Anti-Doping Agency (WADA) standards (16). However, the report concluded that former President Tamás Aján had breached confidential information for the planned dates of OOC testing potentially leaking this information to certain nations or athletes (16). The IWF also deliberately delayed notifying 18 Azerbaijani athletes of their ADRVs, thus enabling them to win medals at international competitions in 2013 (16). The report also identified 62 cases in which adverse

analytical findings had not been followed through or appropriately recorded by the IWF (16). The investigators forwarded these cases and an additional 10 possible cases onto WADA for investigation (16). DNA analysis also confirmed that two urine samples, collected OOC prior to the 2015 World Championships, were manipulated as there was a mismatch in the DNA contained within the urine and the designated athlete who was asked to provide a sample (16). Further investigations still pending on other samples collected OOC prior to this competition (16).

The aim of this analysis of the doping practices of international weightlifters is to aid the sport fight doping as its ongoing commitment to clean sport is required to allow the sport to be on the 2024 Olympic Program (13). By identifying salient prohibited substances by geographical location, a clearer picture of doping practices can be developed. This will aid governing bodies and National Anti-Doping Agencies in improving targeted testing. Analysis of retrospective ADRVs from stored samples will also demonstrate to prospective doping athletes the improvements made in detection science (from LMT discovery (5)) and act as a future deterrent.

2 Methods

2.1 Data entry

Data from 2008 to 2019 was obtained from the IWF Sanction List publicly available on the IWF website (17) in February 2020. For weightlifters who had announced retrospective ADRVs from either the 2008 or 2012 Olympic Games, data was obtained from the IWF Sanction List (17), IOC “Fight Against Doping” Press Releases (18), IOC (19, 20) and IWF Event Results Pages (21, 22) and IWF Anti-Doping News Archives (23) in mid-May 2020. All detected substance names were made uniform and identified to the parent compound which generated the noted metabolite.

For classification of substances as Endogenous AAS (EAAS) WADA technical documents were utilised (24). These state that EAAS administration can cause alterations in the markers of the urinary steroid profile which is comprised of: androsterone, etiocholanolone, 5α-androstane-3α,17β-diol (5αAdiol), 5β-androstane-3α,17β-diol (5βAdiol), testosterone and epitestosterone. Additionally, the administration of testosterone or its precursors, androstenediol, androstenedione, dehydroepiandrosterone or a testosterone metabolite, dihydrotestosterone, or a masking agent such as epitestosterone are proven to alter one or more of the parameters of the urinary steroid profile (25) and therefore any mention of a component of the urinary steroid profile or these substances was denoted as detection of the usage of EAAS.

Each sanction was classified based on: (1) the IWF Continental Federation (Africa, Asia, Europe, Oceania, Pan America), and (2) the category of the detected substance/prohibited method as described by the 2019 WADA Prohibited List (26). Three sanctions were omitted from any analyses that involved comparisons of, or counts of, detected substances/prohibited methods because this information was absent or only the article number that was violated by the Anti-Doping Policy of the IWF was stated.

2.2 Statistical analysis

Fishers exact test was used to investigate if four IWF Continental Federations (Europe, Africa, Asia, Pan America) had differences in the detection of Exogenous AAS, Endogenous AAS and other substances, in a 4 × 3 matrix, from the sanctions between 2008–2019 obtained from the IWF Sanction List publicly available on the IWF website (17) in February 2020. An adjusted alpha level of < 0.05 was used with the Benjamini–Hochberg (27) false discovery rate method for multiple comparisons. Data analysis was conducted using R version 3.6.3 (28) using the tidyverse (29), data.table (30) rcompanion (31) choroplethr (32) and choroplethrMaps (33) packages. The data files and R code used in this study have been made publicly available online (34).

3 Results

3.1 The most frequently detected substances

Five hundred and sixty-five Sanctioned Athletes/Athlete Support Personnel, across 83 different MF, were recorded between 2008 and 2019 (Fig. 1). Five hundred and sixty-two of these sanctions had a named prohibited substance/prohibited method noted. Five hundred and fifty-nine of these sanctions occurred due to the detection of prohibited substances, with only three sanctions occurring due to the use of prohibited methods ($n = 2$ urine substitution, $n = 1$ blood substitution). Of these 559 sanctions, 51 different substances were detected, from 10 different categories within the WADA Prohibited List, with Exogenous and Endogenous AAS accounting for 82% of detected substances (Fig. 2).

Three hundred and ninety-six sanctions occurred from an in-competition (IC) test and 167 from an OOC test with two sanctions testing location undefined. From the ten most detected substances, six substances, Dehydrochloromethyltestosterone (89%), EAAS (76%), Metenolone (100%), Methylhexanamine (100%), Methyltestosterone (71%) and Nandrolone (86%) showed a higher instance of detection IC (Fig. 2).

