

Review



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Relationships among impulsive, addictive and sexual tendencies and behaviours: a systematic review of experimental and prospective studies in humans

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Impulsivity’s relationships to addictive and sexual behaviours raise questions regarding the extent impulsivity may constitute a vulnerability factor for subsequent addictive and sexual behaviours and/or results from each of these. Here, we systematically reviewed empirical support for impulsivity as a precipitating factor or a consequence of addictive or sexual behaviours. We restricted ourselves to recent, human studies with assessments over time, including at least one measure of impulsivity, addictive and sexual behaviours, yielding a review including 29 published reports from 28 studies. Findings point to generalized, self-reported impulsivity as a predictor of addictive and sexual behaviours at a wide range of severity, with elements of both impulsivity and compulsivity to these acts. Alcohol consumption often increases impulsive behaviour, including inclinations towards impulsive and potentially compulsive sexual acts. Research using the Sexual Delay Discounting Task has yielded findings linking impulsivity, addictive and sexual behaviour and as such is a valuable research tool that should be used more extensively. The present review identified gaps to be addressed in further research that concurrently examines facets of impulsivity, addictive and sexual behaviours, especially because criteria for compulsive sexual behaviour disorder have been included in the eleventh edition of the *International Classification of Diseases*.

This article is part of the theme issue ‘Risk taking and impulsive behaviour: fundamental discoveries, theoretical perspectives and clinical implications’.

1. Introduction

(a) Background on impulsivity and addictive and sexual behaviours

Impulsivity, defined as a tendency towards rapid or immediate action with diminished regard for future consequences [1,2], contributes to multiple psychiatric disorders and patterns of risky health-related decision-making. Many psychiatric disorders and related tendencies cluster together, with addictive and risky sexual behaviours being two examples [3]. Addictive behaviours [4] are defined as substance use [5] and other actions that are potentially habit-forming and may occur in excess despite their negative impact. Risky sexual behaviours include sexual activity that is unprotected, with multiple or casual partners, and/or following substance use [6].

There are several commonalities among impulsivity, addictive and sexual behaviours. At low-to-moderate levels, impulsivity, addictive and sexual

behaviour are all normative. At lower levels, impulsivity could be viewed as normative spontaneity [7]. Alcohol, in particular, is considered normative with active debates regarding whether moderate consumption may even have health benefits [8]. Similarly, sexual behaviour that takes risk into account and falls short of compulsive levels is integral to romantic relationships and reproduction [9]. Evidence shows that impulsivity contributes not only to initiation (including relatively early initiation) of addictive and sexual behaviours but also to acceleration of these behaviours [10,11]. Once acceleration occurs, addictive and sexual behaviours can be potentially problematic [12–14].

Specifically, substance use and sexual behaviour that exceed normative levels tend to occur despite possible negative consequences. This is reflected in the definition of substance-use disorders (SUDs): recurrent substance use that leads to functionally and clinically significant impairment including health issues, disability and inability to meet responsibilities [15]. Similarly, compulsive sexual behaviour is typified by considerable distress and/or impairment in aspects of psychosocial functioning [9,10]. Furthermore, when impulsivity, addictive and sexual behaviour shift towards more problematic levels, issues maintaining control typically manifest with each [1–3,9–11]. Two DSM-5 (*Diagnostic and Statistical Manual of Mental Disorders-5*) SUD criteria (i.e. using the substance in larger amounts or for a longer time than intended; difficulties in reducing or stopping use [15]) relate to impaired control over substance use. Measures of impaired control over alcohol use correlate significantly with measures of impulsivity [16]. Furthermore, impulsivity is a component of several psychiatric conditions that also relate closely to risky sexual behaviour, where maintaining personal control over behaviour is a concern (e.g. borderline personality disorder, bipolar disorder) [15].

The insensitivity to negative consequences that typifies problematic substance use and sexual behaviour is also part of the definition of impulsivity [1,2]. But whereas impulsive behaviour is typically equated with reward value and positive affect [17], intensification of addictive and sexual behaviours tends to occur despite their rewarding qualities dissipating over time. This change typifies a shift from the behaviours being characterized by impulsivity towards compulsive or habitual behaviour [9,18,19]. Compulsive behaviours have been defined as actions inappropriate to situations that persist despite lack of a clear relationship to an overall goal, often leading to negative consequences [20]. Owing to this degree of insensitivity to goals and outcomes, consequences will continue to increase with more severe engagement in addictive and/or sexual behaviours.

In addition to impulsivity's role in addictive and sexual behaviour, addictive behaviours can also increase impulsivity [3,10] and lead to sexual behaviour, including risky behaviour [11]. Relationships between substance use and risky sexual behaviour may be exacerbated by delays to condom availability [11]. Suboptimal response to delay is also a facet of impulsivity [21].

(b) Impulsivity as a complex construct

Investigations involving impulsivity should acknowledge its complex, multifaceted nature. A distinction between impulsivity as a temporary state, influenced by substance use and other stimuli, and as a generalized tendency or trait manifested

over time and across contexts is empirically supported [10]. Notably, both generalized/and trait and state impulsivity may influence addictive and sexual behaviours [10,11]. Though specified impulsivity facets have differed across studies, they often are not correlated strongly with one another [10,21]. A common division of impulsivity facets, supported by a recent confirmatory factor analysis [21], is among response, choice and generalized impulsivity with evidence for the former two coming primarily from cognitive tasks and the latter from self-reports.

