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DOI:
10.1080/09687637.2022.2070058

Document Version
Publisher's PDF, also known as Version of record

Citation for published version (Harvard):
Hope, VD, Bond, VW, Boardley, I, Smith, J, Campbell, J, Bates, G, Ralphs, R, Hout, M-CV & McVeigh, J 2023, 'Anabolic androgenic steroid use population size estimation: a first stage study utilising a Delphi exercise', *Drugs: Education, Prevention and Policy*, vol. 30, no. 5, pp. 461-473.
https://doi.org/10.1080/09687637.2022.2070058

Drugs: Education, Prevention and Policy

ISSN: (Print) (Online) Journal homepage: https://www.tandfonline.com/loi/idep20

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To cite this article: Vivian D. Hope, Vincent Walker Bond, Ian Boardley, Josie Smith, John Campbell, Geoff Bates, Rob Ralphs, Marie-Claire Van Hout & Jim McVeigh (2023) Anabolic androgenic steroid use population size estimation: a first stage study utilising a Delphi exercise, Drugs: Education, Prevention and Policy, 30:5, 461-473, DOI: 10.1080/09687637.2022.2070058

To link to this article: https://doi.org/10.1080/09687637.2022.2070058

DRUGS: EDUCATION, PREVENTION AND POLICY
2023, VOL. 30, NO. 5, 461–473
https://doi.org/10.1080/09687637.2022.2070058

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Anabolic androgenic steroid use population size estimation: a first stage study utilising a Delphi exercise

Vivian D. Hope[a], Vincent Walker Bond[b], Ian Boardley[c], Josie Smith[d], John Campbell[e], Geoff Bates[f], Rob Ralphs[b], Marie-Claire Van Hout[a] and Jim McVeigh[b]

[a]Public Health Institute, Faculty of Health, Liverpool John Moores University, Liverpool, UK; [b]Substance Use & Associated Behaviours, Department of Sociology, Manchester Metropolitan University, Manchester, UK; [c]School of Sport, Exercise & Rehabilitation Sciences, College of Life & Environmental Sciences, University of Birmingham, Birmingham, UK; [d]Substance Misuse Programme, Public Health Wales, Cardiff, UK; [e]NHS Scotland, Glasgow, UK; [f]Institute for Policy Research, University of Bath, Bath, UK

ABSTRACT

Harms associated with anabolic androgenic steroids (AAS) use are well-established and a public health concern. Robust estimates of the numbers using AAS are needed to inform responses, however, in the UK these are lacking. Due to the comparative rarity and associated stigma, general population surveys are problematic and data availability limits the use of indirect approaches. To address this, the Delphi method was used to refine the key parameters needed for indirect estimation from attendances at needle and syringe programmes (NSP) for AAS use. An expert panel ($n = 63$) was surveyed three times ($n = 40$, 39, and 37) to refine the parameters needed to generate a likely range from data on NSP attendances. A broad agreement was reached on: regional variations in use; the proportion of men using AAS who only use them orally; the proportion of men who inject AAS using NSP; and the proportion of the AAS population who are women. We conclude that previous general population survey-based estimates of recent AAS use appear implausible, with the likely range indicated by NSP data being up to 10-times higher. AAS use in the UK is more common than previously indicated, but further work is needed to refine population size estimation and characteristics.

ARTICLE HISTORY
Received 20 January 2022
Revised 10 March 2022
Accepted 18 April 2022

KEYWORDS
Anabolic androgenic steroids; prevalence estimation; Delphi method; needle & syringe programmes

Introduction

The use of image and performance-enhancing drugs (IPEDs) is well established, particularly in competitive sport and bodybuilding, and has become increasingly widespread over recent decades making it a public health concern (McVeigh & Begley, 2017). Whilst a wide range of drugs can be used to enhance image and performance, the most commonly used IPED are anabolic androgenic steroids (AAS) (McVeigh et al., 2012; 2021; Sagoe et al., 2014; van de Ven et al., 2020). The motivations for using AAS, either alone or in combination with other drugs, including those related to sporting and athletic performance or, more commonly, for aesthetic purposes with additional reported benefits including increased sex drive and youthful appearance (Begley et al., 2017; Zahnow et al., 2018).

AAS can be used orally or by injection, or more commonly by both routes of administration (Bonnecaze et al., 2020). There is a wide range of harms associated with the use of AAS (Pope et al., 2014b) including both acute, often cosmetic adverse effects (e.g. acne, male patterned baldness, and gynaecomastia) and long-term physical harms that affect the liver, heart, and brain (Baggish et al., 2017; Hauger et al., 2019). Blood-borne viral infections are also a concern (Hope & Iversen, 2019), with UK studies indicating that among those who inject, around 1 in 100 are living with HIV and 1 in 25 have been infected with hepatitis C (Hope et al., 2016). There are further harms associated with the illicit AAS market from adulterated, contaminated, and mislabelled products (Evans-Brown et al., 2009; Frude et al., 2020; Shapira et al., 2018). While the harms associated with AAS are well established, there are also harms associated with other commonly used IPEDs, such as human growth hormone (Evans-Brown & McVeigh, 2009; Pope et al., 2014b).

Considering the well-established harms associated with AAS use, and that AAS are likely to be the most widely used IPED, an understanding of the size of this population is a core component to the assessment of overall harms and associated healthcare needs. Thus, population size estimates are needed to inform the development of appropriate policies and the effective provision of interventions.