3.2 Prohibited substance usage and Continental Federation

Of the 565 Sanctioned Athletes/Athlete Support Personnel counted 199 were from Asia, 267 from Europe, 34 from Africa, and 65 from Pan America. There were no sanctions from Oceania. From the 562 sanctions that had the available data, the proportion of detected substances that were classified as Exogenous AAS, Endogenous AAS (i.e. the most detected substances) and all other substance category types varied by IWF Continental Federation ($p < 0.001$). The proportions of these detected substance types was significantly different between Asia (70%, 15%, 15%) and Pan America (37%, 30%, 33%) ($p < 0.001$), Asia and Africa (50%, 17%, 33%) ($p = 0.039$), Europe (74%, 11%, 15%) and Pan America ($p < 0.001$) and Europe and Africa ($p = 0.015$) with no differences between Asia and Europe or Pan America and Africa, highlighting regional differences in detected prohibited substances.

3.3 Prohibited substance usage and nation

For the 10 nations with the highest number of sanctions, when looking at the 10 most detected substances, each nation had at least one substance that accounted for more than one third of all

detected substances as follows: Azerbaijan (Metandienone 38%), Kazakhstan (Stanozolol 51%), Russia (Dehydrochloromethyltestosterone 52%), Bulgaria (Metandienone 42% and Stanozolol 45%), Belarus (Stanozolol 44%), Armenia (Stanozolol 38%), Ukraine (Dehydrochloromethyltestosterone 40% and Stanozolol 40%), Romania (Stanozolol 60%), Thailand (Metandienone 50% and EAAS 50%) and Moldova (Dehydrochloromethyltestosterone 37%) (Fig. 3).

3.4 Most Affected Nations of 2008 and 2012 Retesting

At the time of analysis, 61 athletes, from 13 different countries, were retrospectively announced to have committed an ADRV via testing positive for prohibited substances from the Beijing 2008 ($n = 25$) and London 2012 ($n = 36$) Olympic Games. Sixteen athletes (64%) with an announced retrospective ADRV from Beijing 2008 were medallists (4 Gold, 5 Silver and 7 Bronze). For Beijing 2008 Kazakhstan and Azerbaijan had more athletes (55% and 60%, respectively) generate a retrospective ADRV than those who did not and for Belarus, Ukraine, Russia, and Kazakhstan more medals were won by athletes who generated a retrospective ADRV (66%, 100%, 57% and 75%, respectively), than those who have not (Fig. 4). Eighteen athletes (50%) with an announced retrospective ADRV from London 2012 were medallists (5 Gold, 5 Silver and 8 Bronze). For London 2012 Russia, Kazakhstan, Belarus, Azerbaijan, and Armenia had more athletes generate a retrospective ADRV (66%, 62.5%, 62.5%, 60% and 60%, respectively), than those who have not and for both Romania and Moldova all athletes that competed generated a retrospective ADRV. All medallists from Ukraine, Kazakhstan, Belarus, Romania, Azerbaijan, Armenia, and Moldova generated a retrospective ADRV and for Russia twice as many medals were won by athletes who generated a retrospective ADRV (Fig. 4).

3.5 Most Affected Categories of 2008 and 2012 Retesting

From Beijing 2008 five weight categories, (Men’s u94kg, Women’s u48kg, Women’s u69kg, Women’s u75kg, and Women’s 75kg+) and from London 2012 three weight categories, (Women’s u53kg, Women’s u63kg and Women’s u69kg) had two medallists produce retrospective ADRVs. In two instances from London 2012 (Men’s u94kg and Women’s u75kg) all medal winners produced retrospective ADRVs, with the Men’s u94kg category being the worst affected with eight athletes generating retrospective ADRVs, six of whom originally placed in the top 10.

3.6 Detected Substances from 2008 and 2012 Retesting

In total, across both the Beijing 2008 and London 2012 Games, 94 prohibited substances were detected with Dehydrochloromethyltestosterone and Stanozolol accounting for 83% of all detected substances. The majority of retrospective ADRVs (58 of 61) contained one of these two substances with Exogenous AAS accounting for 94% of all detected substances. Across both Games, for the 10 nations with the highest number of announced retrospective ADRVs the proportions of detected substances are shown in Fig. 5. For each nation there is at least one substance that makes up ≥ 40% of all detected substances as follows: Kazakhstan (Stanozolol 67%), Russia (Dehydrochloromethyltestosterone 71%), Belarus (Dehydrochloromethyltestosterone 44%, Stanozolol 44%), Azerbaijan (Dehydrochloromethyltestosterone

67%), Armenia (Dehydrochloromethyltestosterone 50%, Stanozolol 50%), Turkey (Stanozolol 71%), Romania (Metenolone 40%, Stanozolol 40%), Ukraine (Dehydrochloromethyltestosterone 100%), China (Growth Hormone-Releasing Peptide-2 75%) and Moldova (Dehydrochloromethyltestosterone 67%).