Response impulsivity has been defined as a proclivity towards immediate action that does not match current environmental demands [22] and as difficulty inhibiting responses [1]. Choice impulsivity is defined generally as diminished willingness or ability to tolerate delay often involving delay discounting: preferences for smaller, sooner over larger, later rewards [21]. Substance use despite negative consequences also relates to this tendency to privilege immediate over longer-term rewards that typifies impulsivity [21]. A related construct is probability discounting, which involves preferences for larger, less certain over smaller, more certain rewards [23]. While response impulsivity [22] and probability discounting [23,24] are sensitive to acute substance effects, delay discounting, at least for hypothetical and actual money, appears to be a relatively stable, individual difference [10]. In contrast to task performance, generalized self-reports capture people's perceptions of their tendencies [10]. The UPPS Impulsive Behaviour scale, a prominent generalized impulsivity measure, assesses sensation-seeking, lack of planning, lack of perseverance, and positive and negative urgencies (i.e. impulsivity stemming from intense positive and negative affective states, respectively) [25,26]. Outside of the UPPS, theory and evidence indicate sensation-seeking is a related but separate construct [21].

(c) The current systematic review

Complex causation and sequencing questions regarding relationships among impulsivity, addictive and sexual behaviours warrant a review of studies that include measures of all three constructs over time (prospectively/longitudinally or experimentally, in the laboratory). Such a review may provide insight into the extent to which impulsivity operates as a precipitating factor or consequence of addictive or sexual behaviours by identifying specific factors underlying relationships, clinical factors and co-occurring conditions. These topics, which have treatment and public health implications, are the focus of the present systematic review of recent literature. Given the importance of the shift from normative to problematic behaviours and the related impulsivity to compulsivity shift, it is necessary to distinguish between studies measuring behaviours at lower and greater severity. By highlighting this distinction, we will call attention to relationships between impulsivity and engagement generally as well as problematically.

(d) Neural and genetic underpinnings

Given the importance of issues of causation to the present review, research involving neuroimaging and/or genetics has a unique potential contribution. Impulsivity entails disruption of a range of neural processes including coordination of motor and cognitive processes, perception and attention [10]. Neurally, impulsivity may be characterized by impaired top-down cortical control of fronto-striatal circuitry and/or over-activity in fronto-striatal reward circuitry [3]. Both

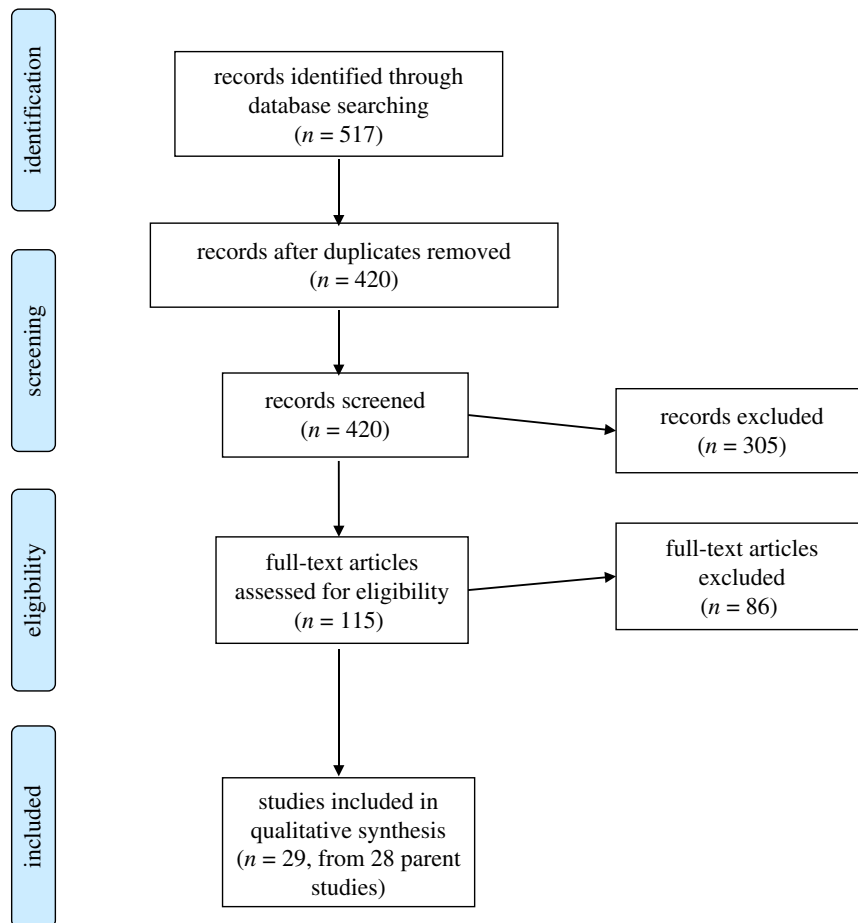


Figure 1. Flow diagram for review. (Online version in colour.)

impulsivity and SUDs may involve dopaminergic neurons that extend from the ventral tegmental area through to the nucleus accumbens (NAc) [3,27]. Addictive behaviours and natural rewards such as sexual activity appear to generate similar reward circuit activity in regions including the amygdala, hippocampus and frontal cortex [27].

