DRINKING AND HUMAN IMMUNODEFICIENCY VIRUS

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IARD Health Reviews offer a referenced overview of recent peer-reviewed, published research on the relationship between alcohol consumption and health outcomes. The Reviews report the findings of the referenced studies and are not intended to provide advice or recommendations. They are not necessarily intended to be exhaustive representations of all scientific research on a given subject and, as research is constantly evolving, they may not include the most recent findings. These materials do not necessarily reflect the views of IARD or its member companies. The reviews report the findings of the referenced studies and are not intended to advise individuals about their drinking. People with specific questions about their drinking are encouraged to consult a healthcare professional; together, they can determine what is best based on individual risk factors, including family history, genetics, and lifestyle. For some people, the better choice may be to not drink at all. IARD Health Reviews should be read in their entirety and not misrepresented or taken out of context.

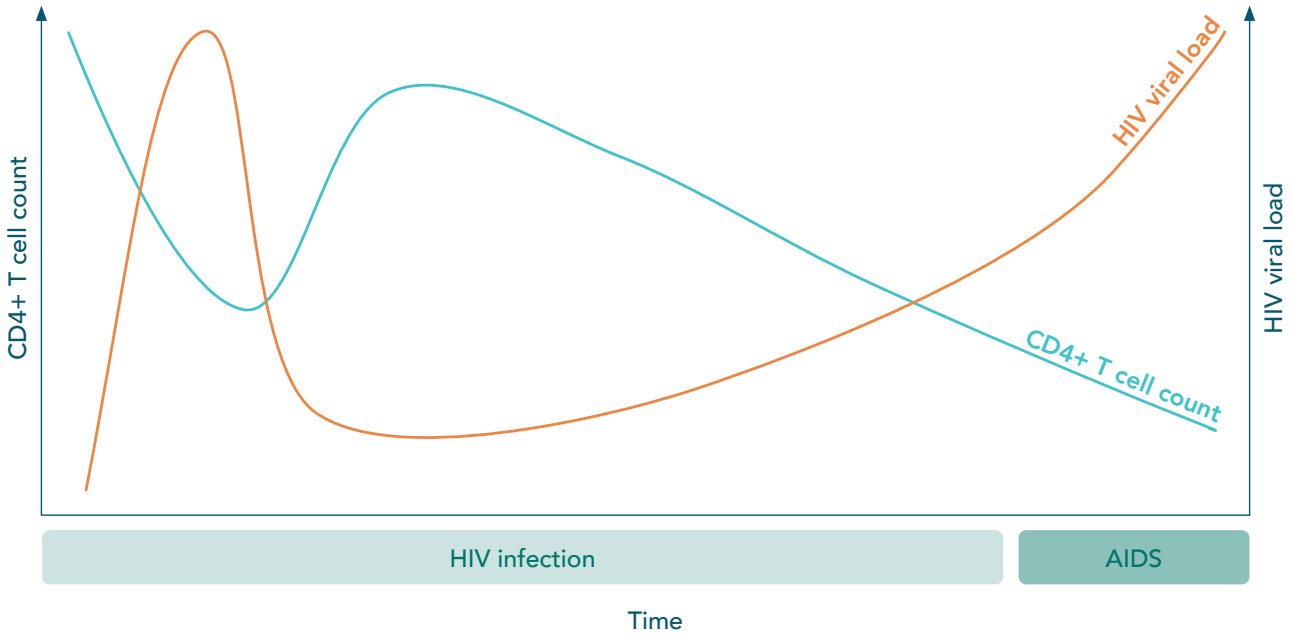
There is a glossary of key terms used in this chapter on **page 31**.

Last literature review: **November 2022**

Human Immunodeficiency Virus (HIV) background

Human immunodeficiency virus (HIV) disease is caused by a virus that attacks the immune system by targeting *CD4+ T lymphocytes (CD4+ T cells)*, white blood cells that help fight off infection [1, 2]. *See the* **Background chapter** *for more information on infectious diseases and the body's immune system.* HIV infects and alters the function of CD4+ T cells to reproduce more infected immune cells, reducing the healthy CD4+ T cell count and increasing the *HIV-viral load* [1] (see Figure 1). Since CD4+ T cells are the primary target of HIV, it is used as a clinical indicator for HIV diagnosis and disease progression [3].

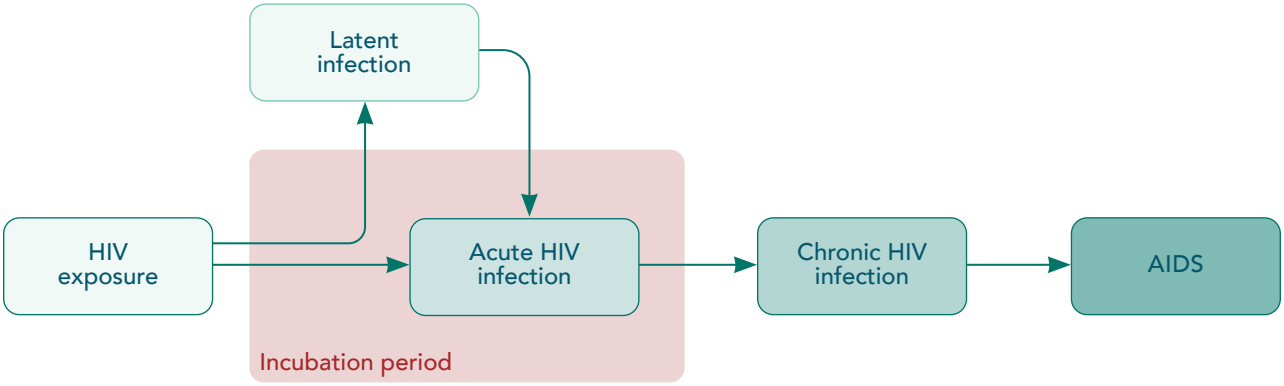
Figure 1. Change in HIV-viral load and CD4+ T cell count after an infection



Source: Fanales-Belasio et al. 2010 [1]

Figure 1 depicts the change in HIV-viral load and CD4+ T cell count after an infection, and Figure 2 describes the natural course of HIV progression. People living with HIV (PLWHIV) with access to *antiretroviral therapy (ART)* are less likely to develop acquired immunodeficiency syndrome (AIDS), an incurable disease that eventually leads to death without access to treatment [1, 2]. With access to ART, an acute HIV infection may not progress to a chronic HIV infection [4] and progression to AIDS may slow down [5].

Figure 2. Natural course of HIV infection and disease progression to AIDS



Notes.
- Individuals with a strong immune system might stay in the latent infection stage until other exposures weaken their immune system.

Source: Fanales-Belasio et al. 2010 & National Institute of Health, 2021 [1, 5]

Without ART, PLWHIV can transmit the virus by exchanging bodily fluids during sexual contact; sharing needles during drug use; mother–to–child transmission during pregnancy, childbirth, or breastfeeding; and receiving unsafe blood transfusions [6, 7].

According to the Joint United Nations Programme on HIV/AIDS (UNAIDS), 85.6 million people have become infected with HIV and 40.4 million have died from AIDS-related illnesses since the start of the epidemic in the 1980s [8]. In 2022, 1.3 million new HIV diagnoses and 630,000 AIDS-related deaths were reported worldwide [8]. *See the* **Background chapter** *of this Health Review for an overview of HIV/AIDS and other infectious diseases.*

In 2021, HIV/AIDS was the 22nd leading cause of death globally [9]. Although global incidence and mortality rates for HIV/AIDS are roughly equal for women and men, these statistics mask a disparity in the burden of disease between high- (HICs) and low-income countries (LICs) [10]. Women in LICs bear a disproportionately large part of this burden: the HIV mortality rate is 93-times higher in LICs than HICs for women [10]. Among men, it is 33-times higher in LICs than HICs [10].

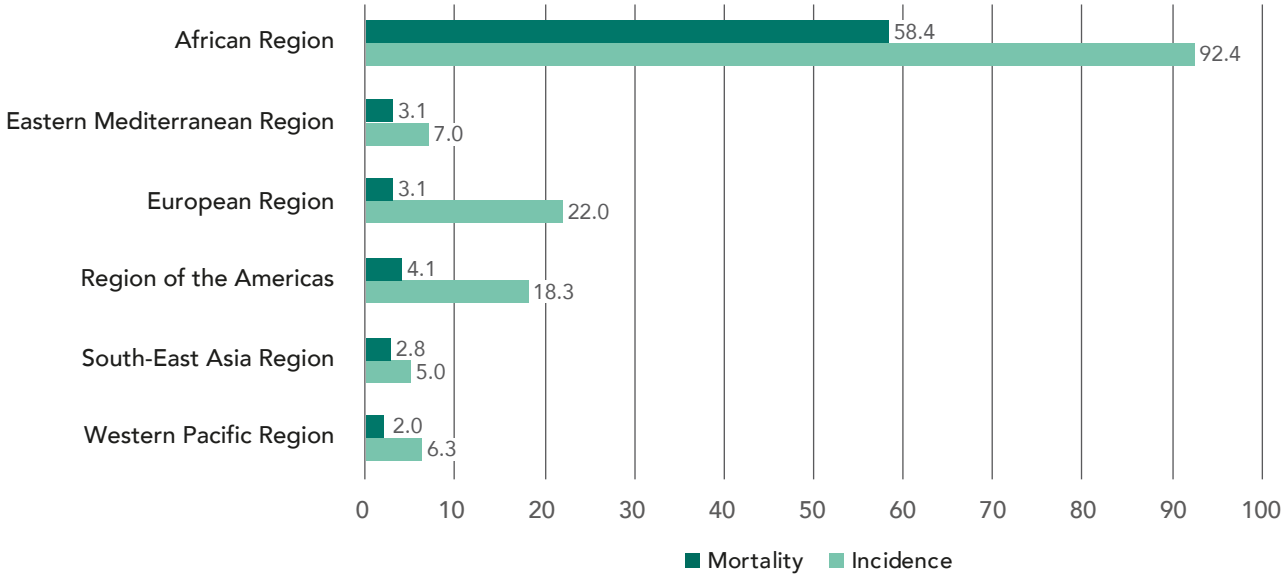
Table 1. 2021 HIV/AIDS age-standardized incidence and mortality rates per 100,000 by World Bank income levels, grouped by sex

Age-standardized rates per 100,000	HIV/AIDS incidence		HIV/AIDS mortality	
	Women	Men	Women	Men
Global	25.7	24.8	10.7	10.7
Low income	87.3	65.9	46.7	43.4
Lower-middle income	20.2	19.3	11.3	10.5
Upper-middle income	24.8	26.9	7.6	9.6
High income	5.7	13.4	0.5	1.3
Low-to-high ratio	15.3	4.9	93.4	33.4

Source: Global Burden of Disease 2021 [10]

When grouped by World Health Organization (WHO) regions, HIV/AIDS incidence and mortality rates are highest in the African region (see Figure 3), which accounted for 92% and 58% of all global HIV/AIDS incident cases and deaths in 2021, respectively [10].