Previous attempts to assess the extent of AAS use in the general population have relied on survey approaches. Whilst these are reliable for the use of substances where prevalence is high (e.g., tobacco or cannabis), they are less reliable where use is less common as they lack statistical power and

CONTACT Vivian D. Hope V.D.Hope@ljmu.ac.uk Public Health Institute, Faculty of Health, Liverpool John Moores University, Liverpool, UK
Supplemental data for this article can be accessed online at https://doi.org/10.1080/09687637.2022.2070058.

so result in uncertain estimates. The robustness of the estimates from these general population surveys has thus been questioned because of the comparative rarity of AAS use, and because of its lack of social acceptability resulting in a reluctance to divulge use (Advisory Council on the Misuse of Drugs, 2010). For example, the Crime Survey for England and Wales (CSEW) – a household-based population survey - estimated the number of people aged 16–59 years using AAS during the year ending March 2020 to be 31,000 (Office for National Statistics, 2020). Yet data from the monitoring of attendances at needle and syringe programmes (NSP) throughout Wales (Turner et al., 2019) indicated that over 12,400 people injecting AAS had attended an NSP service during the 2018–19 financial year. The number using AAS in Wales will be higher than this as not all will be attending NSP. The working-age adult population (i.e., those aged 15–64 years) of Wales is around 1/20 that of all of England and Wales. Additionally, the estimate for 2020 diverges from the estimate of 62,000 for the previous year, with the difference between the two years being statistically significant (Office for National Statistics, 2020). Thus, it appears the CSEW estimate for 2020 is implausible and the large year-on-year variation also raises questions regarding the robustness of these survey-based estimates (Home Office, 2019). This likely underestimation is probably due to under-disclosure of AAS use in population surveys, due to a range of factors including the stigma associated with AAS use (Griffiths et al., 2016; Harvey et al., 2020; Hope et al., 2020). Furthermore, international estimates would suggest higher levels of use in the UK than those derived from the CSEW. In the United States, it has been estimated that up to 4 million people (aged 13–50 years) have ever used AAS (Pope et al., 2014a), while an extensive meta-analysis of available international data indicated a global lifetime prevalence of AAS use of 3.3% (men: 6.4%, women: 1.6%) (Sagoe et al., 2014).

Robust estimates of population sizes can be achieved by a variety of different approaches. When population surveys cannot be reliably used, there is a range of indirect estimation processes that can be utilised (Hickman & Taylor, 2005). These typically utilise existing data and extrapolation methods to produce estimates of population sizes; such approaches have been used extensively to estimate the size of the populations using psychoactive drugs and the prevalence of diseases, such as HIV, that can be concentrated amongst marginalised populations. These approaches include, for example, multipliers, capture-recapture, and multi-parameters evidence synthesis (Hickman & Taylor, 2005). For example, capture-recapture approaches (which analyse the overlaps between person-based data sets that are independent of each other), and multiplier methods (that adjust service use data to allow for those not using through the application of survey derived multipliers) have been widely used to estimate the number of people using or injecting illicit drugs (Hay et al., 2009; Hickman et al., 2006; Larney et al., 2017; Sabin et al., 2016). These approaches are dependent on person-level data from health and social services, or from engagement with the criminal justice system, that records appropriate and specific data on substance use. However, there are few such data sources that do this reliably for those using AAS or other IPEDs in the UK.

NSPs are well established throughout the UK and, in line with national guidance (National Institute for Health & Care Excellence [NICE], 2014; Public Health England, 2015), provide appropriate injecting equipment and safer use information to people who inject IPEDs, as well as to those using drugs for their psychoactive effects. In many UK towns and cities, the predominant client group accessing NSPs are people seeking equipment for IPED injection (Kimergard & McVeigh, 2014), most commonly AAS. There is monitoring of NSP provision in many areas and in some, this is at the individual service user level. Thus, in parts of the UK, information is available on the number of people attending NSPs to collect injecting equipment for the use of AAS and/or other IPEDs. If information is available indicating the proportion of the population injecting AAS that use NSPs and of people using AAS who only do so orally, it is possible to generate estimates of the size of the AAS using population from data on NSP attendances using a multiplier approach. However, whilst suitable person-based data on NSP attendances is available for some areas (Turner et al., 2019; Whitfield & Reed, 2021), the key parameters needed to generate estimates from these data are currently lacking. Whilst there is survey-based data that provide indications of the extent of NSP use and oral only use in the AAS using population, this is potentially biased by NSPs being used as one of the main recruitment settings for these surveys (Begley et al., 2017; Hope et al., 2017).

The lack of other datasets with a robust recording of AAS use and appropriate identifiers prevents the use of capture-recapture approaches. Data from person-level NSP monitoring could be used to generate estimates using a multiplier approach if appropriate multipliers can be generated via surveys. However, population surveys of people using AAS are challenging due to the comparative rarity of AAS use and the associated stigma, and because there is no sampling frame for this population. Thus, the robust estimation of the parameters needed for use in a multiplier method needs an alternative approach. One such approach is to use the Delphi method to build upon the available, albeit biased or incomplete information and data, to establish agreement on the parameters needed using a panel of experts (Hsu & Sandford, 2007).

To enable estimation of the size of the population using AAS in the UK from data on NSP attendances this study set out to clarify the key parameters needed to produce such estimates. Thus, it aimed to better understand: 1. the extent to which the population injecting AAS is using NSPs, 2. the proportion of people who only use AAS orally, and 3. any UK regional variations in the extent of AAS use and the uptake of NSPs. A Delphi exercise was undertaken to build on the available information by drawing on a wide range of expertise to refine key parameters and then assess the plausibility of estimates generated from available NSP data using these refined parameters.

Materials and methods

To achieve our aim the Delphi method was employed to address the key information gaps (Hsu & Sandford, 2007;

Jones & Hunter, 1995). The Delphi method is a process used to arrive at a group opinion or decision by surveying a panel of experts. Experts respond to several rounds of questionnaires, and the responses are aggregated and shared with the group after each round. A panel of experts with extensive knowledge related to AAS use in the UK was recruited and then invited to take part in three surveys. The first two surveys explored the key information gaps, and the third the estimation process and estimates of the number of people using AAS in the UK. The study was approved by the LJMU Research Ethics Committee (ref: 20/PHI/033).

The estimate generation process

Available data indicate that the vast majority of people using AAS in the UK are men (Hope et al., 2013; McVeigh et al., 2021; McVeigh & Begley, 2017; Salinas et al., 2019), with use among women much less common (Andreasson & Henning, 2021; Havnes et al., 2021). Considering this potential heterogeneity in patterns of use between men and women we focused on generating estimates of the number of men using AAS. However, the proportion of people using AAS that are women was explored during the Delphi exercise, to permit the generation of an estimate of an overall number of people who use AAS.

The estimate generation process consisted of several stages. First, we collated aggregated data on the number of men (aged 15–64 years) attending NSP from areas with appropriate monitoring (i.e., where data is collated from all providers within an area into a single record for each person using NSPs). These data were then used to estimate likely ranges for the number of men who have recently used AAS following the process shown in Box 1.