4 Discussion

The time period of this analysis has seen the highest number of ARDVs in weightlifting's history. It has also seen an independent investigation into allegations of anti-doping corruption finding the IWF president to have breached the confidentiality of the planned timing of OOC sample collection, potentially giving advanced notice of OOC testing to individual countries or athletes (16). The president also delayed announcement of ADRVs from 18 Azerbaijani athletes, enabling them to win medals in international events and more than 60 ARDVs have not been followed through properly by the IWF during this time period (16). These missing ADRVs and OOC samples collected prior to the 2015 World Championships where urine manipulation was confirmed to have occurred in two athletes, are still under further investigation (16). This study intended to build a clearer picture of doping practices of weightlifters and how these practices varied across the IWF Continental Federations to enhance future targeted testing.

Over an 11-year period Exogenous and Endogenous AAS accounted for 82% of detected substances from the IWF Sanction List. The effects of AAS on increasing skeletal muscle mass and strength have been well documented (35–40) and these ergogenic benefits are a likely reason for their preference of usage by doping athletes who compete in a strength sport. Europe generated the highest number of sanctions followed by Asia, Pan American and Africa, with no sanctions from Oceania recorded. The proportions of detected Exogenous AAS, Endogenous AAS and all other substance category types varied by IWF Continental Federation. Europe and Asia both respectively showed statistically different ($p < 0.05$) proportions of detection for these three substance types compared to both Africa and Pan America with Exogenous AAS showing the largest difference in the proportion of substance types detected. The most detected Exogenous AAS were Stanozolol, Metandienone and Dehydrochloromethyltestosterone. The preferential usage of these substances from doping athletes in Europe and Asia is likely due to drug availability, through either illegitimate underground sources or through legitimate pharmacies, and societal/historical influence of the usage of certain compounds. Data suggests, once a compound is identified to cause performance enhancement in a certain region, doping athletes or those who supply athletes, pass this information around other willing dopers. This may in turn create a cultural propagation in usage. At the national level there is also a pattern of preferential usage of certain compounds for performance enhancement as when looking at the 10 most detected substances, from the 10 nations with the highest numbers of sanctions, there is at least one substance overrepresented that accounts for 38–60% of detected substances in these countries (Fig. 3). These geographic differences in doping practices could better inform targeted testing applied by anti-doping authorities. For effective doping control international sporting authorities should have anti-doping programs that frequently conduct unannounced OOC testing, across all regions of the globe, to catch doping athletes who intend for prohibited metabolites to clear their urine prior to anticipated IC tests. With Europe and Asia showing the highest number of sanctions and highest prevalency in the usage of Exogenous AAS an extra emphasis

on OOC testing in these regions may be warranted in weightlifting as these substances are likely to be used in training prior to competition where anticipated testing occurs. Furthermore, the overrepresentation of certain detected substances at the national level suggests that targeted educational programs for athletes and support personnel are required to change the consistent pattern of the usage of certain compounds. This finding also corroborates with the notion from the independent report into Anti-Doping corruption into weightlifting that although the ex-president "interfered with the IWF Anti-Doping Commission, *the real problem is the culture of doping that exists in the sport*." (16).

The decision of the IOC to store athletes' samples collected from Olympic Games for 10 years has proven particularly fruitful in weightlifting. The discovery of LTMs has shown that the intention of doping athletes who ceased the usage of Exogenous AAS prior to the 2008 and 2012 Games with the aim of diagnostic metabolites clearing their urine prior to an anticipated test, failed, with Dehydrochloromethyltestosterone and Stanozolol accounting for 83% of detected substances with 95% of announced athlete ADRVs noting at least one of these substances. These findings should send a strong deterrent to prospective doping athletes that, due to LMT discovery, the detection window of these substances has substantially improved and the doping practices of athletes in the runup to the 2008 and 2012 Games may not be possible anymore for future competitions. The IOC has announced that the ITA has planned the "most comprehensive pre-Games testing programme ever conducted" for Tokyo 2020 and that $5 million, spread over 10 years, will be allocated to a comprehensive long-term storage programme (41, 42), potentially acting as a stronger deterrent to prospective doping weightlifters. However, long-term storage is not standard across Continental Games, with the International Federations (IF) having to fund the cost of long-term storage (43). Based on the success shown with weightlifting, the IWF and other IF should further their investment in long term sample storage at Continental Games and other important international competitions to enhance future doping detection.

This analysis of doping practices, over a period of 11 years, has shown avenues that may enhance the future detection of doping weightlifters. For example, with Europe and Asia producing the highest numbers of sanctioned weightlifters, as well as the highest prevalence in the detection of Exogenous AAS, higher rates of targeted OCC testing in these regions may be warranted. Educational programmes on anti-doping may also be required to change the behaviour in nations with the highest number of sanctions especially focussing on detected substances that are overrepresented in their doping weightlifters. Lastly, the prevalence of retrospectively identified doping at the Beijing and London Games shows that the long-term storage of samples should continue, with the aim of increasing this practice at additional competitions to the Olympic Games, as anti-doping science continues to improve its detection methods.