Genetic/familial factors are associated with impulsivity in human and animal studies [3]. Siblings of people with SUDs have higher levels of impulsivity than unrelated, control participants [28]. In large studies, genetic liability characterizing SUDs, impulsivity and related constructs (conduct/antisocial personality disorder) appears to overlap [29].

2. Methods

We reviewed the recent, human literature concerning relationships among impulsivity and addictive and sexual behaviours over time. We restricted ourselves to research including at least one measure of each of these three factors. We limited ourselves specifically to studies including a measure of impulsivity proper as discussed in the introduction. Studies that measured only related phenomena such as impulse-control disorders, risk-taking, or sensation-seeking were excluded (see [21]). Studies reporting on HIV status with no accompanying measure of sexual activity were not considered. Given the high number of reviews concerning these factors, including multiple reviews by our group (e.g. [30]), we limited ourselves to literature published from 2013 forward. Given our specific focus in this review, we also only considered studies examining these relationships over time, including in the short (i.e. laboratory experiments) or longer term (i.e. prospective or longitudinal observational

studies or randomized controlled trials). Thus, cross-sectional studies were excluded.

We searched the literature using PubMed and PsycInfo databases for peer-reviewed, English-language publications. Both databases were searched for these keywords: ‘impulsiv*’, ‘go no go’, ‘go stop’, ‘delay discounting’, ‘barratt’, ‘upps’, ‘alcohol’, ‘drug’, ‘addict*’, ‘HIV’, ‘sexual’ and ‘risky sex.’ We searched terms in groups of three; thus, one keyword representing each of the three factors was included in each search with all permutations exhausted. Excluding duplicates, the search produced 420 papers for review in April 2018.

Two authors examined the initial results for the following inclusion criteria: (1) measurement of impulsivity; (2) measurement of addictive behaviour; (3) measurement of sexual behaviour; (4) study design (experimental, prospective/longitudinal observational or a clinical trial); and (5) inclusion of human participants. First, titles and abstracts of each paper were reviewed to eliminate studies clearly not meeting one or more criteria. The full document of each remaining paper was then reviewed with strong inter-rater reliability at this step (Cohen’s kappa = 0.83). Disagreements were resolved through discussion. The full-text review resulted in 29 papers published from 28 parent studies (figure 1).

Three authors reviewed data from the remaining papers. The following information was extracted: (1) sample size; (2) per cent female participants; (3) key inclusion/exclusion criteria; (4) study design; (5) study groups and conditions; (6) findings relating impulsivity and addictive behaviours; (7) findings relating impulsivity and sexual behaviours; (8) findings relating addictive and sexual behaviour; and (9) findings among all three factors.

Steps undertaken in this systematic review were based on PRISMA procedures [31]; however, steps related to the generation of effect size estimates were not completed. The broad

variety of methods and precise constructs included in the studies selected in this review precluded meta-analysis or other consideration of effect size estimates. Risk of bias steps were also not taken given the lack of randomized controlled trials included in the review and because the types of experiments included in the review tended not to permit full investigator blinding.

3. Results

Owing to space considerations, we have focused text description on the most relevant manuscripts, summarized in table 1; however, the full review results are in electronic supplemental material, table S1. Results are grouped according to which factors were involved (impulsivity and addictive behaviours; impulsivity and sexual behaviours; addictive and sexual behaviours; or relationships among all three). Within these groupings, results were separated according to the level of severity of the reported behaviour. We use the term 'predictive' to refer to longitudinal data suggesting one factor leading to another. Genetic and neuroimaging results, being unique, were reported in their own sections.

(a) Impulsivity and addictive behaviours

(i) Impulsivity and substance use

Using data from the Philadelphia Trajectory Study, change over time in self-reported 'acting without thinking' related significantly to increased alcohol-use frequency over the same time period [40]. In the same study, difficulties delaying gratification on a monetary discounting task were not related significantly to the same measure of drinking frequency, but had a trend-level relationship to heavy drinking (i.e. frequency of consuming five or more drinks for males, four or more for females with no time qualifier). In an 18-month prospective study enrolling older adolescent men who have sex with men, positive and negative urgency as well as sensation-seeking predicted binge drinking (i.e. frequency of having five or more drinks within a 2 h time period), while negative urgency and sensation-seeking predicted marijuana use [45]. In a prospective study, enrolling male college students, generalized, self-reported impulsivity assessed during their first year of college predicted binge-drinking frequency 1 year later [41].

Alcohol administration in an experimental laboratory study did not relate significantly to state impulsivity (extent one feels impulsive, daring, etc. in the moment) self-reported during hypothetical sexual scenarios in young adult, heterosexual, non-problem-drinking males [35].

Among occasional drinkers, laboratory alcohol administration was associated with less steep probability discounting for hypothetical monetary rewards than placebo (i.e. less risk sensitivity). However, in the same study, alcohol did not significantly influence delay discounting of real or hypothetical money [24].

