FOR DEBATE

Substitution and Complementarity in the Face of Alcohol-Specific Policy Interventions

Simon C. Moore*

Violence and Society Research Group, Applied Clinical Research and Public Health, School of Dentistry, Cardiff University, Cardiff CF14 4XY, UK
*Corresponding author: Tel.: +44 (0)29 20 744246; E-mail: mooresc2@cardiff.ac.uk

Abstract — Aim: Policy responses to the growing burden of alcohol-related disease fail to consider the interrelated nature of substance misuse and the potential for complex interactions in response to alcohol-specific interventions. This paper considers possible aggregate level responses to the alcohol policy and whether alcohol policy can be expected to reduce overall harm. **Methods:** A review and discussion of the relevant literature was conducted. **Results:** Evidence indicates that those at greatest risk consume stronger alcoholic beverages more frequently, that they are likely to complement their consumption with a range of intoxicants and that they are more likely to substitute alcohol with other substances. **Conclusions:** Policies aimed at reducing alcohol consumption can be successful. However, evidence suggests a significant minority of consumers are likely to substitute or complement consumption with a range of intoxicants suggesting that policy is unlikely to reduce all-cause mortality and morbidity. Further research into the nature of substitution and complementarity is required.

INTRODUCTION

Although the burden of alcohol-related disease is of growing international concern (Rehm *et al.*, 2003; Anderson, 2009; Zaridze *et al.*, 2009), responses are increasingly focused on alcohol misuse and rarely consider the broader implications of alcohol reduction policies on substance misuse generally. Alcohol-specific policy-level interventions, such as manipulating affordability, may be effective but only when interventions are evaluated using alcohol-specific outcomes (Brand *et al.*, 2007; Anderson *et al.*, 2009). Because consumers can choose to substitute across goods in order to satisfy their needs (Agar *et al.*, 2001), restrictions on alcohol may lead to substitution in favour of other substances of abuse. If this is the case, then unanticipated consequences on the profile of harms in the population of interest may emerge. This paper reviews the available evidence for two features relevant to the interface between intoxicant choice and alcohol policy that might have an impact on harm generally: substitution and complementarity (Bickel *et al.*, 1995), and asks whether a singular focus on alcohol is realistic.

Substitution involves switching from alcohol to other substances of abuse (intoxicants) to achieve the goals of intoxication; complementarity involves the use of alcohol with other intoxicants in order to heighten euphoria or manage the after-effects of consumption (McCance-Katz *et al.*, 1993). Only through a better understanding of the impact of policy on choice can a reduction in all-cause mortality and morbidity be achieved. The focus of this paper is alcohol consumption in the general population and the theoretical motivation comes from consumer demand theory (Bickel *et al.*, 1995) as it is applied to understand the relationship between the demand for goods and their availability. The experimental evidence for complementarity and substitution across intoxicants suggests a complex pattern (Jofre-Bonet and Petry, 2008). Bickel *et al.*'s (1995) review indicates that many substances are complements, such as the relationship between alcohol and tobacco: as the affordability of alcohol decreases and demand decreases, the demand for tobacco also decreases. Complementarity can be symmetrical such as in the case of coffee and tobacco; if the affordability of tobacco decreases, then the demand for both tobacco and coffee decreases and,

similarly, if the affordability of coffee decreases, the demand for both tobacco and coffee decreases. However, when the affordability of phencyclidine (PCP) decreases, the demand for alcohol increases, suggesting alcohol substitutes for PCP. However, the demand for PCP remains unchanged in the face of changes in the affordability of alcohol. In Jofre-Bonet and Petry's (2008) study, heroin addicts were given imitation money and presented with the hypothetical opportunity to buy a variety of substances across a range of prices as the price of heroin and cocaine varied. The price of heroin did not affect the demand for heroin for all participants, indicating price inelasticity[1]. For heroin users, cocaine, marijuana and alcohol were complements to heroin, and valium and tobacco were substitutes. For cocaine addicts, complements to cocaine were heroin and alcohol. Sumnall *et al.* (2004) investigated the choice of alcohol, amphetamine, cocaine and ecstasy as a function of price in a non-clinical sample of poly-substance users. Overall, they found that participants valued intoxication over the specific effects of a single intoxicant. Further, their data suggested that demand was inelastic as the price of alcohol rose, and that cocaine was a complement for alcohol. These experimental results, if generalizable, suggest that policy might have unintended consequences on the profile of consumption in a population and therefore the nature of harm.