Abbreviations

ADRV
Anti-Doping Rule Violations
AAS

Anabolic Androgenic Steroids
EAAS
Endogenous Anabolic Androgenic Steroids
HUNADO
Hungarian Anti-Doping Group
IC
In-Competition
IOC
International Olympic Committee
ITA
International Testing Agency
IWF
International Weightlifting Federation
LTMs
Long-Term Metabolites
MF
Member Federations
OOC
Out of Competition
WADA
World Anti-Doping Agency

Declarations

Ethics approval and consent to participate

Not applicable

Consent for publication

Not applicable

Availability of data and material

The CSV files that contain the data from this study and R Code used in this study are publicly available on OSF: https://osf.io/8j6ya/

Competing interests

Alexander Kolliari-Turner, Brian Oliver, Giscard Lima,3, John P. Mills, Guan Wang, Yannis Pitsiladis and Fergus M Guppy declare that they have no conflicts of interest that are directly relevant to the content of this letter.

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Authors' contributions

Conceptualization: [Alexander Kolliari-Turner]; Data curation [Alexander Kolliari-Turner]; Investigation [Alexander Kolliari-Turner]; Formal analysis: [Alexander Kolliari-Turner]; Methodology: [Alexander Kolliari-Turner, Fergus M Guppy]; Project Administration [Yannis Pitsiladis, Fergus M Guppy]; Software [Alexander Kolliari-Turner]; Supervision: [Guan Wang, Yannis Pitsiladis, Fergus M Guppy]; Visualization [Alexander Kolliari-Turner, John P. Mills, Guan Wang, Fergus M Guppy]; Writing - original draft preparation: [Alexander Kolliari-Turner, Brian Oliver]; Writing - review and editing: [Alexander Kolliari-Turner, Brian Oliver, Giscard Lima, John P. Mills, Guan Wang, Yannis Pitsiladis, Fergus M Guppy].