Figure 3. 2021 HIV/AIDS age-standardized incidence and mortality rates per 100,000, grouped by WHO regions



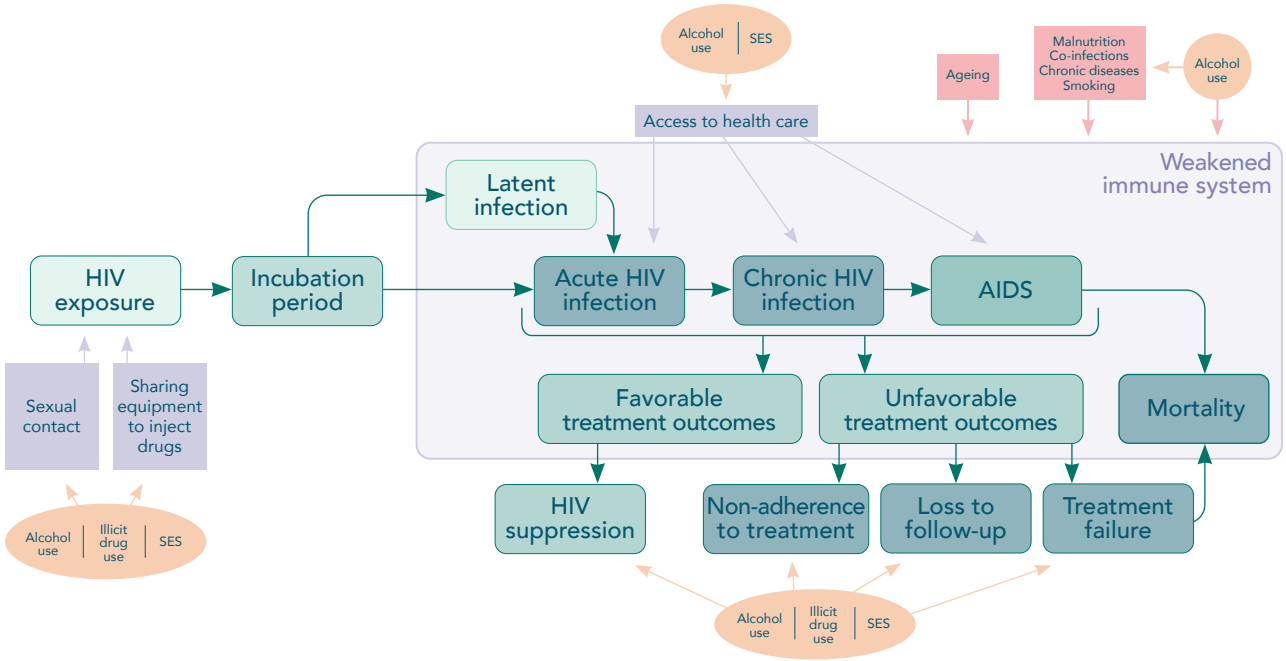
Source: Global Burden of Disease 2021 [10]

In 2022, HIV prevalence was higher among key populations that may have engaged in high-risk behaviors, such as sex workers (2.5%), men who have sex with men (MSM) (7.7%), people who inject drugs (5%), transgender people (10.3%), and incarcerated people (1.4%), than among the general population (0.7%) [8].

RISK FACTORS FOR HIV

HIV infection shares some of the same risk factors as many non-communicable diseases (NCDs) but requires exposure to an infectious pathogen.

Figure 4. Some common direct and indirect HIV risk factors



Key: *Direct risk factors* *Indirect risk factors* *Risk factors for a weakened immune system* *Outcomes of interest*

Notes.
- Individuals with a strong immune system might stay in a latent infection stage until other exposures weaken their immune system.
- Treatment failure could lead to different treatment options or mortality.

The following organizations, among others, provide more information on risk factors associated with HIV/AIDS: **Center for Disease Control and Prevention**; **HIV.gov**; **National Library of Medicine (MedlinePlus)** [2, 7, 11].

Smoking, diet, exercise, weight gain, and heavy drinking are the most common risk factors for NCDs such as heart disease and cancer. These factors can directly contribute to an increased risk of those diseases. In contrast, these same risk factors cannot independently increase the risk of HIV without exposure to the virus. They may be associated with factors that increase the risk of exposure to HIV or the course of its progression (see Figure 4).

A weakened immune system increases susceptibility to HIV infection and increases the risk of disease progression and severity [12]. *See the* **Background chapter** *of this Health Review for an overview of HIV/AIDS and other infectious diseases.* Individual risk factors that may contribute to a compromised immune system and disease progression include aging, co-occurring chronic diseases (such as cardiovascular disease and cancer), heavy alcohol consumption, other co-infections, malnutrition, and smoking, and these factors can occur in any combination [12].

Certain behavioral and environmental factors may increase the likelihood of HIV exposure and infection. These factors include risky sexual behaviors (such as unprotected sex and multiple sex partners) and sharing needles during drug use [1, 6, 13-15].

Several risk factors may also indirectly increase the risk of HIV infection and disease progression through their association with different modes of HIV exposure and response to treatment. These indirect risk factors include heavy alcohol consumption [16], illicit drug use [16], limited access to healthcare [13], mental health disorders [17], and socioeconomic status (SES)[18, 19].

The importance (that is, magnitude, prevalence) of any given risk factor relative to the other risk factors may differ by population because of environmental, socio-economic, behavioral, or genetic differences.

BIOLOGICAL MECHANISMS OF HIV

Co-infection of HIV and sexually transmitted infections (STI)

Sexual behaviors that put one at risk for a sexually transmitted infection may lead to increased risks of multiple infections [12]. Individuals infected with an STI are two-to-three times more likely to become infected with HIV than the general population, due to open sores or inflammation [20]. STI co-infections have also been found to increase the risk of mother-to-child transmission through the release of the virus via bodily fluids, local inflammation, and increased HIV-viral load [21].

HIV and alcohol

The role of alcohol consumption as a risk factor for HIV infection or disease is primarily through its potential effects on the immune system [22]. Heavy alcohol consumption can reduce the immune system's ability to suppress or eliminate invading pathogens [22-24]. *See the* **Background chapter** *for more information on infectious diseases and the body's immune system.*

Indirect mechanisms include an association between alcohol consumption and other risk factors for HIV exposure, infection, treatment outcomes, and mortality, as depicted in Figure 4 and described below.

- Alcohol consumption may reduce one's inhibitions, which can influence behaviors and emotions [25]. This may lead to risky behaviors such as having unprotected sex with a partner of unknown HIV status or sharing needles during drug use, resulting in increased risk of HIV exposure and infection [26].

- Heavy drinking may increase the risk of disease progression through potentially decreasing treatment compliance or utilization of healthcare services [27, 28]

Summary of recent HIV/AIDS research

This chapter of the *IARD Health Review: Drinking and Infectious Diseases* includes studies that examine and report a risk estimate for the association between alcohol consumption and HIV incidence, HIV-related mortality, risky sexual behaviors, and unfavorable HIV treatment outcomes.

The following criteria were used to select studies for inclusion in the summary of research, following a literature search using the IARD Research Database and PubMed (see Appendix 1 for search strategies and the PRISMA flow diagram).

Study designs: meta-analyses (a type of study that pools data from multiple studies), pooled cohort or case-control studies, *prospective or retrospective* cohort studies, and case-control studies; systematic reviews were excluded from the summary of results section due to the absence of risk estimates.
Publication dates: from January 2000 through October 2022
Outcomes: HIV infection (HIV incidence), HIV mortality, risky sexual behaviors (multiple sex partners, unprotected sex), and unfavorable treatment outcomes (*non-adherence to treatment, non-response to treatment, loss to follow-up*)
Exposure: at least two defined levels of alcohol consumption
Sample size: 500+ (total)

In addition to studies that didn't meet the inclusion criteria above, we excluded studies that assessed alcohol consumption using Alcohol Use Disorders Identification Test (AUDIT) or Cut down, Annoyed, Guilty, and Eye-opener (CAGE) scores without defining a corresponding level of alcohol consumption or otherwise describing how different alcohol categories were defined.

If multiple studies assessed multiple populations from the same cohort or survey year and used similar methods of assessing alcohol consumption, the most recent study of the group was included in this review.

When multiple analyses were presented in a study, we included results from models that were fully adjusted. Results of meta-analyses are presented first, followed by results of individual studies to allow comparison of risk estimates across both types of study designs.

In the following tables and text, we report results of studies reporting *relative risk (RR), odds ratio (OR), or hazard ratio (HR)* estimates as "risk estimates" for HIV incidence, mortality, risky sexual behaviors, and unfavorable treatment outcomes. (Please see the Glossary on page 31 for sources and definitions of relative risk and *magnitude of risk* terms as weak, modest, moderate, and strong in epidemiologic research.)

In this section of the review, we report the results of five meta-analyses and 32 individual studies that met the review inclusion criteria. In general, the available research on the role of alcohol consumption as a risk factor for HIV outcomes may be limited by the following study characteristics:

1. Many studies were conducted in countries with a high prevalence of HIV or among a sub-population at high risk for HIV. The findings from these studies may not be applicable to countries with low HIV prevalence or the general population.

    i. 47% were conducted in the African region, which is the region with the highest rate of HIV incidence and mortality.

    ii. 50% of studies were conducted in a key population at high risk for HIV, for example, men who have sex with men, sex workers, people who inject drugs, or people engaging in risky sexual behaviors (unprotected sex, multiple sexual partners).

2. Few studies assessed alcohol consumption using multiple levels of alcohol consumption measured in grams of ethanol per day or week. Instead, many studies used less quantitative assessments of alcohol consumption, sometimes combining nondrinkers and non-heavy drinkers into a single category.

    i. 70% of studies (N=26) assessed alcohol consumption as a binary variable. For example, some studies assessed alcohol consumption as "no drinking versus any drinking" or "no binge drinking versus binge drinking". The findings from these studies do not provide evidence of increasing risk with increasing levels of alcohol consumption (dose-response) or the effect of drinking patterns.

    ii. 19% of studies (N=7) assessed alcohol consumption using a measure of average volume of alcohol consumption (quantity multiplied by frequency), a measure that can be quantified in average grams of ethanol per day.

To facilitate synthesis and reporting, this review organizes the summary of meta-analysis and individual study results according to four HIV outcomes: incidence, mortality among PLWHIV, risky sexual behaviors, and unfavorable treatment outcomes. Table 2 identifies the classification of study-defined alcohol consumption categories by each of five alcohol assessment groups used in this review (see Appendix 2: Table A1, for an expansion of this table). Note that some studies provided multiple alcohol exposure and outcome combinations.