Box 1. Process for estimating the number of men using AAS from data on NSP attendances:

1. The NSP data from each of the areas is allocated into one of three 'prevalence groups' based on whether the region or nation is rated as having either a higher-than-average prevalence, average prevalence, or lower than average prevalence of AAS use.
2. In each of the three prevalence groups, the data on the number of men using NSP for AAS use is totalled and then divided by the number of men aged 15–64 years living in all the areas providing NSP data in that group to give a rate for each prevalence group.
3. These rates are then applied to the total male population aged 15–64 years for all the regions and nations in that prevalence group to generate a number.
4. These numbers are then adjusted using a range to allow for those men injecting AAS but not accessing NSPs, this adjustment could vary by prevalence group.
5. These numbers are then further adjusted using a range to allow for those who only use AAS orally, this adjustment could vary by prevalence group.
6. These ranges are then totalled to give a UK range.

The key information gaps (parameters)

The above estimation process in addition to NSP attendance data requires three key pieces of information:

1. The presence and extent of any regional variations in AAS use,
2. The proportion of men using AAS who only use them orally, and
3. The proportion of men who inject AAS who use NSP (and any regional variation in this).

Whilst surveys of people using AAS/IPEDs and other data sources (see below) can provide insights, there is a lack of robust data on all three of these parameters. The focus of the Delphi exercise was thus to better understand these three parameters.

The NSP data

Data on NSP attendance was collated, where the data within an area was recorded in such a way that there was a single record for each individual service user (even if they are accessing multiple services) and their main drug was recorded. This provides the number of men using AAS attending NSPs in each area. Such data were available for all of Wales and Scotland, as they have national person-based NSP monitoring systems. Data on NSP usage is not centrally collated in England and was not available from many areas due to: NSP not collecting any identifiers; data being collected at the various NSP services within an area using different systems or data items; and/or the main drug used not being recorded. Data were accessed for all of Wales, the majority of Scotland (for some areas the data collection system had only recently been rolled out and so was incomplete), and for England from one sub-region covering nine local authorities that utilise an established local monitoring system, and through the service provider for two other local authorities. Service providers across England were contacted about accessing suitable data from other areas, but suitable data was either not available or had incomplete coverage of services.

These areas cover 100% of the male population of Wales, 61% of Scotland, and 5.4% of England. The 11 local authorities in England included urban, town, and rural locations. Data was collated in 2020 and sought for the financial years (April to March): 2017–18, 2018–19, and 2019–20. The data for the later year was not used due to the impact of COVID-19 in 2020 on the delivery of NSP (Whitfield et al., 2020), so the data for 2018–19 was used.

Other data sources

Data from three other sources were used to provide insights to inform the Delphi survey questions around the three key parameters. Data from the national 'IPEDinfo' survey, which had looked at patterns of IPED use, health and service use among people using IPEDs recruited from across Great Britain (Begley, et al., 2017), was used to inform initial estimates of the proportion of men who use AAS who inject, and among those who inject, the proportion attending NSPs. This survey recruited people using IPEDs, mainly AAS,

through many settings (including NSPs) during the second half of 2016 (Begley et al., 2017). Overall, 542 of the participants had injected AAS, and of these, 68% reported using an NSP in the past year. It also found that of those men who had used AAS by any route ($n = 634$), 15% had only done so orally. However, as recruitment was partly through NSP the proportion using NSP may be over-estimated and the extent of oral-only use under-estimated.

Information from two sources contributed to the assessment of regional variation in AAS use. Firstly, information from anonymous reports concerning AAS to a national charity working to reduce crime (https://crimestoppers-uk.org/give-information) was accessed via UKAD (for the period April 2014 to March 2019). Secondly, anonymous geographic information on direct sales of AAS injection equipment packs (for the years 2018 and 2019) was accessed from a social enterprise that supplies NSP who also offer direct sales (https://www.exchangesupplies.org/shopsect_steroid_injecting.php). Counts of reports or sales were allocated to regions and nations, and rates were calculated (using population data for men aged 15–64 years). These rates were then used to inform the initial allocation of the regions and nations to one of the three prevalence groups (i.e. higher, average, or lower prevalence).

The Delphi panel

Experts were individuals with considerable experience related to AAS use in the UK including those working in the fitness industry, providing services (i.e., practitioners), governance (i.e., policymakers), or research (i.e., academics), as well as individuals with lived experience. These groups are not mutually exclusive, and some panel members had expertise across more than one of these domains. Considerable experience was defined as evidence of engagement with the field for at least two years. This engagement must have involved activities specifically related to AAS use:

- Academics/researchers: either have published papers on AAS use in the UK or be engaged in current research with this population.
- Practitioners: will have been directly involved in providing a targeted health or fitness-related service that works with people who use AAS.
- Policy Makers: will have been involved in either regulation (e.g., doping) or policy-making related to sports or fitness sectors.

Panel members were identified from the membership of the ASUK network (a national network of academics, practitioners, and others engaged in AAS related activities in the UK) and supplemented through networks known to the project team, with initial recruitment being inclusive of all those identified as likely to have sufficient expertise of AAS use either nationally or regionally. In total, 65 people who were involved with services, governance or research were identified as likely to have sufficient knowledge and were invited to take part, with 12 opting out (leaving 53 experts). In addition, 10 individuals with lived experience were invited to take part in the surveys. Of these 63 people, 40 (63%) took part in the first survey.

The Delphi surveys

The first two surveys aimed to explore key parameters, and the third considered the process for producing estimates from NSP data and the plausibility of the estimates produced, alongside other estimates. Consistent with the Delphi method the second and third surveys were informed by the findings of the preceding surveys, and participants were provided with summary feedback on the findings of the preceding survey when invited into the second and third surveys.

The first survey ran from mid-December 2020 to early March 2021. This survey opened by asking participants about their background and their level of knowledge in relation to AAS/IPED use. It then asked several general questions concerning recent patterns of AAS use, before exploring the information gaps related to the three key parameters. For the second and third of these parameters, information from a recent national survey was described and used to adjust anonymised available data on NSP attendances. The participants were then asked to assess the reliability of the survey-based estimates for these two parameters and indicate whether the actual proportions were likely to be higher or lower and indicate plausible proportions. Participants were also asked to place the nine regions of England, and the other three UK nations (i.e., Scotland, Wales, and Northern Ireland) into one of the three prevalence groups based on whether they felt that area probably had higher, average or lower levels of AAS use among men.