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Figures

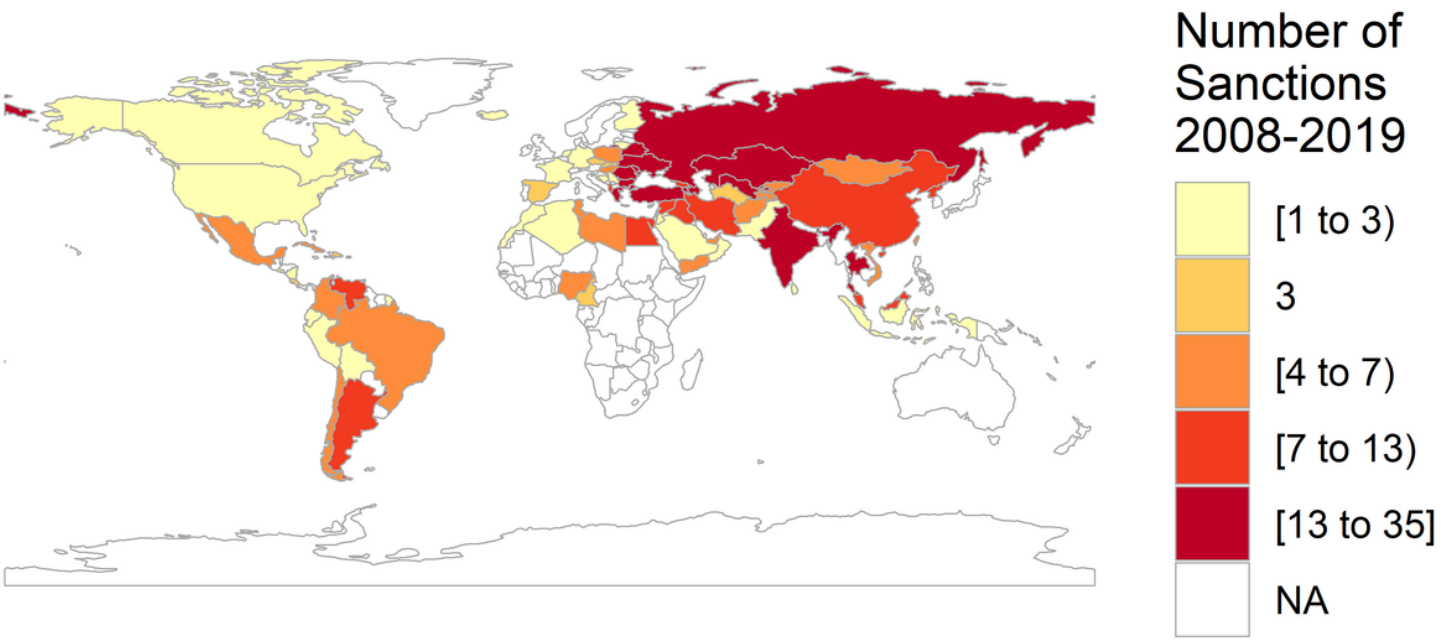

Figure 1

The number of sanctions recorded from the IWF Sanction List (17) between 2008-2019 when it was accessed in February 2020 and their geographical location. NA indicates zero recorded sanctions. Five hundred and sixty-five sanctions were recorded but 553 were used for the creation of this Figure as the following Member Federations (MF) were not present in the country.map dataset in the choroplethrMaps (32) package in R: Puerto Rico (n = 3), Mauritius (n = 2), Palestine (n = 2), Seychelles (n = 2), Aruba (n = 1), Barbados (n = 1) and Bahrain (n = 1). Note: The designations employed and the presentation of the material on this map do not imply the expression of any opinion whatsoever on the part of Research Square concerning the legal status of any country, territory, city or area or of its authorities, or concerning the delimitation of its frontiers or boundaries. This map has been provided by the authors.

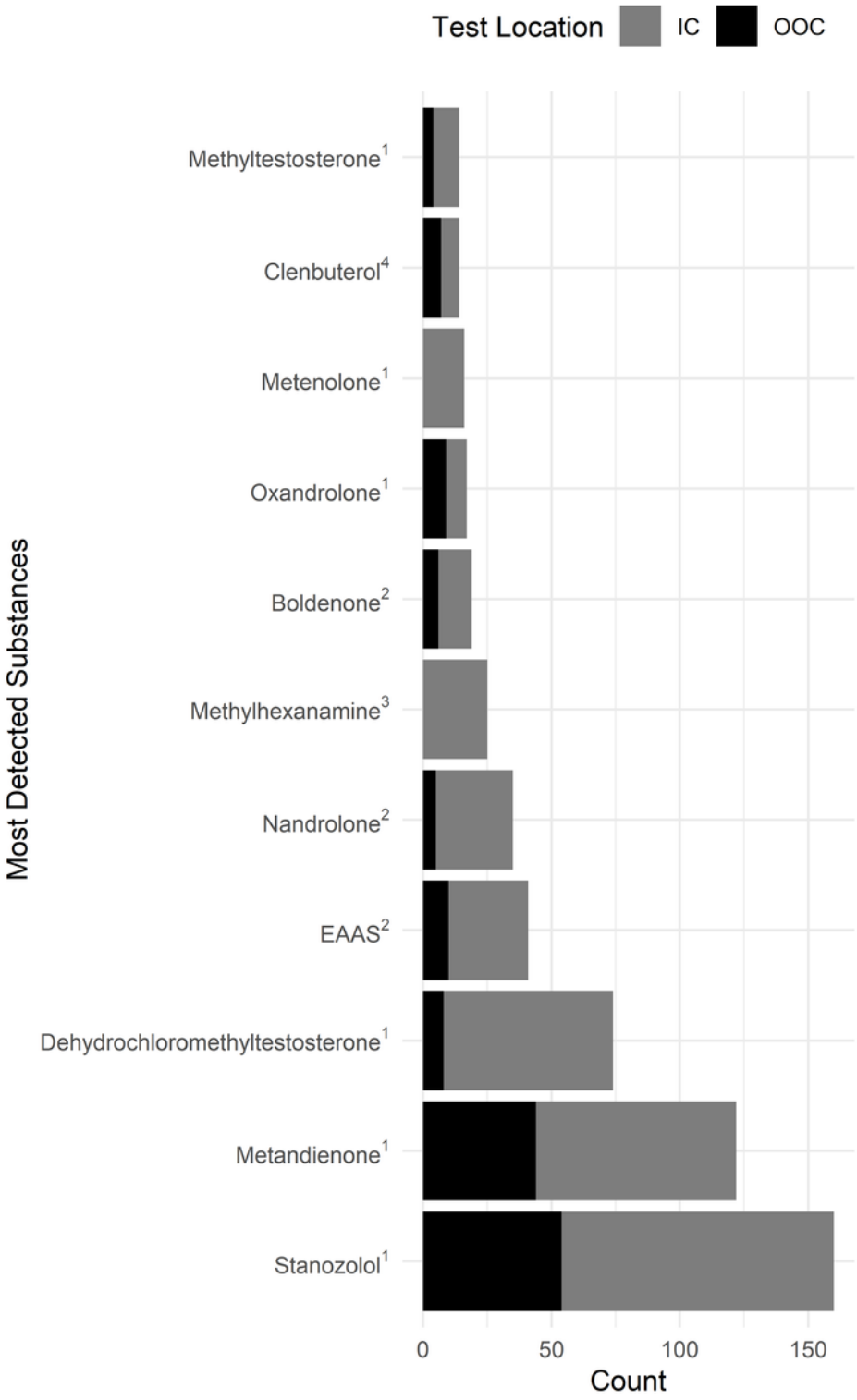

Figure 2

The 10 most detected substances from the IWF Sanction List (17) between 2008 to 2019 and if their detection occurred in-competition (IC) or out-of-competition (OOC) with superscript numbers classifying substances based on the WADA 2019 Prohibited List: Exogenous Anabolic Androgenic Steroid (AAS)1; Endogenous AAS (EAAS)2; Specified Stimulants3; Other Anabolic Agents4 (26). Clenbuterol and