Table 2. Alcohol consumption and HIV outcome matrix

Alcohol assessment groups *(Study defined alcohol consumption categories)*	# Meta-analyses (M) & # Individual studies (I)			
	Incidence	Mortality	Risky sexual behaviors	Unfavorable treatment outcomes
No drinking vs. any drinking Studies that defined two alcohol consumption categories, comparing drinkers with nondrinkers, such as no alcohol use vs. any alcohol use or never alcohol use vs. alcohol use	M: 1 I: 2	M: 0 I: 1	M: 2 I: 1	M: 1 I: 2
Non-risky drinking vs. risky drinking Studies that defined two alcohol consumption categories with one category indicating a heavy drinking level such as alcoholism, harmful drinking, binge drinking; or comparing sex behaviors under the influence of alcohol such as no alcohol before sex vs. alcohol before sex	M: 2 I: 5	M: 0 I: 3	M: 2 I: 1	M: 0 I: 8
No drinking vs. non-risky drinking and risky drinking Studies that defined three alcohol consumption categories with one category indicating studies that defined three alcohol consumption categories with one category indicating no drinking, second category indicating no risky drinking, and the third category indicating risky drinking such as no drinking vs. moderate and hazardous drinking, not drinking vs. no problem drinking and problem drinking, nondrinker vs. never binge and ever binge	M: 0 I: 2	M: 0 I: 1	M: 0 I: 1	M: 0 I: 0
Frequency of alcohol consumption Studies that defined alcohol consumption by how often alcohol is consumed, but not amount, across at least three consumption categories	M: 0 I: 4	M: 0 I: 0	M: 0 I: 0	M: 0 I: 0
Volume of alcohol consumption Studies that defined alcohol consumption with a measure of both frequency of consumption and quantity of alcohol consumed, across at least three consumption categories	M: 0 I: 3	M: 0 I: 0	M: 0 I: 2	M: 0 I: 4
Total number of studies	M: 3 I: 16	M: 0 I: 4	M: 4 I: 5	M: 1 I: 14

Notes.
- Totals exceed the total number of the studies included in the review due to multiple studies reporting results by multiple alcohol consumption measures or HIV outcomes or both.

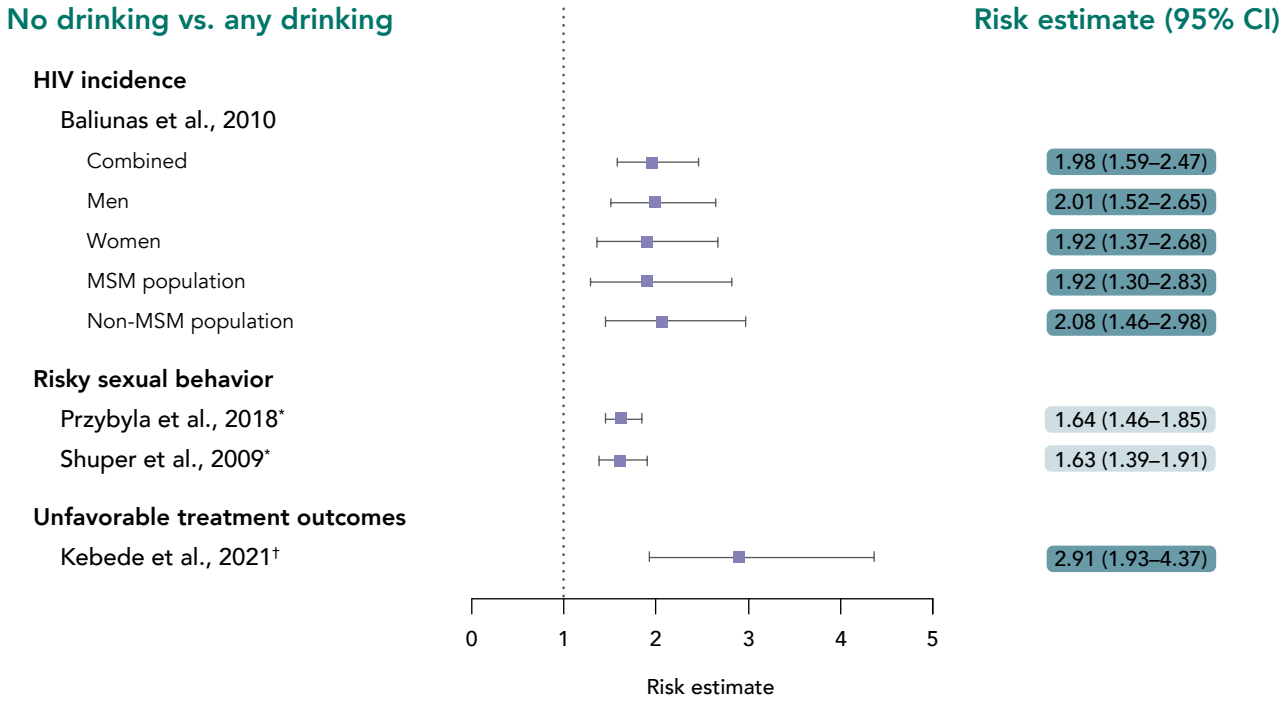
SUMMARY OF RECENT HIV RESEARCH FROM META-ANALYSES

Two meta-analyses reported risk estimates for HIV incidence [29, 30], two reported risk estimates for risky sexual behaviors [31, 32], and one reported risk estimates for unfavorable treatment outcomes [33] (see Figure 5a, 5b, and Appendix 2: Table A2, A4, and A5 for study descriptions).

- All analyses comparing no drinking and any drinking reported an increased risk of HIV incidence [30], risky sexual behaviors [31, 32], and unfavorable treatment outcomes [33].

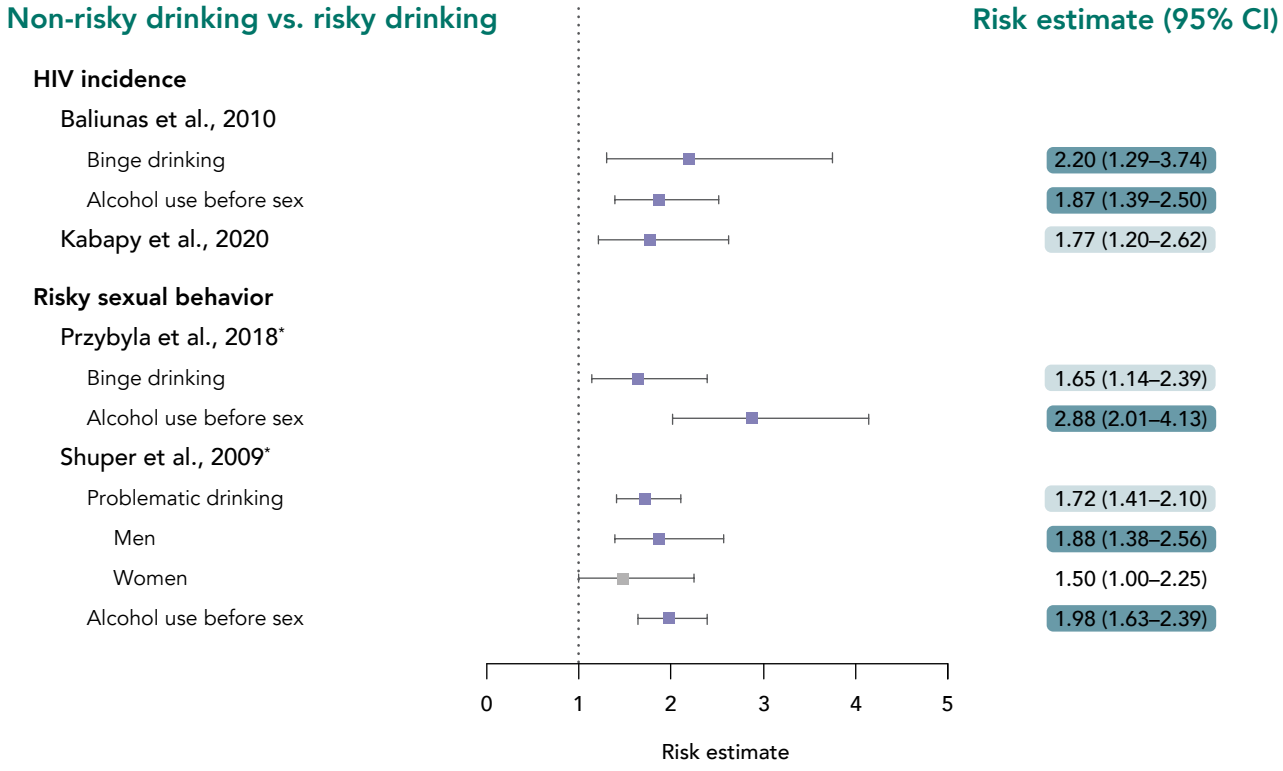
- Analyses comparing no risky drinking and risky drinking reported increased risks of HIV incidence that ranged from 77% to 120% [29, 30], and risky sexual behaviors that ranged from 65% to 188% [31, 32]. The increased risk for risky sexual behavior among women reported by Shuper et al. (2009) was not statistically significant [32].

Figure 5a. Forest plot of the association between any drinking and HIV outcomes, compared to no drinking reported by meta-analyses



Key:
Risk association: increased risk
Magnitude of risk: modest moderate
* Outcome is defined as "unprotected sex" in the study.
† Outcome is defined as "loss to follow-up" in the study.

Figure 5b. Forest plot of the association between non-risky drinking and HIV outcomes, compared to risky drinking reported by meta-analyses



Key:
Risk association: increased risk no association
Magnitude of risk: modest moderate
* Outcome is defined as "unprotected sex" in the study.

Figure Notes:

- See Appendix 2: Figure A1 for assistance on how to read and interpret results of a forest plot.

SUMMARY OF RECENT HIV RESEARCH FROM INDIVIDUAL STUDIES

HIV incidence

Twelve individual studies met the review criteria and examined the association between alcohol consumption and HIV incidence [34-45] (see Appendix 2: Table A2 for study descriptions). The results of these studies are grouped below by their alcohol assessment group.