The second survey ran from mid-April 2021 to mid-May 2021. It built on the findings of the first survey to further refine two of the three parameters for which there was not sufficient consensus: regional variations in AAS use, and the proportion of men who inject AAS who use NSP. The data available from anonymous reports of possible crimes and the direct sales of AAS/IPED injecting kits were used alongside information generated in the first survey to propose prevalence groupings for regions and nations. This survey also asked about the extent to which NSP use may vary between regions and nations.

The third survey ran from mid-June 2021 to mid-July 2021. This survey explored participants' perspectives on the appropriateness of the proposed process of producing estimates from the number of men injecting AAS attending NSP. Questions then examined the plausibility of a range of estimates, firstly those produced using the approach above from the available NSP data and the data on key parameters obtained from the first two surveys, and secondly the other available estimates from the CSEW. This survey also explored adjustments to include women using AAS and to generate estimates of the use of a wider range of IPEDs for muscular enhancement. The data from the three surveys were analysed using descriptive statistics (i.e., counts, averages, and proportions).

Table 1. The number of survey participants & their characteristics.

		N	Proportion
Survey participation	First survey	40	
	Second survey	39	
	Third survey	37	
Characteristics baseline ($n = 40$)			
Which one of these best describes you?	Healthcare professional who has provided care to men using AAS	6	15%
	A provider of a specialist service to people who use AAS	11	28%
	Work in the fitness industry	4	10%
	Academic or researcher	16	40%
	Other	3	8%
In which of these roles do you have expertise related to AAS (can tick more than 1)	Healthcare professional providing care to men using AAS	10	25%
	Providing a specialist service to people who use AAS*	14	35%
	Worker in the fitness industry**	8	20%
	Gym user or sports person	15	38%
	Worker in public health or policy	3	8%
	Researcher or an academic	22	55%
	Other	1	3%
	Someone with personal experience of using AAS	9	23%
How many years of expertise or experience related to the use of AAS among men do you have?	Less than two years	2	5%
	Two to five years	9	23%
	Over five years	29	73%
How would you describe your understanding of AAS use among men in the UK?	Extremely knowledgeable	6	15%
	Very knowledgeable	16	40%
	Moderately knowledgeable	14	35%
	Slightly knowledgeable	4	10%
	Not knowledgeable at all	0	0%

*Services such as outreach, needle & syringe programmes, or specialist clinic/service. **e.g. like a gym or fitness shop owner, manager or worker, a personal trainer, or coach.

Results

The participants

In total, 40 people completed the first survey, 39 the second, and 37 the third. The participants came from a range of backgrounds (40% were academics or researchers) and felt they were knowledgeable about AAS use (Table 1), and the participants were similar across all surveys. Overall, 83% ($n = 33$) thought the number of men using AAS in the UK had increased between 2015 and 2019, and none thought it had declined.

The first survey

Regional variations in AAS use

Participants thought the extent of AAS use among men varied throughout the UK, with 12 (30%) saying it did so by a moderate amount (Table 2). When asked to place each of the regions of England and the other UK nations into either a higher, average or lower prevalence group, the response was poor with many indicating 'don't know' (Supplementary Table A). The answers received were mixed, though there was a fair degree of agreement for four regions: Wales, North East of England, and North West of England having above-average prevalence and South West of England having a below-average prevalence, with two-thirds or more of those who gave an allocation indicating these placements.

Proportion of men who inject AAS using NSP

A series of questions were asked about NSP usage. Participants were first asked to what extent they thought estimates based on NSP data would be impacted by the proportion of men who do not use NSP, and 17 (43%) thought these would be impacted 'a great deal' (Table 2). However, there was little consensus on the proportion using NSP, with participants giving a wide range of responses to the questions asking about this (Table 2). For example, when asked to indicate to the nearest 5% (slider, range 5% and 100%) the proportion of men who inject AAS that they would estimate are directly accessing NSPs, the answers ranged from 10% to 70%, with a mode of 60% and median of 45% (Inter-quartile range (IQR) 25%–60%).

Proportion of men using AAS who only do so orally

A series of questions were asked about the extent of oral-only usage of AAS. Participants were first asked to what extent they thought estimates based on NSP data would be impacted by the number of men who only use AAS orally (i.e., who do not inject them), 16 (40%) thought these would be impacted 'a great deal' (Table 2). There was a broad consensus on the likely proportion of men who only use AAS orally, with most responses to the questions asking about this indicating a range of 15% and 25% (Table 2). For example, when asked approximately what proportion of men who currently use AAS would you estimate are only using AAS orally (to nearest 5%, range 5%–100%) the answers ranged from 10% to 40%, with the mode and median both being 20% (IQR 15%–26.25%).

The second survey

The participants were provided with feedback on findings from the first survey related to the key parameters with their invite for the second survey. This feedback reported that there was broad agreement that between 15% and 25% of men using AAS only do so orally, however, there was no

Table 2. First Delphi survey data on regional variations in AAS use, the proportion of men using AAS who only use them orally, and the proportion of men who inject AAS who use NSP.