For alcohol policy, generally, it is assumed that the costs and benefits of intoxication determine consumption, relative to wealth, which enters the current discussion as a reference point on the cost of consumption, the net representation being affordability (Kahneman and Tversky, 1979; Köszegi and Rabin, 2006). In this paper, a parsimonious model of individual choice is assumed whereby consumers with the

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1 Elasticity and inelasticity are terms that describe the relationship between the demand for a good and its price. More formally, and holding constant all the other determinants of demand, such as income, the price elasticity of demand is the percentage change in the quantity demanded in response to a 1% change in price. For most goods, including alcohol, the demand for alcohol decreases as the price of alcohol increases a relationship described as negative elasticity. For some goods, such as toothpaste, the demand is inelastic, where there is no or very little change in the demand as the price fluctuates. Positive elasticity can be observed in some cases, an example being the demand for some types of wine, and is less formally described as the "snob effect".

goal of intoxication have available a range of intoxicants (including a range of alcohol products of varying quality and strength as well as illicit substances), each differing in value, and health and prospective punitive costs are assumed as a component of the street price. It is also argued that intoxicant choice is weighted by a similarity metric such that substitution is most likely across those intoxicants that offer the most similar effects. A further assumption is that choice is not deterministic but that individuals allocate their resources stochastically across options and in proportion to the prospective returns, rather than selecting and sticking with that option offering the best return (Herrnstein, 1990; Sugrue et al., 2004). The implication is that policies that affect the prospective value of intoxicants can only be expected to shape behaviour as part of a more general stochastic process rather than determine behaviour.

HARM

While alcohol is the most heavily consumed intoxicant worldwide and the volume of harms attributable to alcohol use are considerable (Room et al., 2005), it is fallacious to presume that consumers do not have a choice of intoxicant and are not willing to substitute and complement substances in order to achieve intoxication. The implication is that policy may shift consumption and if a small number of consumers shift to more harmful intoxicants, then the net effect of the alcohol policy may be moderated or an increase in net harm observed. Parsimonious scales of harm (Nutt et al., 2007) that consider intoxicants individually are not suitable to inform policy in the face of these potential complementarity and substitution effects and should, at a minimum, be revised to reflect this. For example, alcohol, cannabis and amphetamines are commonly used to improve the effects of other substances, whereas cannabis and alcohol can be used to help manage the after-effects of some substances, in particular opiates. Another example is the use of analgesics to manage the after-effects of binge drinking, which, coupled with the potentiating effect of alcohol (Landry, 1994), may further contribute to levels of harm. Of particular relevance is cocaine, not only because it is more harmful than alcohol but also due to the risk that drinkers would complement reduced alcohol use with cocaine to more efficiently achieve heightened levels of intoxication. Cocaine is the second most commonly used illegal substance in Europe after marijuana (Lacoste et al., 2009). Consumption of both alcohol and cocaine results in the pharmacologic activity of three, not two, psychoactive drugs through the body's synthesis of cocaethylene, a substance that is associated with more intense and longer-lasting subjective feelings of euphoria than either alcohol or cocaine alone (Landry, 1994). When used in combination with alcohol, the risks of liver damage increase (Landry, 1994). If Sumnall et al's (2004) suggestion, that the goal of intoxication remains constant but the choice of intoxicant changes, generalizes, then managing harm becomes a question of how consumers choose intoxicants rather than simply how much alcohol they consume.