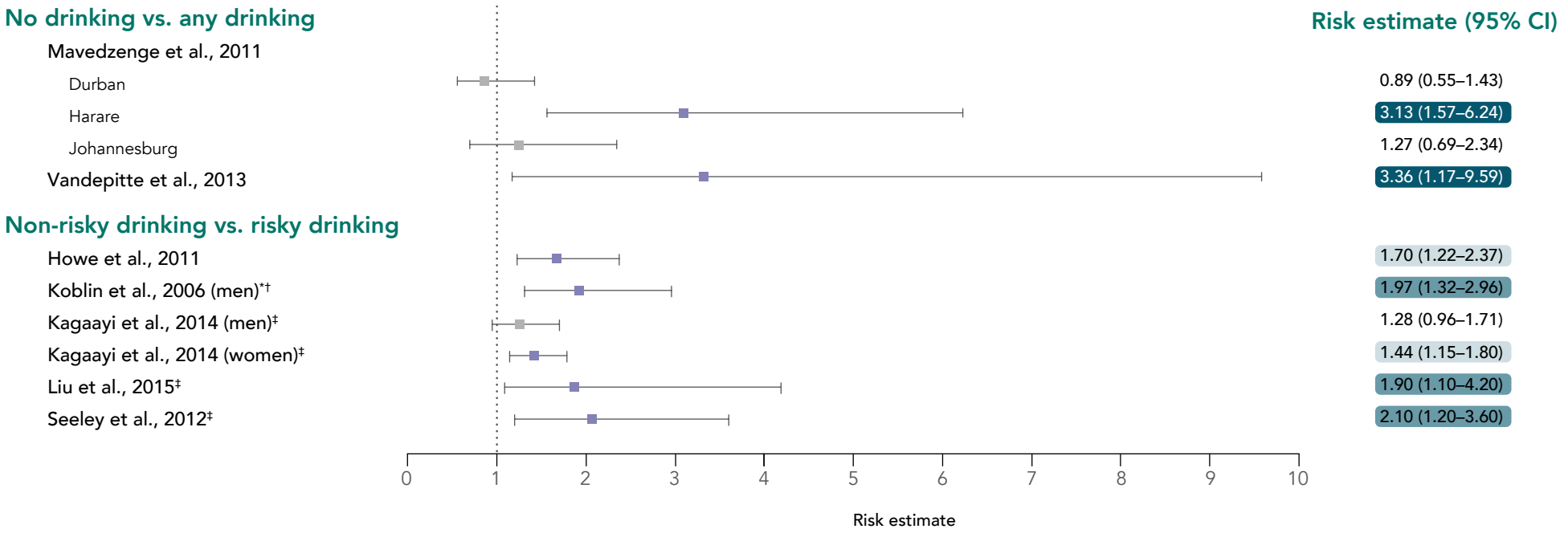
No drinking compared to any drinking

Two studies, contributing four risk estimates, examined the association between HIV incidence and alcohol consumption, assessed as no drinking compared to any drinking. Two out of four risk estimates indicated an increased risk [40, 44] (see Figure 6). These risk estimates included wide confidence intervals [40, 44], indicating uncertainty in the precision of those estimates [46].

Non-risky drinking compared to risky drinking

Five studies, contributing six risk estimates, examined the association between HIV incidence and alcohol consumption, assessed as non-risky drinking compared to risky drinking. Five out of six risk estimates indicated an increased risk of HIV incidence associated with risky drinking, as defined by the study, ranging from 44% to 110% [37 - 39, 43, 45] (see Figure 6).

Figure 6. Forest plot of the association between alcohol consumption and HIV incidence



Key:
Risk association: increased risk no association
Magnitude of risk: modest moderate strong
* This study provided unadjusted risk estimates only.
† Reference group includes light drinking.
‡ This study examined the association between alcohol use before sex and the risk of HIV incidence.

Figure Notes:

► See Appendix 2: Figure A1 for assistance on how to read and interpret results of a forest plot.

No drinking compared to non-risky drinking and risky drinking categories

Two studies examined the association between HIV incidence and alcohol consumption, assessed as no drinking compared to non-risky drinking or risky drinking. Although Plankey et al. (2007) found no association with HIV incidence [41], Vandepitte et al. (2013) found increased risk among two risky drinking groups [44] (see Table 3). These risk estimates included wide confidence intervals, indicating uncertainty in their precision [46].

Table 3. HIV incidence associated with alcohol consumption, assessed as no drinking compared to author-defined categories of drinking, among key populations

Study Reference	No drinking	Non-risky drinking	Risky drinking
Plankey et al., 2007	ref.*†	1.18 (0.94–1.48)	1.13 (0.81–1.56)
Vandepitte et al., 2013 (problem drinking)	ref.*	1.65 (0.48–5.73)	2.85 (0.99–8.17)
Vandepitte et al., 2013 (binge drinking)	ref.*	3.20 (1.10–9.31)	3.87 (1.20–12.52)

This table includes all individual prospective cohort study designs that were published between 2000 and October 2022 and reported risk estimates for drinking at multiple risky levels.
* Reference group may include former drinking, or occasional drinking, or both.
† Reference group included light-to-moderate drinking.

Table Notes:

- Purple shading indicates a statistically significant increase in relative risk, compared, to the reference group.
- White shading indicates no statistically significant increase or decrease in risk, compared to the reference group.

Frequency of alcohol consumption

Four studies examined the association between HIV incidence and alcohol consumption, assessed as frequency of consumption, with mixed and conflicting results [35, 36, 43, 44] (see Table 4).

- One study reported an increased risk associated with drinking less than once a week [36] and another reported an increased risk associated with drinking at least once a week, [43] compared to no drinking.

- One study found a reduced risk in HIV incidence associated with infrequent binge drinking [35].

    - Downen et al., (2020) suggest that the reduced risk may be associated with infrequent binge drinking and risky behaviors [35].

Table 4. Risk of HIV incidence associated with frequency of alcohol consumption

Study Reference	No drinking	< Once a year	≥ Once a year	≤ Once a month	< Once a week	≥ Once a week	Daily
Downen et al., 2020†	ref.*	0.50 (0.30–0.95)	0.30 (0.10–0.70)	0.60 (0.30–1.30)			
Geis et al., 2011	ref.*	1.83 (1.02–3.30)				1.64 (0.91–2.94)	2.01 (1.00–4.07)
Seeley et al., 2012‡	ref.*	1.18 (0.52–2.66)				3.13 (1.62–6.06)	
Vandepitte et al., 2013 (women)‡	ref.*	0.83 (0.09–7.60)				2.72 (0.94–7.87)	2.58 (0.81–8.20)

This table includes all individual prospective cohort and case-control study designs that were published between 2000 and October 2022 and reported risk estimates for different drinking frequencies.
* Reference group may include former drinking, or occasional drinking, or both.
† This study looks at frequency of binge drinking.
‡ This study was conducted among a key population that engages in high-risk behaviours.

Table Notes:

- Vertical bars correspond to the lower and upper limits of each drinking-frequency category as defined by the study authors.
- Purple shading indicates a statistically significant increase in relative risk, compared to the reference group.
- Green shading indicates a statistically significant decrease in relative risk, compared to the reference group.
- Grey shading indicates that the study did not assess risk at this drinking level.
- White shading indicates no statistically significant increase or decrease in risk, compared to the reference group.

Volume of alcohol consumption

Three studies examined the association between HIV incidence and alcohol consumption, assessed as average volume of consumption (g/day: grams per day) [34, 37, 42] (see Table 5).

- Two studies found an increased risk of HIV incidence associated with their heaviest alcohol consumption category: more than or equal to 28 g/day [42] and more than 100 g/day [37].

    - Sander et al.'s (2013) heaviest drinking category combines all drinkers consuming more than 28 grams per day, which makes it difficult to differentiate potential differences in HIV risk between moderate and heavy drinking levels and any drinking [42].

Table 5. Relative risk estimates of HIV incidence associated with average volume of alcohol consumption

Study Reference	Sex	No drinking	Average alcohol grams per day: 0–10	10–20	20–30	30–40	40–50	50–60	60–70	70–80	80–90	90–100	100–110+
Bedoya et al., 2012†	Male	ref.*	3.20 (0.75–13.59)		2.91 (0.65–13.02)				4.28 (0.94–19.57)				
Sander et al., 2013	Male	ref.*	1.10 (0.78–1.54)						1.61 (1.12–2.29)				
Howe et al., 2011	Combined	ref.*	1.09 (0.60–1.98)		1.18 (0.66–2.09)				1.66 (0.94–2.93)				2.12 (1.15–3.90)

This table includes all individual prospective cohort study designs that were published between 2000 and October 2022 and reported risk estimates for drinking at multiple levels.
* Reference group may include former drinking, or occasional drinking, or both.
† This study provided unadjusted risk estimates only.

Table Notes:

- Vertical bars correspond to the lower and upper limits of each drinking level as defined by the study, converted, if necessary, to grams of pure alcohol per day.
- Purple shading indicates a statistically significant increase in relative risk, compared to the reference group.
- White shading indicates no statistically significant increase or decrease in risk, compared to the reference group.
- Dashed line indicates that upper and lower limits of two drinking categories overlapped.

Mortality among people living with HIV

Four studies met the review criteria and examined the association between alcohol consumption and mortality among people living with HIV [47-50] (see Appendix 2: Table A3 for study descriptions). The results of these studies are grouped by their alcohol assessment group below.

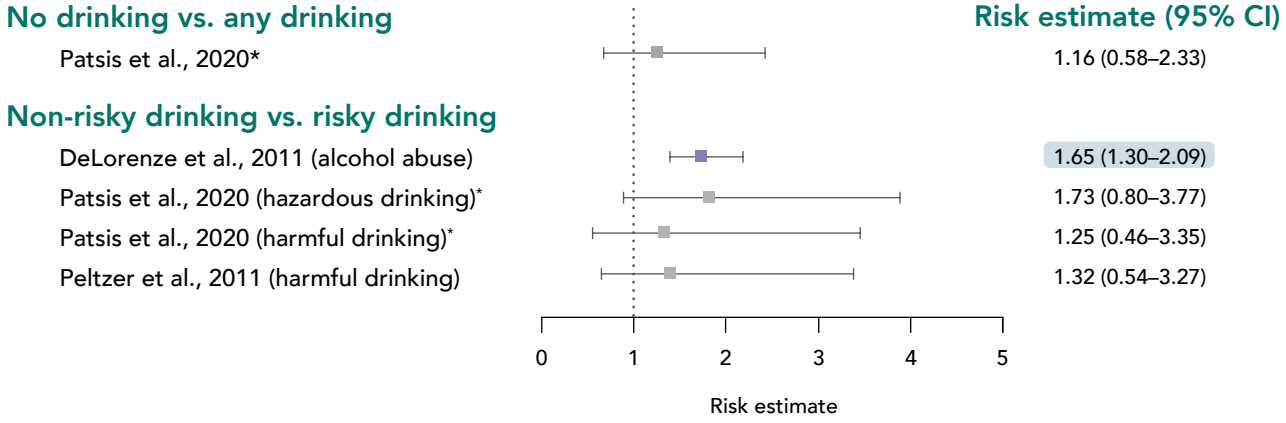
No drinking compared to any drinking

One study examined the association between alcohol consumption, assessed as no drinking compared to any drinking, and mortality, and found no association [48] (see Figure 7).

Non-risky drinking compared to risky drinking

Three studies contributing four risk estimates examined the association between mortality and alcohol consumption, assessed as non-risky drinking compared to risky drinking [47, 48, 50] (see Figure 7).

Figure 7. Forest plot of the association between alcohol consumption and mortality among PLWHIV



Key:
Risk association: increased risk no association
Magnitude of risk: modest
* Outcome is defined as "HIV mortality" in the study.

Figure Notes:

► See Appendix 2: Figure A1 for assistance on how to read and interpret results of a forest plot.