Methyltestosterone are tied in 10th place with 14 occasions of detection each. One data point for Methandienone was omitted as the testing location was not defined.

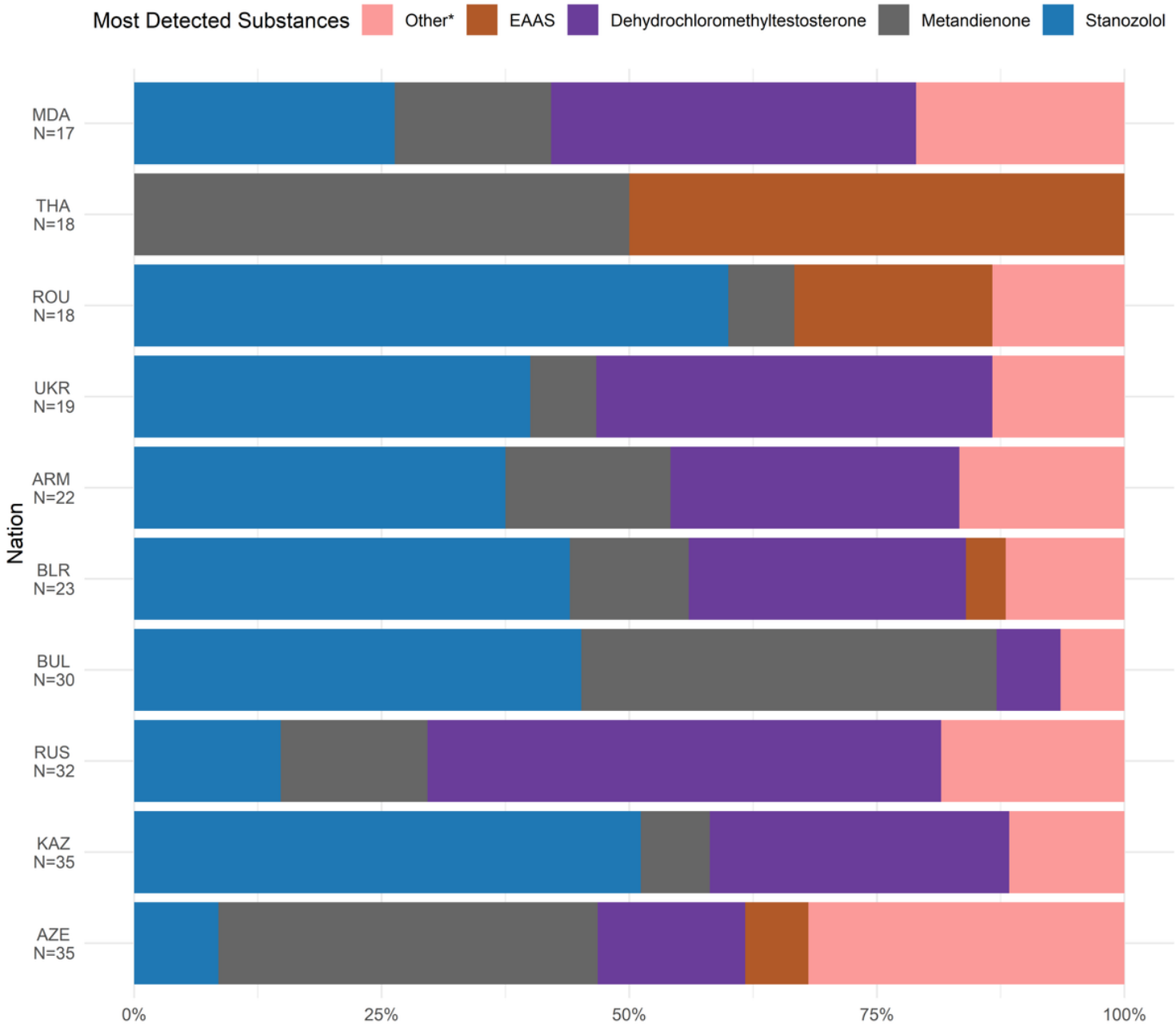

Figure 3

The 10 nations with the highest number of sanctions, from the IWF Sanction List (17) between 2008 to 2019 and for the 10 most detected substances the percentage of times they were detected. Other* denotes either Methyltestosterone, Clenbuterol, Metenolone, Oxandrolone, Boldenone, Methylhexanamine or Nandrolone. EAAS; Endogenous Anabolic Androgenic Steroid. AZE; Azerbaijan, KAZ; Kazakhstan, RUS; Russia, BUL; Bulgaria, BLR; Belarus, ARM; Armenia, UKR; Ukraine, ROU; Romania, THA; Thailand, MDA; Moldova.