		Number	Proportion	Median
Regional variations				
Does the proportion of men currently using AAS vary between different parts of the UK? ($n = 40$)	A great deal	3	8%	
	A lot	8	20%	
	A moderate amount	12	30%	
	A little	9	23%	
	Not at all	0	0%	
	Don't know	*8*	*20%*	
Proportion of men injecting AAS using NSP				
To what extent will the number of men who inject AAS but who do not directly access NSP affect these estimates of the proportion of the male population using AAS? ($n = 40$)	A great deal	17	43%	
	A lot	14	35%	
	A moderate amount	7	18%	
	A little	1	3%	
	Not at all	0	0%	
	Don't know	*1*	*3%*	
Approximately, what proportion of men who inject AAS would you estimate to be directly accessing NSPs? ($n = 40$)	All	0	0%	
	Over 80%, but not all	0	0%	
	Between 60% and 80%	5	13%	
	Between 40% and 60%	9	23%	
	Between 20% and 40%	11	28%	
	Less than 20%	9	23%	
	Don't know	*6*	*15%*	
The national IPEDinfo survey found that 68% men who used AAS reported using an NSP. Compared to this, is the actual proportion of men who currently use AAS accessing NSP? ($n = 40$)	Much higher	1	3%	
	Moderately higher	6	15%	
	Slightly higher	2	5%	
	About the same	8	20%	
	Slightly lower	7	18%	
	Moderately lower	3	8%	
	Much lower	11	28%	
	Don't know	*2*	*5%*	
Approximately (to nearest 5%), what proportion of men who inject AAS would you estimate are directly accessing NSPs? ($n = 31$)	<10	None		45 (IQR 25–60)
	10	2	6%	
	15	1	3%	
	20	2	6%	
	25	3	10%	
	30	1	3%	
	35	3	10%	
	40	2	6%	
	45	2	6%	
	50	4	13%	
	55	2	6%	
	60	5	16%	
	65	3	10%	
	70	1	3%	
	>70	None		
Proportion who only use AAS Orally				
To what extent will the number of men who only use AAS orally (i.e. who do not inject them) affect these estimates of the proportion of the male population using AAS? ($n = 40$)	A great deal	7	18%	
	A lot	6	15%	
	A moderate amount	16	40%	
	A little	9	23%	
	Not at all	1	3%	
	Don't know	1	3%	
Approximately, what proportion of men who are currently using AAS only take them orally? ($n = 40$)	None	0	0%	
	Over 80%	0	0%	
	Between 60% and 80%	0	0%	
	Between 40% and 60%	5	13%	
	Between 20% and 40%	16	40%	
	Less than 20%	11	28%	
	Don't know	8	20%	
The national IPEDinfo survey found that 15% of men who used AAS only reported oral use. Thinking about this figure, do you think the proportion of men who currently only use AAS orally is . . . ($n = 40$)	Much higher	3	8%	
	Moderately higher	7	18%	
	Slightly higher	14	35%	
	About the same	12	30%	
	Slightly lower	3	8%	
	Moderately lower	0	0%	
	Much lower	0	0%	
	Don't know	1	3%	
Approximately (to nearest 5%), what proportion of men who currently use AAS would you estimate are only using AAS orally? ($n = 30$)	<10	None		20 (IQR 15–26.25)
	10	5	17%	
	15	3	10%	
	20	9	30%	
	25	6	20%	
	30	4	13%	
	35	2	7%	
	40	1	3%	
	>40	None		

Table 3. Second Delphi survey data on regional variations in AAS use, and the proportion of men who inject AAS who use NSP.

		Count	%	Mean	Median	Mode	Std. Deviation	IQR		
Regional variations										
Do you think the prevalence of AAS use (injecting or oral) among men is likely to vary between the countries and regions of the UK? ($N = 39$)	A great deal	1	3%							
	A lot	9	23%							
	A moderate amount	22	56%							
	A little	6	15%							
	None at all	1	3%							
Considering the data from the first survey, CrimeStoppers and other sources we have placed the different areas of the UK in to three groups based on their possible overall prevalence of AAS use (injecting or oral) among men. Do you agree with these groupings? From: Strongly agree (=1) to Strongly disagree (=5). ($N = 39$)	*Above*									
	Wales			1.76	2	1	0.85	1	–	2
	North West of England			1.74	2	2	0.72	1	–	2
	Yorkshire & the Humber			1.92	2	2	0.84	1	–	3
	North East of England			1.74	2	1	0.79	1	–	2
	Average									
	Scotland			2.33	2	2	0.84	2	–	3
	Northern Ireland			2.66	3	3	0.78	2	–	3
	West Midlands (England)			2.55	2		0.83	2	–	3
	East Midlands (England)			2.58	3	3	0.79	2	–	3
	Below									
	South West of England			2.54	3	3	1.07	2	–	3
	East of England			2.64	3	3	0.84	2	–	3
	South East of England			2.69	3	3	1.00	2	–	3
	Greater London			3.18	3	3	0.91	3	–	4
Place these five areas in an order that you think might best indicate the likely ranking from highest (=1) to lowest (=5) prevalence of AAS use (injecting or oral) among men. ($n = 34$)	Wales			2.09	2	1	1.19	1	–	3
	North East of England			2.32	2	1	1.15	1	–	3
	North West of England			2.65	2.5	2	1.23	2	–	4
	Yorkshire and the Humber			3.68	4	5	1.22	3	–	5
	Scotland			4.26	5	5	0.99	4	–	5
Place these five areas in an order that you think might best indicates the likely ranking from highest (=1) to lowest (=5) prevalence of AAS use (injecting or oral) among men. ($n = 36$)	Greater London			1.83	1	1	1.16	1	–	2
	Northern Ireland			2.89	3	3	1.35	2	–	4
	South East of England			3.06	3	3	1.04	2	–	4
	East of England			3.19	3.5	4	1.35	2	–	4
	South West of England			4.03	5	5	1.30	3	–	5
By how much do you think the prevalence of AAS use (injecting or oral) among men is likely to vary between areas? ($n = 27$)	Slider from: 1 (no difference) to 5 (fivefold difference)			2.85	2.5	2.5	0.83	3	–	4
Is the prevalence of AAS use (oral & injecting) among men in? Rate: Below average (=1), Average (=2), Above average (=3). ($n = 38$)	Northern England			2.75	3	3	0.51	3	–	3
	The Midlands of England			2.07	2	2	0.58	2	–	2
	London			2.10	2	2	0.77	2	–	3
	Southern England			1.45	1	1	0.63	1	–	2
	Wales			2.77	3	3	0.50	3	–	3
	Scotland			2.36	2	2	0.49	2	–	3
	Northern Ireland			1.87	2	2	0.55	2	–	2
Proportion of men injecting AAS using NSP										
Thinking about those men who are injecting AAS, how likely is the proportion that use needle & syringe programmes (NSP) to be? Rate each proportion from: Extremely likely (=1) to Extremely unlikely (=5). ($n = 38$)	25% use NSP			2.08	2	2	1.18	1	–	2
	30% use NSP			2.30	2	2	1.18	1	–	3
	35% use NSP			2.63	3	2	1.17	2	–	4
	40% use NSP			3.00	3	4	1.11	2	–	4
	45% use NSP			3.35	4	4	1.11	3	–	4
	50% use NSP			3.59	4	4	1.09	3	–	4
	55% use NSP			3.79	4	4	1.17	3	–	5
	60% use NSP			3.89	4	5	1.27	3	–	5
Thinking about those men who inject AAS, the proportion using NSPs: is at least . . . ? ($n = 37$)	25%	23	62%							
	30%	4	11%							
	35%	4	11%							
	40%	6	16%							
Thinking about those men who inject AAS, the proportion using NSPs: . . . and is no more than? ($n = 37$)	45%	22	59%							
	50%	5	14%							
	55%	0	0%							
	60%	10	27%							
The proportion of men injecting AAS who use NSPs varies across the UK? ($n = 38$)	A great deal	5	13%							
	A lot	12	32%							
	A moderate amount	17	45%							
	A little	4	11%							
	Not at all	0	0%							

(*continued*)

Table 3. Continued.