No drinking compared to non-risky and risky drinking categories

One study examined the association between alcohol consumption, assessed as no drinking compared to non-risky drinking and to risky drinking, and mortality, and reported a 16% increased risk of mortality for risky drinking [49]. This risk estimate included a wide confidence interval, indicating uncertainty in the precision of those estimates [46] (see Appendix 2: Table A3 for study descriptions).

Risky sexual behaviors

Five studies examined the association between alcohol consumption and risky sexual behaviors among key populations [34, 51-54] (see Appendix 2: Table A4 for study descriptions).

No drinking compared to any drinking

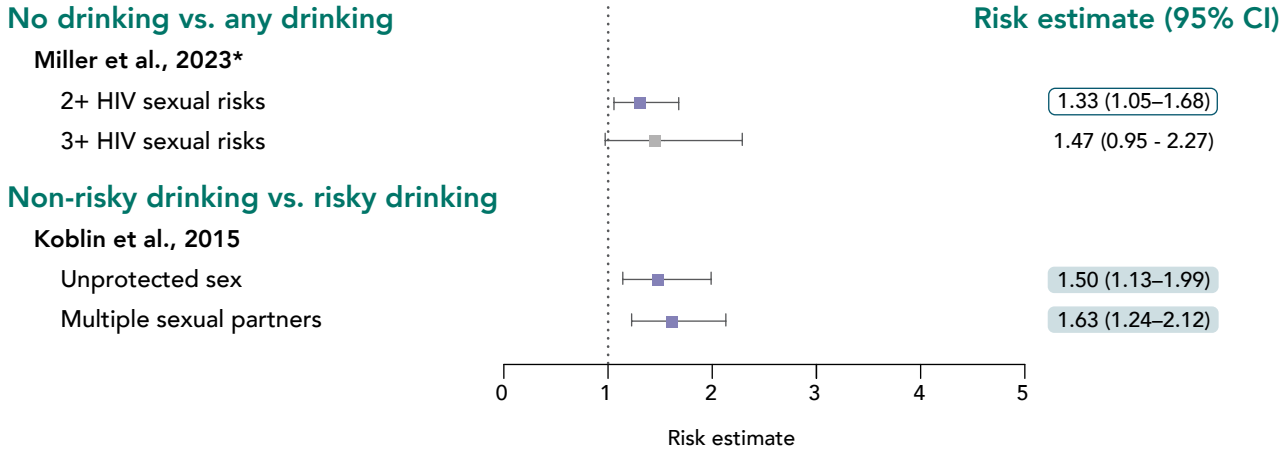
One study of women examined the association between alcohol consumption, assessed as no drinking compared to any drinking, and risky sexual behaviors. The study reported a 33% increased risk of HIV incidence when a minimum of two risk factors were present but found no association if a minimum of three risk factors were present [53] (see Figure 8).

- The study assessed risky sexual behaviors as the presence of an STI, multiple partners, no condom use during last sexual activity, or HIV+ partner [53].

Non-risky drinking compared to risky drinking

One study examined the association between alcohol consumption, assessed as non-risky drinking compared to risky drinking, and risky sexual behaviors and found an increased risk among women for both unprotected sex and multiple sexual partners [52] (see Figure 8).

Figure 8. Forest plot of the association between alcohol consumption and risky sexual behaviors among women



Key:
Risk association: increased risk no association
Magnitude of risk: weak modest
* This study defined HIV sexual risk as having two or more of the following: multiple sex partners, presence of an STI, no condom use at last sex, and HIV+ partner.

Figure Notes:

- See Appendix 2: Figure A1 for assistance on how to read and interpret results of a forest plot.

No drinking compared to non-risky and risky drinking categories

One study examined the association between alcohol consumption (assessed as no drinking, compared to three drinking categories) and risky sexual behaviors (assessed as unprotected sex, multiple sex partners, and alcohol use before sex).

- Gordon et al., (2017) reported an increased risk across all three risky sexual behaviors associated with hazardous drinking [51] (see Table 6).

Table 6. Risky sexual behaviors associated with alcohol consumption, assessed as no drinking, compared to author-defined categories of drinking, among a key population reported in Gordon et al., 2017

Outcomes	No drinking	Non-hazardous drinking	Hazardous drinking	Alcohol abuse
Unprotected sex	ref.*	1.06 (0.88–1.28)	1.53 (1.26–1.87)	1.06 (0.82–1.37)
Multiple sexual partners	ref.*	1.05 (0.85–1.28)	1.45 (1.19–1.77)	1.66 (1.29–2.14)
Alcohol use before sex	ref.*	2.40 (1.81–3.19)	7.49 (5.75–9.75)	6.78 (5.07–9.06)

This table includes all individual prospective cohort study designs that were published between 2000 and October 2022 and reported risk estimates for drinking at multiple risky levels.
* Reference group may include former drinking, or occasional drinking, or both.

Table Notes:

- Purple shading indicates a statistically significant increase in relative risk, compared to the reference group.
- White shading indicates no statistically significant increase or decrease in risk, compared to the reference group.

Volume of alcohol consumption

Two studies examined the association between alcohol consumption, assessed as average volume of consumption (grams per day), and risky sexual behaviors. Both studies reported an increased risk of risky sexual behaviors associated with their heaviest drinking categories, > 56 g/day [34, 54], and ≥ 70 g/day [54], compared to no drinking (see Table 7).

Table 7. Risk of risky sexual behaviors associated with average volume of alcohol consumption among a key population

Average alcohol grams per day		0	10	20	30	40	50	60	70	80	90	100	110+
Study Reference	No drinking												
Bedoya et al., 2012	ref.*	1.02 (0.71–1.46)			1.17 (0.80–1.72)				1.56 (1.03–2.36)				
Woolf-king et al., 2013	ref.*				1.83 (0.68–4.90)			1.43 (0.48–4.22)			3.68 (1.13–11.98)		

This table includes all individual prospective cohort study designs that were published between 2000 and October 2022 and reported risk estimates for different drinking at multiple levels.
* Reference group may include former drinking, or occasional drinking, or both.

Table Notes:

- Vertical bars correspond to the lower and upper limits of each drinking level as defined by the study, converted, if necessary, to grams of pure alcohol per day.
- Purple shading indicates a statistically significant increase in relative risk, compared to the reference group.
- White shading indicates no statistically significant increase or decrease in risk, compared to the reference group.
- Dashed line indicates that upper and lower limits of two drinking categories overlapped.

Unfavorable treatment outcomes

Fourteen studies met the review criteria for examining the association between alcohol consumption and unfavorable treatment outcomes [37, 50, 55 - 66] (see Appendix 2: Table A5 for study descriptions).

No drinking compared to any drinking

Two studies examined the association between alcohol consumption (assessed as no drinking, compared to any drinking) and unfavorable treatment outcomes (assessed as non-adherence to treatment [58] and non-response to treatment [64]) (see Figure 9).

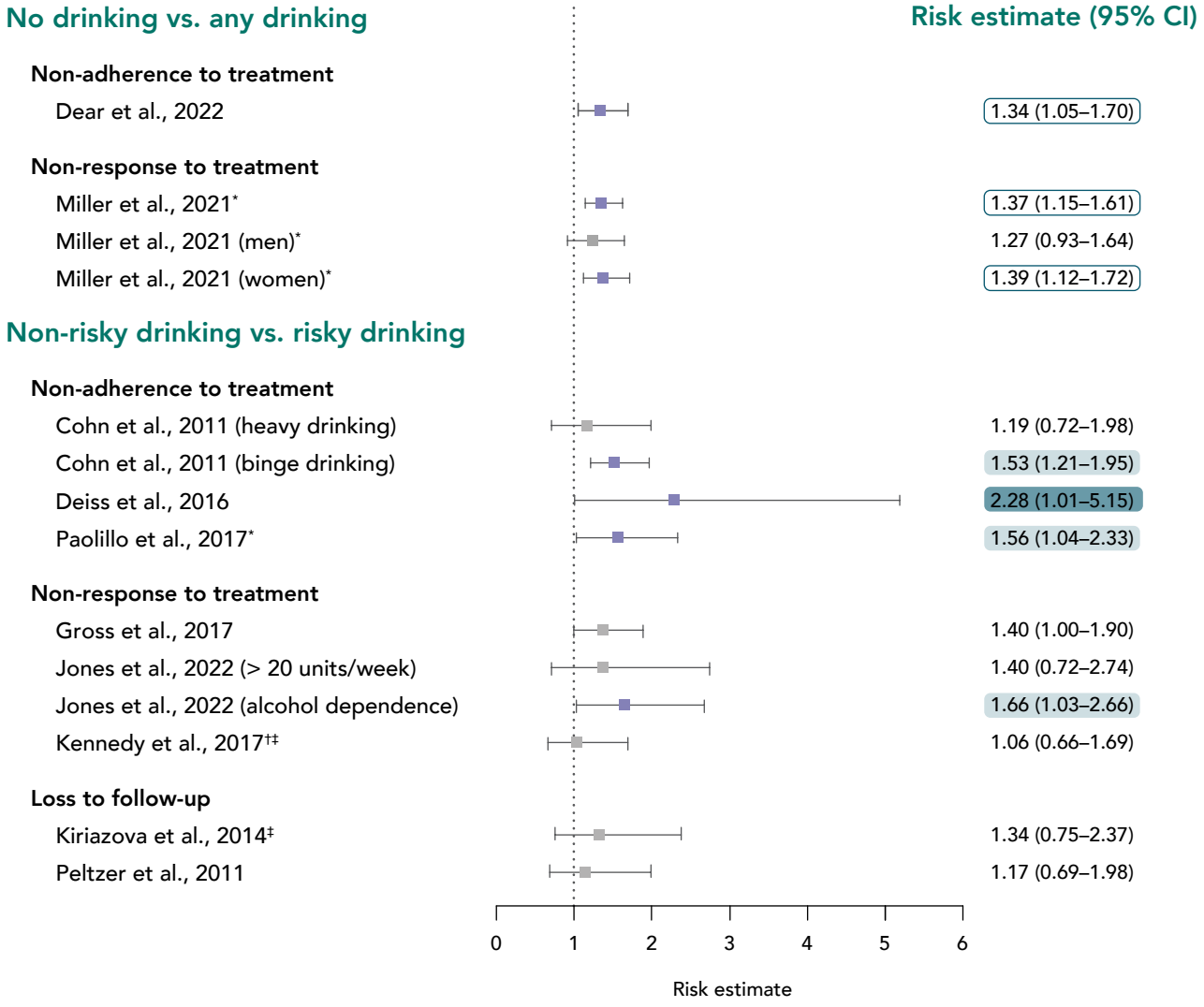
- Both studies reported an approximate 37% increase in risk associated with any drinking [58, 64].

Non-risky drinking compared to risky drinking

Eight studies contributing 10 risk estimates examined the association between alcohol consumption (assessed as non-risky drinking compared to risky drinking) and unfavorable treatment outcomes (assessed as non-adherence to treatment [56, 59, 65], non-response to treatment [60, 61, 66], and loss to follow-up [50, 62]) (see Figure 9).