(ii) Impulsivity and problem use/use disorder

In an experimental study not involving substance administration comparing participants meeting criteria for DSM-IV alcohol dependence with healthy control subjects, a trend-level between-group difference regarding monetary discounting was reported [38].

Laboratory cocaine administration among those with cocaine-use disorder led to the same null finding for

monetary discounting and for cocaine discounting as with alcohol among occasional drinkers in the laboratory study reported above. Furthermore, the effect of alcohol on probability discounting was not replicated with cocaine [39].

(iii) Summary

Findings support the conclusion that greater generalized, self-reported impulsivity is associated with greater subsequent frequency of alcohol consumption and heavy drinking specifically. However, evidence supporting relationships of alcohol use and use disorder with greater delay discounting is mixed. Laboratory alcohol but not cocaine administration influenced probability discounting of money, but not delay discounting of money.

(b) Impulsivity and sexual behaviour

(i) Impulsivity and sexual intercourse

Among first-year female undergraduates in a prospective study entailing monthly self-reports, generalized impulsivity predicted receiving oral sex (with parallel findings for sensation-seeking). Sensation-seeking also related to vaginal-sex frequency [36]. In the Philadelphia Trajectory Study, stronger working-memory predicted lower likelihood of sexual intercourse (particularly unprotected intercourse) at follow-up, mediated by lower levels of 'acting without thinking' and greater tendencies to delay gratification, two facets of impulsivity [40]. In the same study, greater endorsement of 'acting without thinking' correlated with increased unprotected intercourse. There were also relevant null findings. Among sexually active female undergraduates, neither generalized, self-reported impulsivity nor sensation-seeking related to condom use in a study involving monthly self-reports over 1 year [48].

Multiple experimental studies relating impulsivity to sexual tendencies used the Sexual Delay Discounting Task (SDDT) [51]. In this task, participants are asked which individuals in photos they would consider for hypothetical, casual sex, based on physical appearance alone, provided the environment was right and they liked the person's personality. Participants are instructed to assume they are single and available with no chance of pregnancy. Of those selected, participants are further instructed to pick four individuals with whom they would most (1) and least (2) want to have sex and select the persons they perceive most (3) and least (4) likely to have sexually transmitted infections (STIs). Participants are then asked a series of eight visual-analogue-scale questions for each of those partners. The initial question has a range from 0 indicating immediate sex *without* a condom to 100 indicating immediate sex *with* a condom. Subsequent questions keep the 0 statement and change the 100 statement to add increasing delays to sex with a condom. In results involving this task, we considered responses to these questions as relating to both sexual behaviour and impulsivity. In an in-treatment sample of females with opioid-use disorder, generalized, self-reported impulsivity [52] correlated significantly with lack of willingness to wait for condom-protected sex (i.e. greater sexual delay discounting). However, in the same study, a null result was reported between sexual delay discounting and monetary delay discounting [37]. A similar null result for monetary delay discounting was reported among individuals with cocaine-use disorder [53]. In contrast to the prior generalized self-reported impulsivity finding [52],

Table 1. Brief summary of key manuscripts included in the review. All relationships positive unless otherwise noted. Acronyms: AD, alcohol dependence; AWT, acting without thinking; CSB, compulsive sexual behaviour; IDG, inability to delay gratification; LHPP, phospholysine phosphohistidine inorganic pyrophosphate phosphatase; NA, no significant results reported; NR, not reported; OD, opioid dependence; STIs, sexually transmitted infections; SDDT, sexual delay discounting task; SPDT, sexual probability discounting task.

first author and year	study design	1. Significant relationships between impulsivity and addiction measures	2. Significant relationships between impulsivity and sexual behaviour measures	3. Significant relationships between addiction and sexual behaviour measures	4. Significant relationships among the three
Ashenhurst [32]	longitudinal	genetic findings linking alcohol dependence with externalizing factor including impulsivity; impulsivity assessed using a subset of the Zuckerman – Kuhlman inventory that measures sensation seeking and lack of planning	NA	genetic findings linking alcohol dependence with externalizing factor including risky sex (i.e. self-reported condom use with exclusive and non-exclusive partners)	NR
Dariotis [33]	experimental	substance use (i.e. current and lifetime self-report alcohol and drug use confirmed by urine screen) and sexual impulsivity	substance use and sexual impulsivity HIV knowledge and sexual impulsivity (inverse)	see column 1; sexual impulsivity assessed using the SDDT	see column 1
Davis [34]	prospective	NR	self-reported impulsivity (i.e. trait impulsivity on the Eysenck personality inventory) and sexual-aggression perpetration	NA	NR
Davis [35]	experimental	NA	relationship among sexual aggression, condom use resistance and self-reported state impulsivity	alcohol intoxication and condom use resistance	NA
Fielder [36]	prospective	NR	self-reported impulsivity (i.e. subscale of impulsiveness-monotony avoidance scale) and sexual hookups	substance use (i.e. past month heavy drinking, marijuana and tobacco use) and sexual hookups	NR
Herrmann [37]	experimental	OD related to sexual impulsivity (i.e. SDDT)	self-reported impulsivity (i.e. BIS-11) related to sexual impulsivity	see column 1	NR

(Continued.)