SIMILARITY

Although alcohol is price elastic, greater elasticity is often observed in products where there are better substitutes (Ornstein, 1980), whether that is beer for wine or alcohol for marijuana. Evidence suggests that across intoxicants there are considerable similarities with the propensity to substitute being in proportion to the similarity of intoxicants' anticipated effects (Klee et al., 1990). Boys et al. (2001) explored five functional domains for substance use in 364 poly-substance users using a snowball sampling method: changing mood, physical effects, social purposes and to facilitate activity and to manage the effects from other substances. The top three functions that intoxicants served, across men and women, were relaxation, intoxication and stimulation. The study by Boys considered alcohol, cannabis, amphetamines, cocaine, methylenedioxymethamphetamine (MDMA) and lysergic acid diethylamide (LSD) and found that the only functions that all six did not share were 'lose weight' and 'aid sleep'. Thus, consumption goals are primary and the choice of intoxicant is secondary, at least in poly-substance users. This is critical and further suggests that alcohol policy cannot remain substance-specific, focused on the method of intoxication, as consumers appear to be more interested in the effects rather than the vehicle. It might be argued that policies of interdiction prevent licit to illicit substitution. The effect of policies of interdiction can be realized as reducing the affordability of illicit substances (see above) and therefore reduce the probability an illicit intoxicant would be chosen (Herrnstein, 1990). However, the available evidence suggests that choice is realistic for many.

AVAILABILITY

Surveys of use strongly suggest that a range of substances are both available and used in combination and that the use of one substance is a risk factor for multiple use (Boys et al., 1997; Lingford-Hughes and Clementi, 2008). Kedia et al. (2007) examined patterns of mono- versus poly-substance use in data taken from the intake records of 69,891 patients admitted to publicly funded treatment programmes in Tennessee between 1998 and 2004 and found that 48.7% of those admitted used more than one substance. Alcohol with cocaine, and alcohol with both marijuana and cocaine were the most common combinations, cited in 12% ($n = 8,734$) and 8.9% ($n = 6,202$) of admissions, respectively. Barnwell and Earleywine (2006) reported that 25% of 2,600 respondents to their Internet survey used both marijuana and hallucinogens, 17% used both marijuana and sedatives, and the combinations of alcohol with sedatives and alcohol with hallucinogens were each used by 14% of respondents. In a sample of 19,084 16–23 year olds, of those reporting past-year use of club drugs (including methamphetamine, MDMA and LSD), ~99% also used alcohol, 97% used marijuana, 96% used cocaine and 47% used inhalants (Wu et al., 2006). A sample of over 4,000 American adolescents saw 27.6% of respondents using both alcohol and marijuana (Collins et al., 1999). Calafat et al. (1999) found that 50.6% of recreational drug users used both alcohol and cannabis, and 11.9% used alcohol and MDMA and 10.4% used all three substances. Boys et al. (1997) surveyed Australians who had visited a rave within the 6 months up to survey. Of those who admitted drug use, over 75% claimed to use more than one substance. Moreover, high strength alcoholic drinks, in particular spirits, appear to be a risk factor for

complementarity: both Miller and Plant (2003) and Sutherland and Willner (1998) found that smoking and use of illicit substances was more common in those who primarily drank spirits than among those who drank mostly wine or beer. Concurrent use of alcohol and cocaine in those admitted to an addiction treatment unit for those with alcohol and drug dependence is increasing. A study of 465 patients conducted by Lyne et al. (2010) found that concurrent use of cocaine and alcohol in this population increased significantly from 8% in 1995 to 37.9% in 2006. A survey of 7,798 11–15 year olds in the UK found that 52% had consumed alcohol, 32% had smoked tobacco and 22% had tried illicit substances and by the age of 18 years 86% had tried at least one illicit substance (Diment et al., 2009). The British Crime Survey (2008–2009) (Walker et al., 2009) recently included questions on alcohol and drug use. Data from over 30,000 respondents who were 16 years of age or older suggests that 30% claimed to have taken marijuana, 11% amphetamines, 9% amylnitrate, 8% cocaine, 7% ecstasy; 10% claimed they had never consumed alcohol. For drinkers who claimed to drink alcohol nearly every day, the average number of other substances tried was 3.4 compared with drinkers who drank once or twice a month or less frequently, where the average number of other substances tried was less than one. Those who are more likely to misuse alcohol, presumably the target group for the alcohol policy, appear to be those most likely to consume both licit and illicit substances. Although survey data provide little information on how substances are combined, if at all, these data do suggest that current policies of interdiction cannot be relied on as a means of limiting exposure to and the use of illicit substances.