- Four of the 10 risk estimates found an increased risk of non-adherence to treatment [56, 59, 65] and non-response to treatment [61] associated with risky drinking.
- One risk estimate included a wide confidence interval [59], indicating uncertainty in the precision of those estimates [46].
- The remaining risk estimates found no association between alcohol consumption and unfavorable treatment outcomes [50, 56, 60-62, 67].

Figure 9. Forest plot of the association between alcohol consumption and unfavorable treatment outcomes



Key:
Risk association: increased risk no association
Magnitude of risk: weak modest moderate

* The study provided risk estimates for "adherence" and "viral suppression", therefore the reciprocals of the original risk estimates were calculated to represent the risk of "non-adherence to treatment" and "non-response to treatment".
† This study provided unadjusted risk estimates.
‡ This study was conducted among a key population.

Figure Notes:

► See Appendix 2: Figure A1 for assistance on how to read and interpret results of a forest plot.

Volume of alcohol consumption

Four studies examined the association between alcohol consumption (assessed as average volume of alcohol consumption (grams per day)) and unfavorable treatment outcomes (assessed as non-adherence to treatment [55, 57], non-response to treatment [55, 57, 63], and loss to follow-up [37]) (see Table 8 and Appendix 2: A5 for study descriptions).

- Benning et al.'s study among women found an increased risk for non-adherence to treatment across all levels of alcohol consumption and an increased risk for non-response to treatment associated with drinking more than 14 g/day [55].

- Conen et al. found an increased risk of non-adherence to treatment associated with drinking more than 40 g/day among women and more than 60 g/day among men, compared to their respective reference groups [57].

- All five other risk estimates indicated no association between alcohol consumption and unfavorable treatment outcomes [37, 57, 63].

Table 8. Risk of unfavorable treatment outcomes associated with volume of alcohol consumption

Study Reference	Sex	Average alcohol grams per day: No drinking	0	10	20	30	40	50	60	70	80	90	100	110+
Non-adherence to treatment														
Benning et al., 2020†	Female	ref.*	1.14 (1.03–1.27)		1.69 (1.37–2.13)		1.96 (1.67–2.33)							
Conen et al., 2013	Female	ref.*				1.13 (0.72–1.76)			2.24 (1.42–3.52)					
Conen et al., 2013	Male	ref.*						1.13 (0.72–1.76)		2.24 (1.42–3.52)				
Non-response to treatment														
Benning et al., 2020†	Female	ref.*	1.05 (0.99–1.11)		1.35 (1.18–1.54)		1.45 (1.28–1.61)							
Lesko et al., 2021‡	Female	ref.*	1.11 (0.94–1.32)					1.33 (0.95–1.87)						
Conen et al., 2013	Female	ref.*				0.52 (0.21–1.27)			1.42 (0.65–3.07)					
Lesko et al., 2021‡	Male	ref.*		1.08 (0.99–1.18)						1.22 (1.00–1.50)				
Conen et al., 2013	Male	ref.*						0.52 (0.21–1.27)		1.42 (0.65–3.07)				
Loss to follow-up														
Howe et al., 2012§	Combined	ref.*	0.92 (0.76–1.13)			0.83 (0.68–1.02)				0.87 (0.69–1.09)				0.80 (0.61–1.05)

This table includes all individual prospective cohort study designs that were published between 2000 and October 2022 and reported risk estimates for different drinking at multiple levels.
* Reference group may include former drinking, or occasional drinking, or both.
† The study provided risk estimates for "adherence" and "viral suppression", therefore the reciprocals of the original risk estimates were calculated to represent the risk of "non-adherence to treatment" and "non-response to treatment".
‡ Lesko et al., 2021 has the additional alcohol exposure category "low-risk, binge", defined as "consuming > 4 drinks on one occasion for women or > 5 drinks for men" (not shown in visual). The risk estimate and confidence intervals for men's "low-risk, binge" is 1.17 (1.06–1.29), and for women is 1.19 (0.98–1.44). This study also provided the overall risk estimate for men and women combined but did not define the combined average drinks per week (not shown in the visual). The risk estimates are "low-risk, no binge" 1.09 (1.01–1.18), "high-risk" 1.24 (1.04–1.49), and "low-risk, binge" 1.17 (1.07–1.28).
§ This study was conducted among a high-risk population.

Table Notes:

- Vertical bars correspond to the lower and upper limits of each drinking category as defined by the study converted, if necessary, to grams of pure alcohol per day.
- Purple shading indicates a statistically significant increase in relative risk compared to the reference category.
- White shading indicates no statistically significant increase or decrease in risk, compared to the reference group.

HIV Outcomes Summary

- Seventy-eight percent (n=25) of individual studies included in the review found an increased risk of HIV incidence, mortality, risky sexual behaviors, or unfavorable treatment outcomes associated with varying levels of alcohol consumption.

- However, most of these studies (15 studies) assessed alcohol consumption as a binary variable, either as any drinking compared to no drinking or risky drinking compared to non-risky drinking. This type of measure does not provide information about whether HIV risk increases according to the amount of alcohol consumed.

- Only seven individual studies, and no meta-analyses, assessed the relationship between alcohol and an HIV outcome using a higher-quality measure of alcohol consumption: average volume of alcohol in grams per day.

    - Studies using an average volume measure showed that an increased risk of HIV incidence (in two out of three studies), risky sexual behaviors, and non-adherence to HIV treatment was associated with heavier drinking levels but not lower levels. One study was an exception; Benning et al. (2020) reported an increased risk of non-adherence to HIV treatment across all drinking levels [55].

    - There appeared to be limited or no evidence of an association between alcohol consumption and risk of non-response to treatment or loss to follow-up.

    - Results from studies using a non-quantitative assessment of alcohol consumption by defining non-risky and risky drinking groups compared to no drinking groups seem to generally support the results from the studies using average volume of alcohol consumption—risk was associated with heavier drinking but not all drinking.

- It is difficult to draw conclusions about the relationship between alcohol consumption and HIV outcomes due to the following research characteristics of the studies included in this review:

    - A small number of studies using a quantitative assessment of alcohol consumption, such as average volume

    - Reliance on studies conducted in regions with high prevalence of HIV or among a key population at high risk for HIV

    - Some mixed results within individual HIV outcomes

- These factors may limit the generalizability of some study results and the overall strength of evidence of currently available research.

Future Research

HIV is a widely studied topic with interrelated behavioral risk factors that make it challenging to understand the unique role alcohol plays in its incidence and progression.

Overall, this review's findings were inconclusive due to the limited number of studies that met the inclusion criteria; lack of differentiation between abstaining, former drinking, and various drinking patterns; and the majority of research focusing on key populations with high prevalence of HIV outcomes. Future studies could consider investigating these relationships using more nationally representative populations. More studies assessing study participants' long-term history of drinking patterns are needed to separate former drinking or occasional drinking from long-term or lifetime abstaining, to better understand the risk relationship between HIV outcomes and alcohol exposure over a lifetime. To provide insight into whether the association between drinking and HIV changes according to drinking patterns, studies that investigate the association between alcohol and HIV outcomes should use more rigorous methods to quantify average volume of alcohol consumption in grams per day or grams per week and binge drinking.

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Glossary

- **Antiretroviral therapy (ART)** is an HIV treatment that consists of a combination of drugs that suppresses HIV-viral load.

- **CD4+ T lymphocytes (CD4+ T cells)** are a type of white blood cell (also called "helper T cells") that help fight off infection by triggering the immune system to destroy viruses, bacteria, and germs and is recognized by HIV because of the presence of a protein called CD4+.

- **Hazard ratio (HR)** measures how often an event or outcome (for example, tuberculosis) occurs in one group (for example, drinkers) compared to how often it happens in another group (for example, nondrinkers) and is commonly used to measure survival. A hazard ratio equivalent to one (HR = 1) means no difference in outcome occurrence between both groups and a hazard ratio greater than or less than one (HR > 1 or HR < 1) means outcome occurred in one group more than the other.

- **HIV-viral load** is the amount of HIV in an infected person's blood [14].

- **Loss to follow-up** is when participants in a study or clinical setting miss follow-up visits or assessments after an initial baseline visit, making it difficult to track their health status or outcomes.

- **Non-adherence to treatment** is defined as non-compliance to a treatment regimen.

- **Non-response to treatment** indicates no improvement in patient symptoms or function despite adherence to treatment regimen.

- **Odds ratio (OR)** is a measure of association between an exposure (for example, alcohol) and an outcome (for example, tuberculosis) and is more commonly used in case-control studies. An odds ratio above one (OR > 1) indicates higher odds of the outcome, an odds ratio equal to one (OR = 1) indicates no effect on the odds, and an odds ratio less than one (OR < 1) indicates lower odds of the outcome.

- **Prospective studies** select a population without the outcome of interest (for example, tuberculosis) and assess the exposure of interest (for example, alcohol consumption) and then determine whether the outcome occurred after the study follow-up period concluded.

- **Relative risk (RR)** is a measure that compares the probability of a given outcome (for example, HIV) among a group of people with a given risk factor (for example, alcohol consumption) with the probability of that outcome among a group of people without the risk factor (for example, nondrinkers). A risk estimate above one (RR > 1) indicates an increased risk of the outcome associated with the exposure and a risk estimate below one (RR < 1) indicates a reduced risk of the outcome associated with the exposure. If the risk estimate is equivalent to one (RR = 1) then there is no association between the outcome and the exposure.

- The **magnitude of relative risk** describes the strength of the association between the exposure and outcome of interest, or the relative risk estimate. There are several terms used to describe or interpret different relative risk estimates. Some commonly used descriptors are weak, small, moderate, medium, strong, or large [67-69], however, the risk estimates associated with each term may differ or overlap (see Figure 2A-C). For example, according to Schoenbach and Rosamond, 2000 [67], a moderate risk is equivalent to a relative risk of 1.8 to 3.0, but Ferguson, 2016, states that moderate to strong risk is equivalent to a relative risk greater than 3.0 [69].

- **Retrospective studies**, such as case-control or cohort studies, begin with identification of individuals with the outcome of interest (for example, tuberculosis) and then assess participants with recent or past exposure (for example, alcohol consumption).

Figure 2A. Descriptions of magnitude of risk

1.0	No association (null value)
1.1–1.3	Weak
1.4–1.7	Modest
1.8–3.0	Moderate
3–8	Strong

Source: Schoenbach and Rosamond 2000 [67]

Figure 2B. Descriptions of magnitude of risk

	Trivial	Small	Moderate	Large	Very Large	Nearly perfect	Perfect
Correlation	0.0	0.1	0.3	0.5	0.7	0.9	1
Diff. in means	0.0	0.2	0.6	1.2	2.0	4.0	infinite
Freq. diff.	0	10	30	50	70	90	100
Rel. risk	1.0	1.2	1.9	3.0	5.7	19	infinite
Odds ratio	1.0	1.5	3.5	9.0	32	360	infinite

Source: Hopkins, 2002 [68]

Figure 2C. Descriptions of magnitude of risk

Effect size: Interpretation suggestions for social science data

Type of effect size estimate	Included indices	RMPE	Moderate effect	Strong effect
Group difference	d, Δ, g	0.41	1.15	2.70
Strength of association	r, R, φ, p, partial r, β, rh, tau	0.2	0.5	0.8
Squared association indices	r^2, R^2, η^2, adjusted R^2, ω^2 ε^2	0.04	0.25	0.64
Risk estimates	RR, OR	2.0*	3.0	4.0

Note.