Table 1. (Continued.)

first author and year	study design	1. Significant relationships between impulsivity and addiction measures	2. Significant relationships between impulsivity and sexual behaviour measures	3. Significant relationships between addiction and sexual behaviour measures	4. Significant relationships among the three
Jarmolowicz [38]	experimental	AD related to sexual impulsivity (i.e. SDDT)	NR	see column 1	NR
Johnson [24]	experimental	alcohol administration and sexual impulsivity (i.e. SDDT & SPDT) and preference for probabilistic monetary rewards	NR	see column 1 alcohol administration and increased sexual desire	see column 1
Johnson [39]	experimental	cocaine administration and sexual impulsivity (i.e. SDDT & SPDT)	NA	see column 1	see column 1
Khurana [40]	longitudinal	alcohol use (i.e. lifetime and past month yes/no) and self-reported impulsivity	multiple forms of impulsivity (i.e. AWT & IDG) and sexual activity/risk (i.e. vaginal sex and condom use)	NR	form of impulsivity and sexual risk partially mediated by alcohol use
Kingree [41]	longitudinal	self-reported impulsivity predicted binge drinking	self-reported impulsivity predicted sexual aggression	less binge drinking accounted for protective effect reducing sexual aggression and with less sexual aggression perpetration; assessed using the revised sexual experiences survey	NR
Koffarnus [42]	experimental	cocaine use (i.e. DSM-IV-TR) and sexual impulsivity (i.e. SDDT)	NR	see column 1	NR
Messman-Moore [43]	prospective	NR	NR	sexual victimization (measured using Sexual experiences survey) and heavy drinking/related problems (i.e. AUDIT-C); to a lesser degree, with marijuana (i.e. frequency of involvement subscale of the CARE-revised)	sexual victimization and impulsivity (i.e. DERS subscale), in models accounting for substance use measures

(Continued.)

Table 1. (Continued.)

first author and year	study design	1. Significant relationships between impulsivity and addiction measures	2. Significant relationships between impulsivity and sexual behaviour measures	3. Significant relationships between addiction and sexual behaviour measures	4. Significant relationships among the three
Polimanti [44]	observational/ experimental	NR	NR	AD (i.e. DSM-IV criteria) and risky sexual behaviour (semi-structured assessment for drug dependence and alcoholism [SSADA] section of antisocial personality); interaction involving LHPP rs34997829 and relationship between AD and STIs	findings linking same genotype and areas of brain associated with impulsivity
Puckett [45]	longitudinal	self-reported impulsivity and self-reported binge drinking	NR	NR	relationships of internalized homophobia with risky sexual behaviour (assessed using HIV-risk assessment for sexual partnerships [H-RASP]) and with self-reported binge drinking moderated by self-reported impulsivity (subscales of UPPS-R)
Simons [46]	prospective	NR	NR	intoxication (an estimate calculated from self-reported alcohol consumption) and self-reported rates of risky sexual behaviour	these relationships were moderated by level of effortful control
Voon [47]	experimental	NR	sexual desire (measured using a continuous video-rating scale) and areas of brain associated with impulsivity (as measured by UPPS-P Impulsive behaviour scale), especially in those with CSB; significant difference between CSB and control subjects on self-reported impulsivity	NA	NR

(Continued.)

Table 1. (Continued.)

first author and year	study design	1. Significant relationships between impulsivity and addiction measures	2. Significant relationships between impulsivity and sexual behaviour measures	3. Significant relationships between addiction and sexual behaviour measures	4. Significant relationships among the three
Walsh [48]	prospective	NR	NA	relationships between substance use (measured using self-reported heavy episodic drinking and marijuana use) and sexual activity depended on partner type; measured condom use and alternative contraception use rates in past sexual activities; also collected type of partner for past sexual activities (e.g. a stranger, a friend)	NA
Wray [49]	experimental	NR	NR	alcohol intoxication related to unprotected sex intentions assessed using rating of two video scenarios	NA
Zinzow [50]	longitudinal	NR	NA	alcohol use and sexual assault (measured using the revised sexual experiences survey)	NR

non-significant findings were reported between generalized self-reported impulsivity and sexual delay discounting in young adults [33].

(ii) Impulsivity and sexual aggression

Among male undergraduates, generalized, self-reported impulsivity assessed during the first year of college statistically predicted sexual aggression (i.e. unwanted sexual contact, coercion, attempted and completed rape) assessed with a 35-item self-report in the third year of college [41]. Generalized, self-reported impulsivity also related to self-reported sexual-aggression perpetration among young adult males reported during a three-month prospective study [34]. Similarly, in the course of a longitudinal study across the 4 years of college, subgroups of male undergraduates reporting prior use of varied rape tactics all reported higher scores than non-perpetrators on an antisocial factor based on self-reports including generalized impulsivity. Furthermore, those endorsing prior forcible rape scored higher on this antisocial factor than other types of perpetrators [50].

In the context of an experimental, laboratory alcohol administration study, a relationship between self-reported history of sexual aggression and intentions to resist condom use was mediated by self-reported state impulsivity [35].