		Count	%	Mean	Median	Mode	Std. Deviation	IQR		
Is the proportion of men who inject AAS that use NSPs in? Rate: Below average (=1), Average (=2), Above average (=3). ($n = 39$)	Northern England			2.32	3	3	0.82	2	–	3
	The Midlands of England			2.19	2	2	0.68	2	–	3
	London			1.78	2	1	0.80	1	–	2
	Southern England			1.33	1	1	0.56	1	–	2
	Wales			2.40	3	3	0.82	2	–	3
	Scotland			2.38	2	2	0.58	2	–	3
	Northern Ireland			1.41	1	1	0.62	1	–	2

consensus on the other key parameters. They were provided with a summary of the findings above on regional variations in AAS use and on the proportion of those injecting AAS who use NSPs.

Regional variations in AAS use

A series of further questions asked about variation in the extent of AAS use by region or nation (Table 3). Based on findings of the first survey and data from CrimeStoppers and the direct sales of injecting equipment, the 12 areas were placed into the three groups and the participants' agreement with these placements was sought. Overall, participants broadly agreed with the placements other than for London. Results from subsequent questions also supported these placings, other than for London, and indicated that London would probably be best placed in the average prevalence group. Overall, the findings also suggested some uncertainty in relation to the placing of Northern Ireland (see Box 2 for group allocations).

Box 2. Estimates of the likely range for the number of men who have recently used AAS and the parameters used
The process in box 1 was used to produce two sets of likely ranges.
Parameters used
Regional prevalence grouping:
Both estimates used:
Proportion only using AAS orally:
Both estimates used the following: 15% or 25% only using AAS orally
Proportion who injecting using NSP:
The first estimate used: 25% or 40% of men injecting AAS accessing NSPs in the lower and average prevalence groups, and for the higher prevalence group we used 40% or 60% using NSPs
The second estimate used: 25% or 40% of men injecting AAS accessing NSPs for all three prevalence groups.
The estimated likely ranges.
Data on NSP attendances for 2018–19 was used for five areas.
The first estimate was:
A likely range of between 289,000 and 569,000 men. This is approximately 1.4%–2.7% of the men aged 15–64 years in the UK. It would indicate that between 1 in 37 and 1 in 71 men aged 15–64 years in the UK had recently used AAS.
The middle of the parameter ranges (35% or 50% of those who inject use NSP, and 20% only use orally) was used to produce a central estimate for the likely range. This central estimate was 384,000 men aged 15–64 years or 1.83%. This is 1 in 55 men.
The second estimate was:
A likely range of between 328,000 and 687,000 men. This is approximately 1.6%–3.3% of the men aged 15–64 years in the UK. It would indicate that between 1 in 31 and 1 in 63 men aged 15–64 years in the UK had recently used AAS.
Again, for the second estimate, the middle of the parameter ranges (35% of those who inject use NSP, and 20% only use orally) was used to produce a central value estimate for the likely range. This central value was 447,000 men aged 15–64 years or 2.1%. This is 1 in 48 men.

Proportion of men who inject AAS using NSP

Two questions were asked about NSP usage (Table 3), and most of the responses indicated a range of 25%–40% of those injecting AAS using NSP, though a minority thought the range was somewhat higher with the next most popular range being 40%–60%. Participants were also asked about how the proportion of men who inject AAS using NSPs might vary by broad areas of England and the nation. This indicated that the participants felt NSP use by men who inject AAS was highest in Wales, Scotland, and Northern England, and lowest in Southern England and Northern Ireland.

The third survey

Participants were presented with feedback on the findings from the second survey with their invitation to the third survey. Firstly, there was broad agreement that overall, between 25% and 45% of men who inject AAS use NSPs, but that use was likely to be higher in some areas (with this possibly between 40% and 60% using NSP). Secondly, in relation to regional variation in AAS use there was broad agreement that the prevalence was: higher than average in Wales, North West of England, Yorkshire & the Humber, and North East of England; average in Scotland, West Midlands (England) and East Midlands (England); and lower than average in South West of England, East of England, and South East of England. Though the positioning of Greater London and Northern Ireland was less certain, these probably had an average prevalence.

Estimation process and estimates:

Most of the participants thought the estimation process (Box 1) was generally appropriate (Table 4). Two sets of estimates of likely ranges were produced from this process with a variation in one of the parameters (Box 2). The participants thought both sets of estimates were plausible, with 76% rating the first estimate as 'extremely or somewhat appropriate' and 70% doing so for the second one (Table 4). There was a similar agreement in relation to the estimates of the likely mid-points for these two ranges (Table 4).

When asked about the plausibility of the estimated number of men and women aged 16–59 years using AAS in the past year from the two most recent CSEW (Home Office, 2019), most participants felt that these were not plausible (Table 4). When asked to select the estimate they felt was most plausible from the four considered above, almost three-fifths selected the second estimate produced in this study from NSP data (Table 4): 328,000 and 687,000 (central value

447,000) men aged 15–64 years had recently used AAS in the UK.

AAS use among women

Over two-thirds (68%) of the participants felt that the prevalence of AAS use (injecting or oral) among women varied a great deal from that among men, with the remaining participants all saying it varied by either a lot or a moderate amount (Supplementary Table B). Overall, the participants felt that women made up only a small proportion of the AAS using population in the UK (Supplementary Table B), with their responses overall indicating that women accounted for between 5% and 10% of the total population using AAS.

Use of IPEDs for muscular enhancement other than AAS

When asked by how much estimates of AAS use among men and women would need to be increased to give a likely range for the number of people using IPEDs for increasing muscularity, to allow for those people who use IPEDs other than AAS, their responses were mixed (Supplementary Table B) with 38% indicated by a moderate amount. When asked to indicate by how much an estimate of the number of people using AAS would need to be increased on a scale from 1 (no adjustment) to 2 (doubling) in 0.1 increments, responses were heterogeneous, with no agreement (Supplementary Table B).