- *RMPE = recommended minimum effect size representing a "practically" significant effect for social science data. For effects with highly valid dependent measures (e.g., death) and using rigorous controlled outcomes trials, lower values may have practical value. RR = relative risk; OR = odds ratio.*
- **These are not anchored to r and should be interpreted with caution.*

Source: Ferguson, 2016 [69]

Appendix 1

SEARCH STRATEGIES

Systematic reviews/Meta analyses

IARD Research Database

1. IARD databases=Research; Document date on or after '01 Jan 2010' and IARD keywords equals 'sti, hiv' and (IARD keywords equals 'meta analysis, review' or Publication type equals 'review' or Composite phrase 'systematic review' or Composite phrase 'narrative review' or Composite phrase 'scoping review' or Composite phrase 'critical review' or Composite phrase 'literature review')
   - Search Date: 12 Jun 2022

2. IARD databases=Research; Keywords: ("hiv" OR "sti") AND ("meta analysis" OR "systematic review") AND Date add from 12 June 2022 to 31 Oct 2022
   - Search date 31 Oct 2022

Pubmed Database

1. Pubmed Search: ("HIV Infections"[Mesh] OR HIV[TIAB] OR "human immunodeficiency virus"[TIAB]) AND ("Alcohol Drinking"[Mesh] OR "Alcohol-Related Disorders"[Mesh] OR alcohol*[TIAB] OR drink*[TIAB]) AND ("Review"[Publication Type] OR "Systematic Review"[Publication Type] OR "Meta-Analysis"[Publication Type] OR "systematic review"[TIAB] OR "meta analysis"[TIAB]) from 2010
   - Search Date: 12 Jun 2022

2. Revised Pubmed Search: ("HIV Infections"[Mesh] OR HIV[TI] OR "human immunodeficiency virus"[TI]) AND ("Alcohol Drinking"[Mesh] OR "Alcohol-Related Disorders"[Mesh] OR alcohol*[TIAB] OR drink*[TIAB]) AND ("Review"[PT] OR "Systematic Review"[PT] OR "Meta-Analysis"[PT] OR "systematic review"[TIAB] OR "meta analysis"[TIAB]) AND 2022/06/12:2022/10/31[EDAT] AND English language only AND Pubdate from 2000
   - Search Date: 31 Oct 2022

Individual Studies

IARD Research Database

1. IARD databases=Research; Keywords=("sti" OR "hiv") AND ("prospective study" OR "retrospective study" OR "case control study"); Languages=English; Publication Types=Research Paper; Published From=2010-01-01
   - Search Date: 03 Jul 2022

2. IARD databases=Research; Keywords=("sti" OR "hiv") AND ("prospective study" OR "retrospective study" OR "case control study"); Languages=English; Publication Types=Research Paper; Publish From=2000-01-01; Date Added From=2022-07-03;

Date Added To=2022-10-31

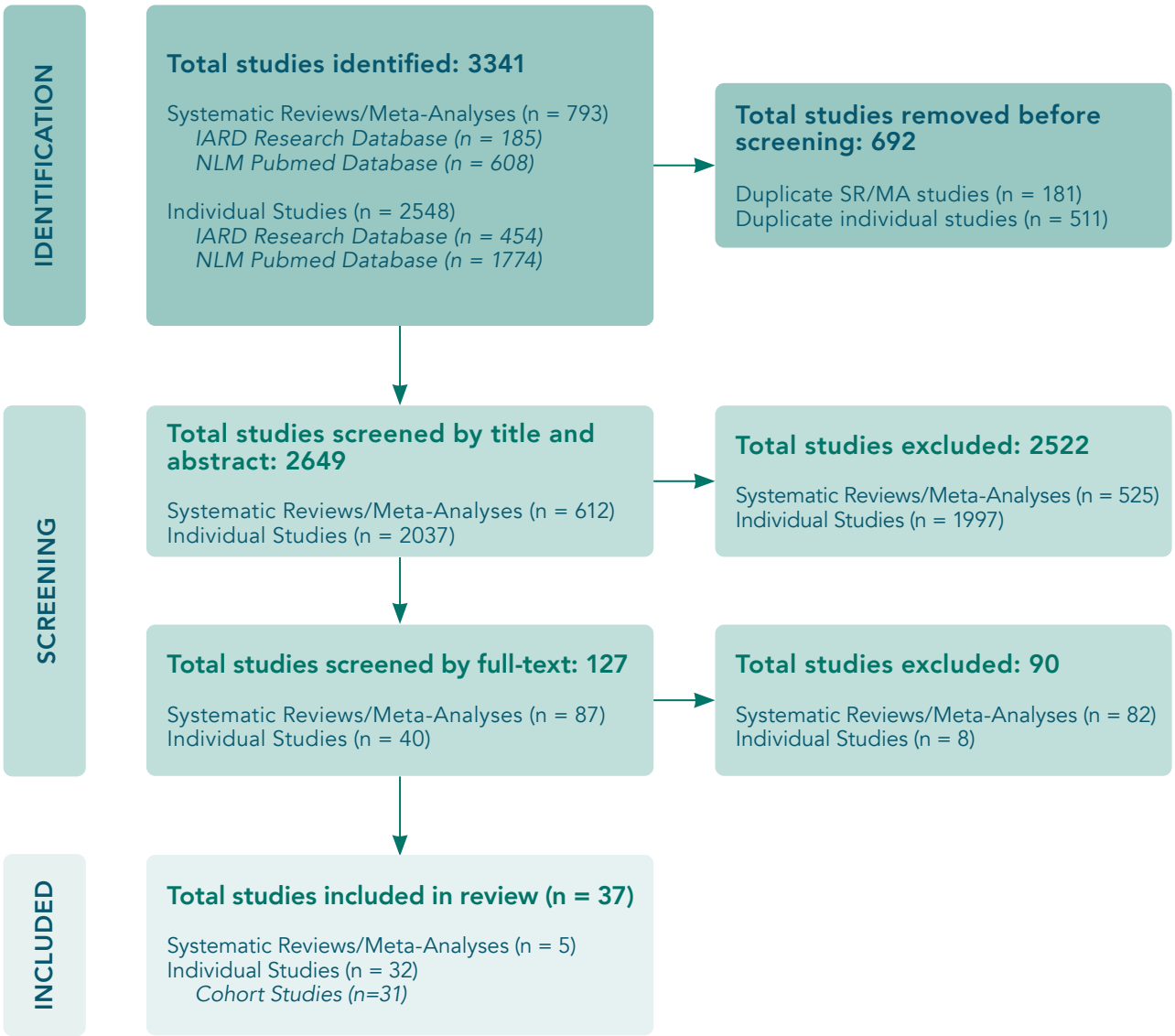
- Search Date: 31 Oct 2022

3. IARD databases=Research; Keywords=("sti" OR "hiv") AND ("prospective study" OR "retrospective study" OR "case control study"); Languages=English; Publication Types=Research Paper; Publish From=2000-01-01; Publish To=2009-12-31
   - Search Date: 31 Oct 2022

Pubmed Database

1. Pubmed Search: ("HIV Infections"[Mesh] OR HIV[TI] OR "human immunodeficiency virus"[TI]) AND ("Alcohol Drinking"[Mesh] OR "Alcohol-Related Disorders"[Mesh] OR alcohol*[TIAB] OR drink*[TIAB]) AND ("Cohort Studies"[Mesh] OR "Case-Control Studies"[Mesh] OR "Retrospective Studies"[Mesh] OR cohort[TIAB] OR longitudinal*[TIAB] OR "prospective study"[TIAB] OR "retrospective study"[TIAB]) AND English language only AND Publication Date from 2000/01/01
   - Search Date: 31 Oct 2022

PREFERRED REPORTING ITEMS FOR SYSTEMATIC REVIEWS AND META-ANALYSES (PRISMA) FLOW DIAGRAM OF STUDY SELECTION



Appendix 2

Figure A1. Understanding and interpreting forest plots.

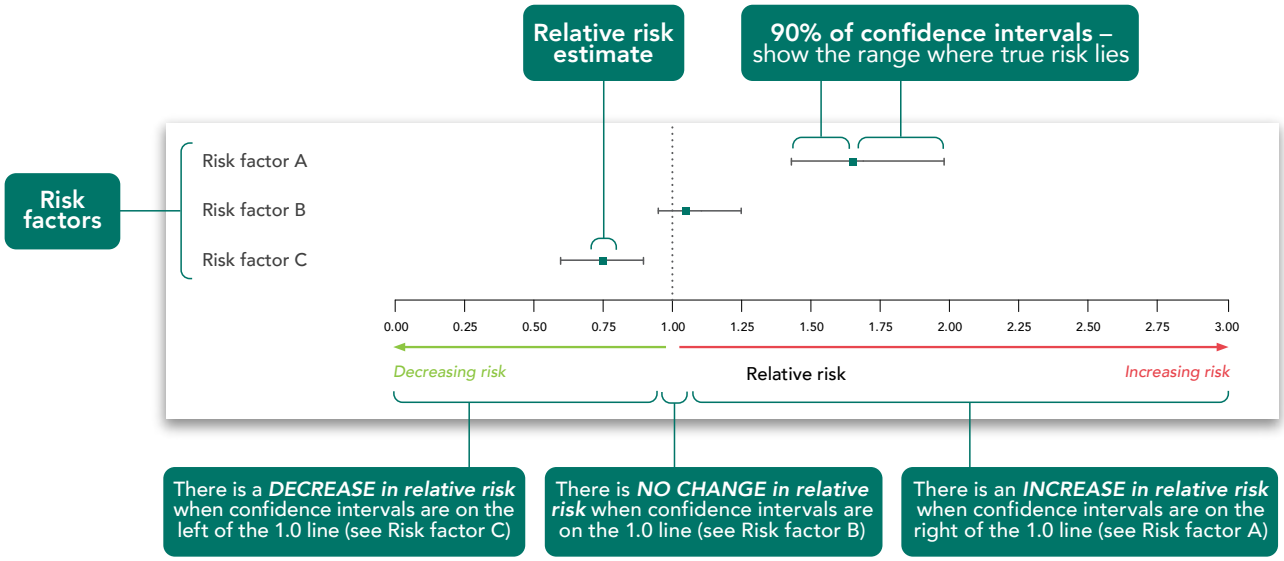


Table A1. Description of studies that compared alcohol consumption and risk of HIV incidence, HIV mortality, risky sexual behaviors, and unfavorable treatment outcomes