(iii) Summary

In observational/prospective research, generalized, self-reported impulsivity statistically predicted sexual intercourse including without a condom, though there was one null finding. There was also evidence of a link between generalized, self-reported impulsivity and greater sexual delay discounting (i.e. less professed willingness to wait for a condom for sexual activity) in experimental research though there was also a null finding. Monetary delay discounting was not related significantly to sexual delay discounting. Observational/prospective and experimental findings linked generalized impulsivity to sexual aggression.

(c) Addictive and sexual behaviours

(i) Substance use and sexual intercourse

Among first-year female undergraduates in a study entailing monthly self-reports, frequency of heavy drinking and marijuana use statistically predicted performing and receiving oral and vaginal sex [36]. In an ecological momentary assessment study enrolling sexually active undergraduates, lower levels of alcohol intoxication statistically predicted safer sexual activity (particularly in women), but as severity of intoxication increased, likelihood of unprotected sex increased significantly [46]. Among sexually active first-year female undergraduates, alcohol use (any and heavy) was more likely to be implicated in sexual activity with less familiar partners. This was not the case for marijuana, which was associated with decreased likelihood of protected sex in established relationships [48].

In an experimental laboratory study involving alcohol administration enrolling alcohol-consuming individuals without alcohol-use disorder, participants chose more photos depicting hypothetical sexual partners in a sexual-desire task following alcohol compared to placebo. Alcohol was also associated with increases in self-reported negative/aversive aspects of sexual arousal/desire [24]. In another laboratory

study enrolling alcohol-consuming individuals without alcohol-use disorder, alcohol intoxication was directly associated with intentions to resist condom use [35]. In a different laboratory study among sexually active, primarily heterosexual undergraduates (mostly heavy drinkers), alcohol intoxication was positively associated with intention to engage in unprotected sex [49].

(ii) Substance use and sexual aggression

Among first-year male undergraduates, lower binge drinking related to less sexual aggression prospectively [41]. In another study, perpetrators of incapacitated and forcible assault were more likely than those engaging in verbal coercion to report alcohol use beforehand [50]. Null findings were reported between alcohol use and sexual assault re-victimization [43] and perpetration [34] among young adults in other studies.

(iii) Summary

In observational studies, any drinking and heavy drinking and, to a lesser extent, marijuana use were related to various types of intercourse including riskier sex. Experimental laboratory studies provided strong evidence that alcohol administration was associated with intentions to engage in unprotected sexual activity. Notably, this research included findings linking alcohol with inclinations to engage in sexual activity despite parallel increases in self-reported negative/aversive aspects of sex. Observational studies also yielded evidence linking alcohol with forms of sexual aggression, though there were also null findings.

(d) Impulsivity, addictive and sexual behaviour

(i) Impulsivity, substance use and sexual intercourse

The aforementioned relationship between change in acting without thinking and sexual intercourse, particularly without condom use in the Philadelphia Trajectory Study was mediated partially by changes in alcohol use [40]. Regarding moderation, among older adolescent men who have sex with men, relationships between internalization of stigma and both binge drinking and unprotected sexual activity were stronger among those reporting negative or positive urgency [45]. The aforementioned daily diary findings linking increasing alcohol intoxication to unprotected intercourse were driven by undergraduates with low levels of effortful control [46]. However, among sexually active female undergraduates, non-significant moderation by self-reported, generalized impulsivity and sensation-seeking was reported for multiple relationships between alcohol and condom use [48].

In experimental studies not involving substance administration, self-reported number of substances used related significantly to greater sexual delay discounting on the SDDT among young adults [33]. In addition, individuals with recreational cocaine use exhibited higher sexual delay discounting on the SDDT than control participants, with findings indicating that recreational cocaine use was linked to inclinations to forgo condom use [42]. Recreational cocaine use was defined as infrequent use, typically small amounts in social situations without functional and clinical impairment.

Among occasional drinkers, alcohol administration in the laboratory was associated with greater sexual delay discounting. This same study tested a probability discounting version of the task in which likelihood of a STI varied. Following

alcohol, compared to placebo, participants were more likely to accept a degree of STI risk. Similar findings were reported in the aforementioned cocaine study for sexual delay and probability task variants [39]. By contrast, in the aforementioned study of sexually active, primarily heterosexual undergraduates [49], there were no significant relationships between monetary discounting [54] and all other study variables following alcohol consumption.

(ii) Impulsivity, problem substance use and sexual intercourse

Participants with alcohol-use disorder [38], opioid-use disorder [37] and cocaine-use disorder [42] exhibited greater sexual delay discounting on the SDDT than did control participants.

(iii) Impulsivity, problem substance use and sexual aggression

Among female undergraduates, generalized, self-reported impulsivity statistically predicted likelihood of incapacitated sexual re-victimization, even after accounting for alcohol-related problems and marijuana use [43].

(iv) Summary

Observational/prospective studies supported relationships among any drinking, heavy drinking and drinking to intoxication; generalized, self-reported impulsivity; and unprotected sexual intercourse. However, the precise hypotheses and findings regarding mediation or moderation varied across studies, limiting the extent to which specific conclusions may be drawn. Experimental studies produced consistent findings that use of more substances and SUDs were associated with greater sexual delay discounting and that alcohol administration was also associated with increased sexual discounting. Relationships to monetary discounting were not as strong. Limited findings in female undergraduates linked generalized impulsivity to sexual re-victimization above and beyond the role of marijuana and problem alcohol use.