Discussion

This study, in addition to refining the key parameters needed to estimate the likely numbers using AAS from NSP attendance data, supports the concerns about the robustness of estimates for recent AAS use from the CSEW. Our findings indicate that AAS use is likely to be much more common than the CSEW estimates suggest. Most of the panel felt that a likely range of between 328,000 and 687,000 (central value 447,000) men aged 15–64 years in the UK having recently used AAS was a plausible estimate. However, this would equate to as many as 1 in 31 men having recently used AAS, and two-fifth of the panel preferred lower estimates. There was broad agreement that between 5% and 10% of those using AAS were women, applying this to the estimates above would suggest that between 17,000 and 76,000 women had recently used AAS in the UK.

Whilst we met our aims to refine the key parameters and test the estimation process, there are some potential limitations with our approach that should be considered. Firstly, whilst we had a relatively high level of participation among those invited and drop out through the surveys' waves was limited, two-fifths of the panel members were researchers (although some of these had relevant experience in other areas). To address potential barriers to participation related to the stigma associated with the use of AAS (Griffiths et al., 2016; Hope et al., 2020) and ensure a good level of community engagement we provided an anonymised option for survey participation, and, overall, approximately a quarter of our panel reported personal experience of AAS use. However, it is possible that a panel with a different composition may have produced parameter ranges and estimates that differed from those generated here. Secondly, whilst the overall participation rate was good and attrition low, the response rate for individual survey questions varied, with low responses for some questions probably reflecting some uncertainty among the participants. This appeared to relate to knowledge that may be limited by the geography in which people had worked/lived. When identifying panel members, the geography of their knowledge was considered (i.e., focusing on people with experience across a number of locations), though our surveys focused primarily on refining key parameters, rather than the actual estimates, the selection of a preferred estimate at the end may have challenged some panel members' knowledge. Finally, the likely ranges generated need to be viewed cautiously due to the limited suitable and accessible data on NSP attendances for England, which is where all the low prevalence regions are located and so there was very limited NSP data underpinning the estimates for these regions.

Nevertheless, our analysis provides a more robust understanding of the likely extent of NSP use among those men using AAS, the proportion of men who only use AAS orally, and the proportion of the AAS using population who are women. These are key to estimating the extent of AAS use from NSP data in the UK and may be useful in informing similar estimation approaches in other countries. Whilst the proportion only using orally and women were close to the proportions indicated by data from surveys of this population, the proportion of those currently injecting who are attending NSP is estimated to be much lower than would be indicated by past UK surveys (Begley et al., 2017; Hope et al., 2013). The national 'IPEDinfo' survey (Begley et al., 2017) found that 68% of men who injected AAS reported recent use of an NSP, compared with the preferred range of 25%–40% using NSP obtained here. In part, at least, this will reflect the fact that these surveys were often focused on recruiting those who inject, and many surveys of this population have, at least in part, recruited through or via NSPs (Begley et al., 2017; van de Ven et al., 2019).

Panel members agreed that there was marked regional variation in both the use of AAS and of NSP by men injecting AAS. Whilst there was general agreement about those areas with a higher prevalence of AAS use, there was a degree of uncertainty about the placing of other areas. This may in part reflect the panel members coming from across the UK and their understanding of the extent of AAS use reflecting those areas in which they have personal knowledge. The 12 areas considered were the nine regions of England and the other three UK nations, however, within these regions and nations, there is likely to be heterogeneity in the prevalence of AAS use. This is also likely to impact people's understanding of likely levels of use across these areas. Ideally, it would be appropriate to utilise smaller geographies, such as higher-tier local authorities, when assessing prevalence in different areas. However, across the UK this would mean trying to place around 200 areas into different prevalence groups which would be challenging. Further work is thus needed to better understand geographic variations of AAS use across

Table 4. Third Delphi survey: estimation process and estimates.