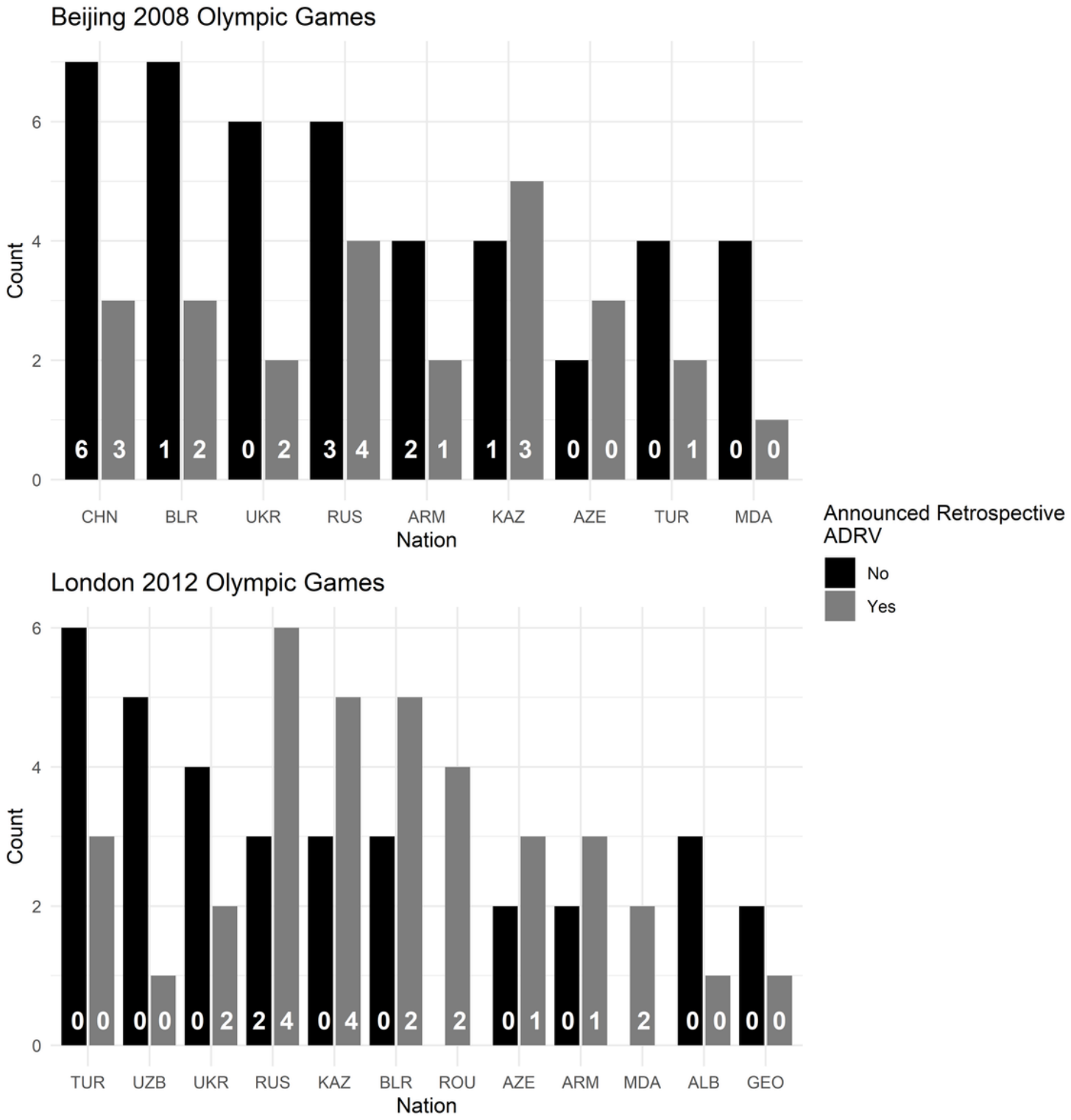

Figure 4

The number of weightlifters that competed from each nation announced to have given retrospective Anti-Doping Rule Violation(s) (ADRV) from the Beijing 2008 and London 2012 Olympic Games. Numbers inside bars show the number of original medallists. Weightlifters with announced retrospective ADRV who did not start are included. In Beijing 2008 one athlete from UKR committed an ADRV during the games and is excluded in these counts. CHN; China, BLR; Belarus, UKR; Ukraine, RUS; Russia, ARM;