4. Genetic and neuroimaging studies

Data on molecular mechanisms through which alcohol use may contribute to risky sexual behaviour are scant. Our review yielded two relevant studies with implications for impulsivity. Genetic analyses were included in a longitudinal study in which participants were assessed initially during their first year as undergraduates [32]. They used 'deep phenotyping' to relate an externalizing factor including self-reported substance misuse, generalized impulsivity and risky sexual behaviour to 3281 single nucleotide polymorphisms (SNPs) in 104 genes that have been related to alcohol dependence in prior research. They reported significant enrichment of associations between these SNPs and the externalizing factor, though not to the substance misuse, impulsivity or risky sexual behaviour variables individually. This suggests that associations among alcohol dependence and other forms of externalizing generally, including misuse of other substances, impulsivity and risky sexual behaviour, are attributable at least in part to common genetic factors, though genetic factors may not be responsible for relationships among specific types of externalizing features. In the other study, a genome-wide gene-by-alcohol-dependence analysis led to identification of LHPP rs34997829 [44], which has been associated with other psychiatric conditions [55]. There was a significant interaction

such that the relationship between LHPP rs34997829 and STIs was moderated by an alcohol-dependence diagnosis, thus verifying the relevance of this SNP to sexual behaviour and problem alcohol use. The investigators then conducted a follow-up neuroimaging study in another sample and found the C allele of LHPP rs34997829 related to patterns of neural activity in regions associated with impulsivity (see electronic supplementary material, table S1). In another fMRI study, ratings of subjective sexual desire were positively correlated with activity in the dorsal anterior cingulate cortex (dACC) among heterosexual males with and without compulsive sexual behaviour. Exposure to sexually explicit videos was associated with greater activation of the dACC, ventral striatum and amygdala in men with as compared to without compulsive sexual behaviours, with functional connectivity within these regions associated with sexual desire/craving to a greater degree in the men with compulsive sexual behaviours [47]. A more recent study not included in our review found greater ventral striatal activity to anticipatory cues for erotic images in men with problematic pornography use compared to those without [56]. Problematic pornography use has been linked to generalized impulsivity in prior research [57]. Blood-oxygen-level dependent imaging (BOLD) signal within this region was linked to response time to erotic cues and sexual behaviours [56]. The dACC, ventral striatum and amygdala have been associated with drug cue reactivity and facets of impulsivity in prior studies as well [30,58]. In summary, limited genetic and neuroimaging findings suggest commonalities regarding genetic factors and dysfunctional activity in key regions of the brain underpin relationships among impulsivity, addictive and sexual behaviours.

5. Discussion

Arguably the most salient pattern of findings from our review is the varied predictive value of self-report measures of generalized impulsivity. Based on their value, these measures should be incorporated in all research involving addictive or sexual behaviours. Generalized, self-reported impulsivity was predictive of other self-reported addictive and sexual behaviour outcomes in observational/prospective studies and intentions towards risky, impulsive sexual activity in the laboratory [36,37,40,45]. Notably, in observational studies, generalized impulsivity predicted both sexual aggression on the part of young males and sexual re-victimization among females [34,41,43,50]. This pattern suggests that generalized impulsivity predicts both impulsive sexual activity, which is likely driven in part by anticipated or actual reward, and patterns of sexual activity that may be compulsive in nature (i.e. occurring despite negative consequences and less likely to be rewarding). The young age of participants in these studies is notable; thus, relationships between generalized impulsivity and sexual aggression/compulsive sexual activity may not necessarily take many years to develop. Though further research enrolling both males and females is needed, initial findings suggest that these results pertain to both young adult males and females.

The present findings support the prior observation of dual causation between impulsivity and substance use [38,40,41,45]. Alcohol administration in the laboratory was associated with probability discounting of money [24] and greater sexual delay and probability discounting [24,39],

which pertains both to impulsivity and inclinations towards risky (i.e. unprotected) sexual behaviour.

In observational studies, heavy drinking predicted risky sexual activity [36,46,48]. Though included in fewer studies, marijuana use was also associated with sexual intercourse, with limited findings linking marijuana use to risky sexual behaviours [36,48]. In laboratory research, alcohol was associated not only with inclinations to engage in intercourse but also with increased self-reported negative/aversive aspects of intercourse [24]. This finding raises the possibility that alcohol use, even among those without alcohol-use disorders, may trigger inclinations to sexual activity that could be considered compulsive. This possibility should be addressed in future research. Heavy drinking was also associated with sexual aggression [50], though these findings were not as consistent as with self-reported, generalized impulsivity. These relationships suggest that to prevent or treat sexual aggression, targeting impulsive tendencies through pharmacotherapy, behavioural interventions or both may be beneficial.