Of the substances assigned some level of expected harm (Nutt et al., 2007), only two are typically available through both licit and illicit markets: tobacco and alcohol. There are therefore comparatively more opportunities for policy interventions in the case of tobacco and alcohol, which include influencing price and reducing availability through, for example, the state monopolization of alcohol distribution as seen in Sweden with the introduction of the Systembolagat (similar monopolies are Vínbúð in Iceland, Alko in Finland, Vinmonopolet in Norway and the Liquor Control Board of Ontario, Canada). In Sweden, retailers are only permitted to sell low-alcohol beverages with the state controlling the supply of stronger alcoholic beverages. Similarly, Australia also requires that alcohol is only available through dedicated commercial outlets. Other community-level interventions have included bans on the off-sale of alcohol in some remote Australian communities, such as Fitzroy Crossing in Western Australia. Options for policy-level interventions in illicit markets are mostly restricted to interdiction and sanction. Price, as well as factors that affect the relative price of substances such as wealth, has therefore been of interest in considering the relationship between policy-level interventions on the one hand and consumption behaviour on the other[2]. The following section explores how policy-level interventions

affect consumption decisions and relates those changes to the previous discussion on substance-related harm.

SUBSTITUTION

Empirical observations suggest an association between the affordability of alcohol and measures of population-level alcohol consumption: as alcohol becomes less affordable, less alcohol is consumed (Chaloupka et al., 2002; Koski et al., 2007; MacKillop and Murphy, 2007; Herttua et al., 2008, 2009; MacKillop et al., 2009; Meier et al., 2009). Observing that as affordability decreases and the demand for alcohol also decreases does not imply, however, that consumers are consuming less to meet their needs for intoxication. As already noted, demand elasticity can be explained by consumers substituting alcohol with other intoxicants [some may even choose to consume methanol (Davis et al., 2002), a toxic variant of drinking ethanol] such that the goals of intoxication are still met and consumers are still exposed to significant harm. A useful discussion of this effect is presented in McKee's commentary on Russian alcohol policy in the late 1980s and early 1990s (McKee, 1999). Levels of alcohol consumption in Russia are some of the highest in the world (McKee, 1999; Zaridze et al., 2009). The associated levels of harm motivated the Russian state to impose restrictions during the 1980s and 1990s that included raising the price of alcohol by over 25%. Although the data available for assessing the impact of such actions is understandably limited, McKee's analysis suggests that these interventions did have some initial success. However, the long-term outcome was to partly motivate a dramatic increase in the production and consumption of illicit alcohol, which in turn appears to have led to alcohol-related harm returning to baseline after a few years. While the quality of illicit alcohol during this period is not known, some evidence from Eastern Europe suggests that illicit alcohol is both stronger and may be more likely to contain other toxins (Lachenmeier et al., 2009). The rapid increase in the alcohol price in Russia motivated consumers to substitute licit alcohol with illicit alcohol, likely exposing themselves to similar levels of harm and possibly greater harm and, critically, placing themselves outside of further policy-level interventions.

Another form of substitution is where low- and moderate-strength alcohol is substituted with stronger alcohol. While moderate drinkers are more sensitive to changes in alcohol affordability, heavier drinkers are less affected are also more likely to substitute. Heavier drinkers also appear to be less likely to choose beverages based on taste, instead choosing beverages that offer the most alcohol for the least price (Nelson, 2003; Hogan et al., 2006), a form of alcohol-limited substitution. Gruenewald et al. (2006) used point-of-sale data from the Systembolagat in Sweden to assess the impact of a reduction in the affordability of alcohol on substitution across brands of varying quality. They observed that as affordability decreased, rather than consume less, drinkers switched to lower-cost brands. Moreover, these trade-offs were substantial both within a beverage type, for example, substituting a high-quality wine with a low-cost wine, and between beverages, for example, substituting wine with spirits. This alcohol-limited substitution can affect the distribution of harm across a population as stronger beverages are more associated