Armenia, KAZ; Kazakhstan, AZE; Azerbaijan, TUR; Turkey, MDA; Moldova, UZB; Uzbekistan, UKR; Ukraine, ROU; Romania, ALB; Albania, GEO; Georgia

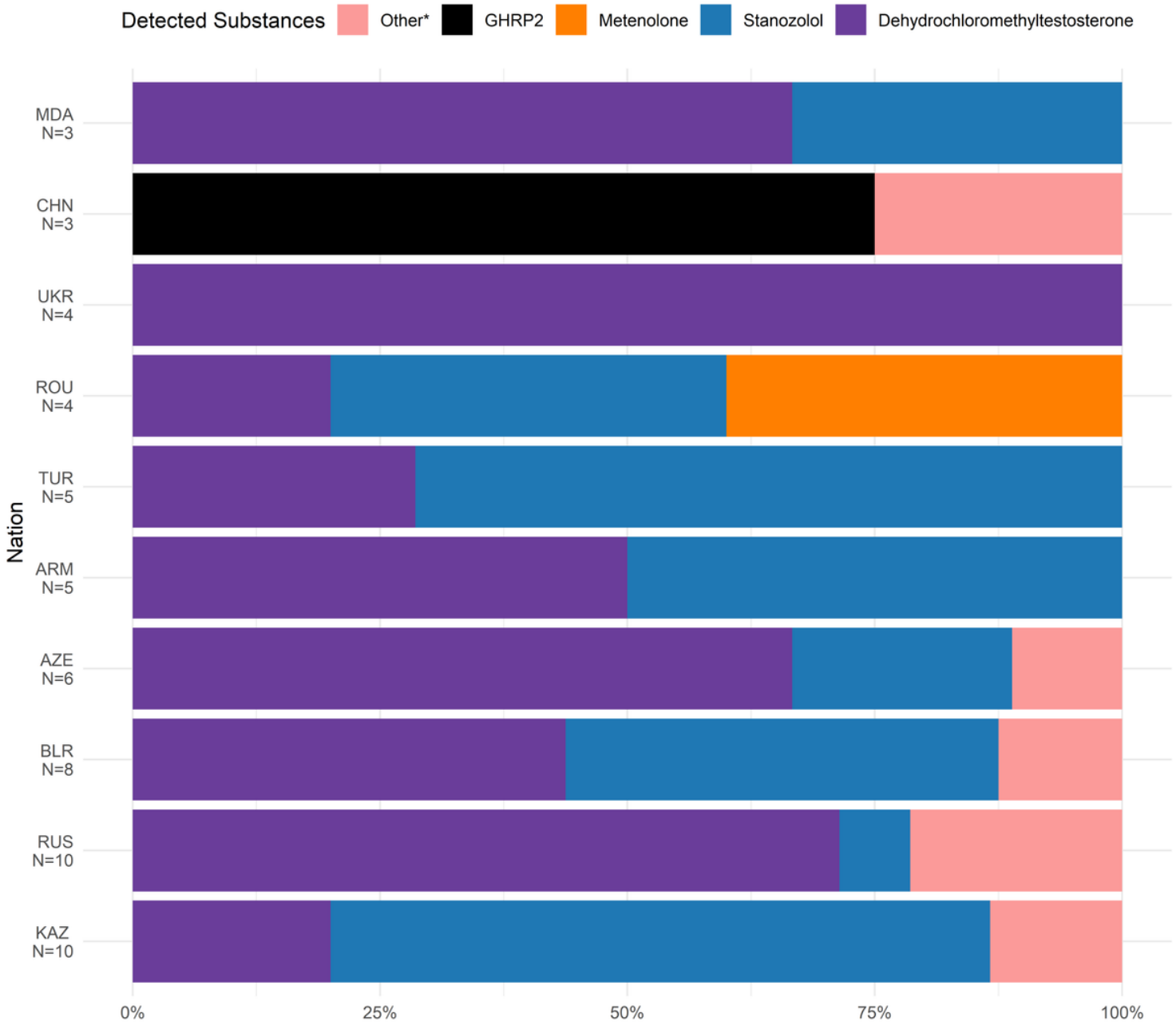

Figure 5

The 10 nations with the highest number of announced retrospective Anti-Doping Rule Violations (ADRVs) from both the Beijing 2008 and London 2012 Olympic Games and the percentages of detected substances identified. Other* denotes either Drostanolone, Erythropoietin, Oxandrolone, Sibutramine or Tamoxifen. GHRP2: Growth Hormone-Releasing Peptide-2. KAZ; Kazakhstan, RUS; Russia, BLR; Belarus, AZE; Azerbaijan, ARM; Armenia, TUR; Turkey, ROU; Romania, UKR; Ukraine, CHN; China, MDA; Moldova.