There were findings supporting relationships among impulsivity and addictive and sexual behaviours from the limited studies that included measures of all three constructs. However, in addition to these studies being limited in number, they included varied measures and different hypotheses in terms of relationships among the constructs (e.g. relating to moderation or mediation). Additional studies in the future should include measures of all three constructs. Furthermore, the SDDT is a valuable research tool for examining existing individual differences (e.g. those with versus without alcohol-use disorders) and for evaluating effects of substance administration in the laboratory on inclinations towards impulsive and risky sexual decision-making.

Issues of sexual orientation and sexual activity with same versus opposite sex partners are pertinent; however, only one study included addressed this issue. This study enrolled only men who have sex with men. The study raised an important issue regarding relationships between internalized homophobia and both heavy drinking and risky sexual outcomes, reporting that these relationships are stronger among individuals reporting greater generalized impulsivity. It is concerning that impulsive individuals may experience particularly strong negative ramifications of stigma. These issues should be addressed further and, where appropriate, more studies should enroll both individuals who engage in sexual activity with primarily same and opposite sex partners to permit comparisons between these groups.

Genetics and neuroimaging data are limited, but the included studies suggest SNPs that relate concurrently to impulsivity and addictive and sexual behaviours [32,44]. Similarly, limited available neuroimaging data implicate brain regions relevant to all three factors, uncovered at resting state and during completion of tasks relevant to impulsivity and sexual activity [44,47]. Notably, Voon and colleagues reported that functional connectivity among the dACC, ventral striatum and amygdala, which also typifies drug cue reactivity and impulsivity, related more closely to sexual desire than liking in men with compulsive sexual behaviour [47,59]. This suggests an element of compulsivity is relevant to associations among impulsivity, addictive and sexual behaviours. Genetic and neuroimaging research are avenues that should be used further in advancing knowledge of shared and unique etiologies and treatment implications.

The present review had limitations including an overall lack of findings linking problem substance use/use disorder to sexual activity/aggression along with a lack of reporting on findings directly addressing relationships among our three constructs of interest. Tasks capturing response impulsivity were under-used. Studies in this review also tended not to account for personality disorder symptoms and/or diagnoses in participant recruitment and statistical analyses. Sexual behaviours and inclinations were almost exclusively considered as outcome measures. While this is valuable, studies tended to ignore sexual behaviour, arousal, intentions and other related factors as possible precipitants of substance use or impulsive behaviours. The review also did not include studies of paraphilias, and these should be examined in future investigations.

6. Conclusion

Findings from the present review argue strongly for the predictive value of self-reported, generalized impulsivity. Notably, these findings included relationships to sexual aggression and re-victimization, outcomes that could be considered relevant to compulsivity. Self-reports of generalized impulsivity should be incorporated into all future research involving addictive or sexual behaviours. Alcohol administration was associated with probability discounting of money along with probability and delay discounting of sexual activity and increased inclinations towards sexual activity including elements of compulsivity. Findings from this review support the value of the SDDT with and without substance administration in the laboratory.

The present review identified several research gaps, including the need for more studies: reporting on relationships among facets of impulsivity and addictive and sexual behaviours; recruiting both females and males (as well as trans-gendered individuals) and testing for individual differences and interactions involving gender; investigating possible differences relating to sexual orientation/preferences for sexual activity with same and/or opposite sex partners; studying types of sexual-activity preferences; using response impulsivity tasks; and incorporating genetic testing and neuroimaging. Future research addressing all three factors simultaneously should incorporate substances other than alcohol (including tobacco) along with gambling and gaming disorders. With respect to the latter, gaming disorder, as well as compulsive sexual behaviour disorder, have been included in the eleventh edition of the International Classification of Diseases [60], and gaming and pornography use behaviours may be linked in nuanced ways [59]. Thus, potentially complex relationships involving substance use and impulsivity with respect to these conditions warrant additional investigation.

While effects of substance administration (particularly alcohol) on state impulsivity and increased sexual activity have been investigated more frequently, notably absent were studies examining increased state impulsivity and substance use resulting from stimulation of sexual desire, arousal, etc. There is precedent for examining the impact of non-substance triggers on state impulsivity and substance use (e.g. stress [61]). Sexual activity as a trigger for impulsivity and increased substance use should be addressed in future studies.

In closing, impulsivity (particularly, generalized, self-reported) often predicts engagement in addictive and

sexual behaviours at a wide range of severities, with elements of both impulsivity and compulsivity to these acts. Alcohol consumption often increases impulsive behaviours, including inclinations towards impulsive and potentially compulsive sexual acts. The present review identified a number of research gaps to be addressed in future studies.

Data accessibility. Additional resources uploaded as electronic supplementary material.

Authors' contributions. R.F.L., B.H.P.R. and N.M.G. contributed to the literature review. R.F.L. wrote the initial draft of the manuscript with assistance from B.H.P.R. and N.M.G.; M.N.P. revised the manuscript and conceived the focus of the review with R.F.L. All authors gave final approval for publication.

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Gaming; has participated in surveys, mailings or telephone consultations related to drug addiction, impulse-control disorders or other health topics; has consulted for and/or advised gambling and legal entities on issues related to impulse-control/addictive disorders; has provided clinical care in a problem gambling services program; has performed grant reviews for research-funding agencies; has edited journals and journal sections; has given academic lectures in grand rounds, CME events and other clinical or scientific venues; and has generated books or book chapters for publishers of mental health texts.

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