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*2 Consumption is not solely determined by price, of course. Taste, which may in this case be endogenous, plays a significant role evidenced by the significant premium some drinkers are willing to pay on certain wines. While taste, in its broadest sense, can be influenced through social marketing campaigns and popular culture, these are not typical policy-level interventions and are not considered here.

with alcohol-related harm. Results from a study by Gronbaek *et al.*, (1995) suggest that those who drink spirits are at greater risk of cardiovascular and cerebrovascular disease. Furthermore, in a study examining alcohol-related harm Lesjak (2009) found that serving only low- and mid-strength beer, not spirits, at the 2009 'St. Pat's day' event in Sydney resulted in a reduction of alcohol-related harms recorded in accident and emergency hospital clinics compared with previous events where high-strength beer and spirits were available.

Saffer and Chaloupka (1999) estimated the effect of changing alcohol, cocaine and heroin price and marijuana decriminalization on the demand for each. They concluded that marijuana decriminalization would increase past-month marijuana consumption by 8.4%, and past-year marijuana consumption by 7.6%. They estimated that the price elasticities for alcohol, cocaine and heroin were −0.30, −0.28 and −0.94, respectively. They also reported a modest substitution effect between alcohol and marijuana but concluded that a complementary relationship between these four substances was most likely. This contradicts at least one experimental study suggesting price inelasticity under addiction, particularly for heroin users (Jofre-Bonet and Petry, 2008), and studies indicating substitution between alcohol and marijuana (McGlothlin *et al.*, 1970). One very likely reason for this discrepancy may be due to the data sets used by Saffer and Chaloupka. They relied on a household survey that may have under-sampled risky consumers; a feature of numerous studies considering the relationship between policy-level interventions and consumption. For example, studies of Internet survey response rates suggest that high-risk drinkers are more prone to attrition (McCoy *et al.*, 2009). Further, the data used by Saffer and Chaloupka were pooled cross-sectional data rather than individual-level data, substantially weakening the conclusions that can be drawn.

Substitution is typical across similar substances as observed during shortages in the availability of marijuana that occurred in 1969 in the United States due to a policy that increased the resources available for interdiction. In their study of how these shortages impacted on consumption, McGlothlin *et al.* (1970) found ~50% of marijuana users substituted to another substance, of whom half switched to alcohol and the other half moved to mostly hallucinogens. McGlothlin *et al.* suggested that the substitution of marijuana with other illicit substances may be easier, compared with substituting alcohol with marijuana, as consumers were already exposed to an illicit market and will likely have social networks in which illicit substance use is common. The implication being that should alcohol policy shift consumers from a licit market to an illicit market, then this could encourage further use of illicit substances (Melberg *et al.*, 2010). Those most at risk of substituting for alcohol are younger drinkers with high consumption levels (Meier *et al.*, 2009) and who are characterized as exhibiting conduct order more generally (Melberg *et al.*, 2010). Furthermore, Clements and Daryal (2005) studied substitution effects between marijuana and alcohol consumption through presenting students with an hypothetical scenario in which marijuana was legalized. Students, predicted that their levels of alcohol consumption, in the face of marijuana legalization, would fall but with daily drinkers and those who drank spirits more likely to substitute compared with drinkers who consumed alcohol less frequently.

This heterogeneity may go some way in explaining the occasionally conflicting findings in respect of the relationship between alcohol and marijuana use.