			Count	%
Is this approach to generating a likely range for the number of men who have recently used AAS appropriate? ($N = 37$)		Extremely appropriate	10	27%
		Somewhat appropriate	18	49%
		Neither appropriate nor inappropriate	4	11%
		Somewhat inappropriate	5	14%
		Extremely inappropriate	0	0%
The first estimate gave a likely range of 289,000 and 569,000. This is approximately 1.4%–2.7% of the men aged 15–64 years in the UK. It would indicate that between 1 in 37 and 1 in 71 men aged 15–64 years in the UK had recently used AAS. What is your level of agreement with the plausibility of this estimate? ($N = 37$)		Strongly agree	7	19%
		Somewhat agree	23	62%
		Neither agree nor disagree	3	8%
		Somewhat disagree	4	11%
		Strongly disagree	0	0%
Thinking about the proportion of men who have recently used AAS in the UK ($n = 37$)	*Is the upper end of this range, i.e. 1 in 37 (2.7%)*	Much too high	1	3%
		Slightly too high	6	16%
		About right	20	54%
		Slightly too low	8	22%
		Much too low	2	5%
	Is the lower end of this range, i.e. 1 in 71 (1.4%)	Much too high	1	3%
		Slightly too high	5	14%
		About right	23	62%
		Slightly too low	4	11%
		Much too low	4	11%
We used the middle of the ranges (35% or 50% of those who inject use NSP and 20% only use orally) to produce a central estimate for the likely range. This central value was 384,000 men aged 15–64 years or 1.83%. This is 1 in 55 men. What is your level of agreement with the plausibility of this estimate? ($n = 37$)		Strongly agree	5	14%
		Somewhat agree	21	57%
		Neither agree nor disagree	2	5%
		Somewhat disagree	8	22%
		Strongly disagree	1	3%
The second estimate a gave a likely range of 328,000 and 687,000 men had recently used AAS. This is approximately 1.6%–3.3% of the men aged 15–64 years in the UK. It would indicate that between 1 in 31 and 1 in 63 men aged 15–64 years in the UK had recently used AAS. What is your level of agreement with the plausibility of this estimate? ($n = 37$)		Strongly agree	4	11%
		Somewhat agree	22	59%
		Neither agree nor disagree	4	11%
		Somewhat disagree	6	16%
		Strongly disagree	1	3%
Thinking the proportion of men who have recently used AAS in the UK ($n = 37$)	*Is the upper end of this range, i.e. 1 in 31 (3.3%)*	Much too high	3	8%
		Slightly too high	11	30%
		About right	17	46%
		Slightly too low	5	14%
		Much too low	1	3%
	Is the lower end of this range, i.e. 1 in 63 (1.6%)	Much too high	1	3%
		Slightly too high	6	16%
		About right	22	59%
		Slightly too low	7	19%
		Much too low	1	3%
Again, for our second estimate, we used the middle of the ranges above (35% those who inject use NSP and 20% only use orally) to produce a central estimate for the likely range. This central value was 447,000 men aged 15–64 years or 2.1%. This is 1 in 48 men. What is your level of agreement with the plausibility of this estimate? ($n = 37$)		Strongly agree	4	11%
		Somewhat agree	22	59%
		Neither agree nor disagree	3	8%
		Somewhat disagree	7	19%
		Strongly disagree	1	3%
The Crime Survey for England and Wales estimate of number of people aged 16–59 years who reported using AAS in the past year during the year ending March 2020 was 31,000. What is your level of agreement with the plausibility of this estimate? ($n = 37$)		Strongly agree	2	5%
		Somewhat agree	4	11%
		Neither agree nor disagree	4	11%
		Somewhat disagree	8	22%
		Strongly disagree	19	51%
The Crime Survey for England and Wales estimate of number of people aged 16–59 years who reported using AAS in the past year during the year ending March 2020 was 31,000. What is your level of agreement with the plausibility of this estimate? ($n = 37$)		Strongly agree	1	3%
		Somewhat agree	10	27%
		Neither agree nor disagree	3	8%
		Somewhat disagree	7	19%
		Strongly disagree	16	43%
Which one of the four estimates of recent AAS above do you think is the most plausible? ($n = 37$)		289,000 and 569,000 (central value 384,000) men aged 15–64 years using AAS in UK, our first estimate	13	35%
		328,000 and 687,000 (central value 447,000) men aged 15–64 years using AAS in UK, our second estimate	22	59%
		31,000 men & women using aged 16–59 using AAS in England and Wales, from the Crime Survey 2019/20	0	0%
		62,000 men & women using aged 16–59 using AAS in England and Wales, from the Crime Survey 2018/19	2	5%

the UK. However, the need for this could, at least in part, be mitigated by having robust person-based monitoring data on NSP use for more areas. Currently, person-based is only available in Wales, Scotland, and a few areas of England, even though guidance advises the undertaking of such monitoring (National Institute for Health & Care Excellence [NICE], 2014; Public Health England, 2015).

The parameters needed to derive estimates of the numbers of people using AAS from data on NSP attendances may be affected, particularly the proportion of those injecting AAS using NSP, by changes in NSP service delivery and utilisation. The recent and ongoing COVID-19 pandemic and the restrictions and guidance that have been implemented in response to this during 2020 and 2021 have had an impact on the uptake and use of NSPs, including among those using AAS (Whitfield et al., 2020). Whilst these changes in service use related to COVID-19 may be temporary, it is possible that they could lead to longer-term changes, for example, an increase in the direct purchase of needles and syringes from online suppliers. Currently, it is unclear if the impact of COVID-19-related guidance and restrictions will have any long-term effect on NSP use by those who use AAS.

This study has strengthened our understanding of the proportion of men using AAS who only use them orally, the proportion of men who inject AAS who use NSP, and the proportion of those who use AAS that are women by developing new evidenced-based estimates. The expert panel was also supportive of generating estimates of the number of people using AAS from data on NSP attendances. In areas where there is robust monitoring of NSPs, the use of the information from this study on the key parameters should permit the generation of local estimates of the numbers using AAS. Further work is, however, needed to better understand geographic variations in AAS use and the relationship between AAS use and the use of other IPEDs for muscular enhancement. The longer-term impact of COVID-19 on NSP attendance by those using AAS will need assessment, as any changes in the patterns of NSP use among those using AAS would impact the key parameters and so may result in these needing to be re-assessed.

It is clear from the work undertaken as part of this study that the currently available estimates of the numbers using AAS derived from the CSEW are too low. The estimates generated here indicate that the extent of recent use might be 10 times higher than indicated by the CSEW, suggesting that lifetime use of AAS might be in-line with the US and global estimates (Pope et al., 2014a; Sagoe et al., 2014). Whilst further work is needed to generate more robust estimates of AAS use, this finding has important implications for policymaking. The indication that AAS use is much more common than had been previously assessed, would mean that the extent of the responses required to address AAS use and to reduce harm was greater. If AAS use in the UK is greater than previously estimated, then policymakers will need to identify approaches to increase contact with services, such as NSP, to enhance access to healthcare and harm reduction interventions. Additional interventions and methods of delivery may be required to reach this diverse population and respond effectively to their needs (Bates et al., 2021).

Whilst we have improved our understanding of the key parameters needed for estimating the numbers using AAS from data on NSP attendances, the national estimates we have derived from the application of these to the available NSP data need to be treated with a degree of caution. For those areas that have robust NSP monitoring data, the parameters refined in this study will facilitate the local estimation of the numbers using AAS. However, without robust national NSP monitoring data, generating precise and accurate national estimates will remain challenging. Further work is thus needed to improve our understanding of regional variations in the extent of AAS use and to understand any potential impacts of the COVID-19 pandemic on NSP attendance patterns.

Disclosure statement

The authors report there are no competing interests to declare.

Funding

This work was initially unfunded and supported by the authors' institutions, its completion was part-funded by National Institute for Health Research (NIHR) Public Health Research Programme [Ref.132730]. The views expressed are those of the author(s) and not necessarily those of the NIHR or the Department of Health and Social Care.

ORCID

Vivian D. Hope http://orcid.org/0000-0001-5712-5734
Ian Boardley http://orcid.org/0000-0001-5651-7816
Josie Smith http://orcid.org/0000-0002-7671-104X
Geoff Bates http://orcid.org/0000-0001-6932-2372
Rob Ralphs http://orcid.org/0000-0001-8359-2598
Marie-Claire Van Hout http://orcid.org/0000-0002-0018-4060
Jim McVeigh http://orcid.org/0000-0001-5319-6885

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