Pacula (1998) investigated the relationship between alcohol and marijuana using the National longitudinal Survey of Youth. Pacula's analysis suggested that increasing the price of beer through taxation had the effect of significantly reducing the demand for both marijuana and alcohol. Pape *et al.* (2009) also suggest that alcohol and marijuana are complements and that therefore a positive consequence of alcohol reduction strategies may be the reduction of marijuana use. This effect does not generalize. One of the largest studies of American students (from 43 states) was conducted between 1980 and 1989 and coincided with an increase in the legal drinking age, the result being an increase in marijuana consumption (DiNardo and Lemieux, 2001). A study by Valliant is also informative (Valliant and Milofsky, 1982). Valliant prospectively followed a group of 400 men from the age of 14 until 47 years. In this sample, 110 abused alcohol, of which 49 were able to achieve 12 months of abstinence. In considering the processes that supported abstinence, Valliant observed that many substituted alcohol with some other form of consumption, marijuana in some cases and other substitutes included confectionery, diazepam, chlordiazepoxide, tobacco and spiritualism. Valliant considered users who did not receive any formal treatment. It is therefore informative to consider evidence for substitution in users who undergo more formal treatment programmes, where several studies suggest that substitution may not feature. Patkar *et al.* (2006) found that cocaine-dependent individuals did not increase their levels of tobacco consumption across treatment. Darke *et al.* (2006) found that heroin addicts undergoing treatment did not increase their use of other substances: lower-frequency heroin use corresponded with reductions in the frequency of opioid, cocaine, amphetamine and benzodiazepine consumption, and alcohol consumption remained stable. Similarly, Kadden *et al.* (2009) found that marijuana users receiving treatment for their dependence did not increase their use of alcohol during this time, and that this was sustained over a 1 year follow-up period. Peters and Hughes (2009) investigated the daily patterns of substance use of 28 daily marijuana users abstaining from marijuana but where users were not instructed on their use of other substances. Further, and addressing potential ceiling effects, participants were selected who were not risky users of alcohol but were moderate drinkers. Peters and Hughes (2009) found that marijuana users did substitute marijuana with alcohol over the study period. Broadly, these studies suggest abstinence across substances during treatment is associated with the usual recommendation of abstinence from all substances to patients in formal treatment programmes. This is instructive as, if this finding generalizes, then it might suggest that abstinence in consequence of a substance-specific alcohol policy might not prevent substitution and that a more effective solution is for individualized treatment that promotes abstinence generally.

DISCUSSION

The evidence available to assess the impact of the alcohol policy on substance use generally is sparse. However, it

would appear that a range of intoxicants are available to consumers, implying that for many policies of interdiction are ineffective, and that a significant proportion are willing to substitute. While some studies using pooled survey data suggest that substitution does not occur, these analyses are weak with the bulk of available evidence indicating that alcohol consumption diminishes as the use of illicit substances increases and that younger, heavier drinkers are most likely to substitute and complement their alcohol consumption. This presents a challenge to the notion that alcohol can be considered independently of other intoxicants, and one that is further supported by the way in which harm is attributed. Indices of harm that assume independence between intoxicants fail to account for the added complexity that substitution and complementarity presents; targeting resources at reducing the consumption of one intoxicant does not mean harm is necessarily reduced as consumers can switch to more harmful substances. Because alcohol potentiates the effect of other intoxicants, it is likely that a reduction in alcohol consumption would not only address those alcohol-specific harms but also those harms ascribed to the complementary use of alcohol. Finally, intoxication is primary with the choice of intoxicant being secondary: consumers are willing to select those intoxicants that are able to, either in isolation or when combined with other intoxicants, achieve their desired state. Assumptions of independence are not justified and substance-specific policies unwarranted.

Returning to the parsimonious model outlined in the Introduction, a productive way of capturing how policy might be refined to influence consumption might be to assume that consumers perform some cost–utility analysis whereby they consider the affordability of an intoxicant or intoxicants in combination relative to the goal of intoxication, where intoxication might involve duration as well as the nature of the 'high'. Here, intoxicant choice is secondary to consumers' goals for intoxication and under such conditions there is reasonable evidence to suggest that, at least for some drinkers, the mixture of intoxicants used to achieve the goal of intoxication will change. A better understanding of complementarity and substitution and more information on how these complex relationships between intoxicants elicit harm could be used to develop models (Agar, 2004) that might be used to simulate and test the implications of a range of policy options.

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