Alcohol assessment groups		HIV Outcomes			
		HIV incidence *(newly-diagnosed HIV infection)*	HIV mortality	Risky sexual behavior	Unfavorable treatment outcomes
Total meta-analyses		2	0	2	1
Total individual studies		12	4	5	14
No drinking vs. any drinking *Studies that defined two alcohol consumption categories, comparing drinkers with nondrinkers, such as no alcohol use vs. any alcohol or never use alcohol vs. use alcohol*					
Baliunas et al., 2010 (meta-analysis)*	Alcohol consumption (yes/no)	✓			
Dear et al., 2022	Alcohol use (yes/no)				✓
Kebede et al., 2021 (meta-analysis)	Use alcohol vs. never use alcohol				✓
Mavedzenge et al., 2011	Alcohol consumption (yes/no)	✓			
Miller et al., 2023	Alcohol use (yes/no)			✓	
Miller et al., 2021	Alcohol use in the past year (yes/no)				✓
Patsis et al., 2020*	Alcohol use (yes/no)		✓		
Przybyla et al., 2018 (meta-analysis)*	Alcohol consumption (yes/no)			✓	
Shuper et al., 2009 (meta-analysis)*	Any alcohol drinking vs. none			✓	
Vandepitte et al., 2013*	Alcohol use (yes/no)	✓			
Non-risky drinking vs. risky drinking *Studies that defined two alcohol consumption categories with one category indicating a heavy drinking level, such as alcoholism, alcohol abuse, or binge drinking, or comparing sex under the influence of alcohol, such as no alcohol before sex vs. alcohol before sex*					
Baliunas et al., 2010 (meta-analysis)*	Binge alcohol consumption vs. no binge alcohol consumption; Alcohol consumption prior to sex (yes/no)	✓			
Cohn et al., 2011	Heavy drinking in the past 30 days: > 4 drinks/day (yes/no); Binge drinking at least once in the last 30 days: ≥ 5 drinks within a couple of hours (yes/no)				✓
Deiss et al., 2016	At-risk drinking vs. not at-risk drinking				✓
DeLorenze et al., 2011	Alcohol use only vs. none		✓		
Gross et al., 2017	Hazardous alcohol use in prior year (yes/no)				✓

Continued on next page

Table A1. Description of studies that compared alcohol consumption and risk of HIV incidence, HIV mortality, risky sexual behaviors, and unfavorable treatment outcomes *(Continued)*

Howe et al., 2011*	Binge drinking: prior 6 months (yes/no)	✓			
Jones et al., 2022	> 20 units alcohol/week from AUDIT score vs. ≤ 20 units alcohol/week; Alcohol dependence: CAGE score ≥ 2 and current alcohol consumption (yes/no)				✓
Kabapy et al., 2020 (meta-analysis)	Alcoholism (yes/no)	✓			
Kagaayi et al., 2014	Used alcohol before sex, as reported by partner (yes/no)	✓			
Kennedy et al., 2017	Binge alcohol use (yes/no)				✓
Kiriazova et al., 2014	Binge drinking in the past 30 days: > 14 drinks per week or > 4 drinks on a single occasion for men, and > 7 per week or > 3 on a single occasion for women (yes/no)				✓
Koblin et al., 2015	Heavy alcohol use: ≥ 4 drinks daily or drinking ≥ 6 on a typical day that the women consumed alcohol (yes/no)			✓	
Koblin et al., 2006	Heavy alcohol use vs. none, light, moderate (ref.)	✓			
Liu et al., 2015	Sex after drinking alcohol since the last study visit (yes/no)	✓			
Paolillo et al., 2017	At-risk drinking vs. not at-risk drinking				✓
Patsis et al., 2020*	Hazardous alcohol consumption: AUDIT score ≥ 8 vs. non-hazardous alcohol consumption: AUDIT score < 8; Harmful alcohol consumption: AUDIT score ≥ 16 vs. non-harmful alcohol consumption: AUDIT score < 16		✓		
Peltzer et al., 2011	Hazardous or harmful alcohol use: AUDIT score ≥ 2 (yes/no)		✓		✓
Przybyla et al., 2018 (meta-analysis)*	Binge/problematic drinking: AUDIT score > 7 or met or exceeded gender-specific threshold for number of drinks on a single drinking occasion (yes/no) Alcohol in sexual context: alcohol use before or during sex (yes/no)			✓	
Seeley et al., 2012*	Previous sex under the influence of alcohol (yes/no)	✓			
Shuper et al., 2009 (meta-analysis)*	Problematic drinking vs. no drinking/moderate drinking; Alcohol use in sexual contexts (yes/no)			✓	

Continued on next page

Table A1. Description of studies that compared alcohol consumption and risk of HIV incidence, HIV mortality, risky sexual behaviors, and unfavorable treatment outcomes *(Continued)*

No drinking vs. non-risky drinking and risky drinking *Studies that defined three alcohol consumption categories with one category indicating no drinking, second category indicating no risky drinking and the third category indicating risky drinking, such as no drinking vs. moderate and hazardous drinking, not drinking vs. no problem drinking and problem drinking, nondrinker vs. never binge and ever binge*					
Fairbairn et al., 2016	Hazardous alcohol use: no drinking (ref.), moderate, hazardous		✓		
Gordon et al., 2017	Alcohol use: not a current drinker (no report of drinking for more than 12 months) (ref.); non-hazardous drinker (AUDIT score < 3 for women and < 4 for men in the past 12 months); binge or heavy episodic drinking (EOG 6 drinks on one occasion at least monthly); alcohol abuse/dependence (using 1 inpatient or 2 outpatient ICD-9 codes with alcohol-related diagnosis a year prior and up to 6 months after enrollment)			✓	
Plankey et al., 2007	Alcohol use: abstains/low to moderate drinking (ref.); moderate to heavy drinking (at least weekly drinking of 3–4 drinks or drinking ≥ 5 or more drinks less than monthly); binge drinking (≥ 5 drinks per occasion occurring at least monthly)	✓			
Vandepitte et al., 2013*	CAGE alcohol use: not drinking (ref.), not problem drinking, problem drinking Binge drinking in last 3 months: nondrinker (ref.), never binge, ever binge	✓			
Frequency of alcohol consumption *Studies that defined alcohol consumption by how often alcohol is consumed, but not amount, across at least three consumption categories*					
Downen et al., 2020	Alcohol consumption: never (ref.), one or more times per month or per week or every day, one or more times per year, less than once per year	✓			
Geis et al., 2011	Alcohol consumption: never (ref.); occasionally, less than weekly; occasionally, weekly; daily	✓			
Seeley et al., 2012*	Alcohol consumption: never (ref.), rarely (at least once a month or less), regularly (at least once a week)	✓			
Vandepitte et al., 2013*	Alcohol use: not using (ref.), less than once a week, at least once a week, daily	✓			

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Table A1. Description of studies that compared alcohol consumption and risk of HIV incidence, HIV mortality, risky sexual behaviors, and unfavorable treatment outcomes *(Continued)*

Volume of alcohol consumption *Studies that defined alcohol consumption with a measure of both frequency of consumption and quantity of alcohol consumed*					
Bedoya et al., 2012	Alcohol use: never (no drinks in the past month) (ref.), light (< 3 drinks/day), moderate (4–5 drinks/day), heavy (> 6 drinks/day)	✓		✓	
Benning et al., 2020	Alcohol use: none (ref.), 0–7 drinks/week, 7–12 drinks/week, > 12 drinks/week				✓
Conen et al., 2013	Alcohol consumption for women, g/day: nondrinkers/light risk (ref.) (< 20 g/day); moderate risk (20–40 g/day); severe risk (> 40 g/day) Alcohol consumption for men, g/day: nondrinkers/light risk (ref.) (< 40 g/day); moderate risk (40–60 g/day); severe risk (> 60 g/day)				✓
Howe et al., 2011*	Alcohol consumption drinks/week over the prior two years: 0 drinks/week (ref.), 1–5 drinks/week, 6–20 drinks/week, 21–50 drinks/week, 51–140 drinks/week	✓			✓
Lesko et al., 2021	Alcohol consumption for women, g/day: nondrinkers (ref.); low risk, no binge (> 0 and < 7 drinks/week); low risk binge (> 4 drinks on one occasion); high risk (> 7 drinks/week) Alcohol consumption for men, g/day: nondrinkers (ref.); low risk, no binge (> 0 and < 14 drinks/week); low risk binge (> 5 drinks on one occasion); high risk (> 14 drinks/week)				✓
Sander et al., 2013	Alcohol consumption: nondrinkers (ref.), moderate drinkers (1–14 drinks/week), heavy drinkers (> 14 drinks/week	✓			
Woolf-king et al., 2013	Alcohol consumption: nondrinkers (ref.), moderate drinkers (1–14 drinks/week), heavy drinkers (> 14 drinks/week			✓	

* Indicates a study that assesses alcohol consumption using multiple methods.

Table A2. Description of studies that compared alcohol consumption and risk of HIV incidence

Author, year	Study design*	Location	High HIV prevalence *(Y/N)?*	Study population or study inclusions†	Key population‡ *(Y/N)?*	Sex	Age group *(years)*	Reference group	Alcohol exposure *(as defined by the study)*	Risk estimate (95% CI)§
No drinking vs. any drinking										
Baliunas et al., 2010	MA	Australia, Jamaica, Tanzania, Thailand, Uganda, United States	Y	1. cohort, case-control, or nested case-control studies 2. alcohol consumption as exposure group with reference group as no alcohol consumption or lowest exposed category 3. outcome is HIV incidence among men who have sex with men (MSM), family clinic attendees, and military conscripts	Y	combined	15+	no alcohol consumption	any alcohol consumption	1.98 (1.59–2.47)
				1. cohort, case-control, or nested case-control studies 2. alcohol consumption as exposure group with reference group as no alcohol consumption or lowest exposed category 3. outcome is HIV incidence among family clinic attendees and military conscripts						2.08 (1.46–2.98)
				1. cohort, case-control, or nested case-control studies 2. alcohol consumption as exposure group with reference group as no alcohol consumption or lowest exposed category 3. outcome is HIV incidence among MSM		male				1.92 (1.30–2.83)
				1. cohort, case-control, or nested case-control studies 2. alcohol consumption as exposure group with reference group as no alcohol consumption or lowest exposed category 3. outcome is HIV incidence among MSM, family clinic attendees, and military conscripts						2.01 (1.52–2.65)
				1. cohort, case-control, or nested case-control studies 2. alcohol consumption as exposure group with reference group as no alcohol consumption or lowest exposed category 3. outcome is HIV incidence among family clinic attendees and military conscripts		female				1.92 (1.37–2.68)

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Table A2. Description of studies that compared alcohol consumption and risk of HIV incidence *(Continued)*

Mavedzenge et al., 2011	P-C	South Africa (Durban)	Y	Sexually active HIV- women recruited from the general population at family planning, well baby and general health clinics, and community groups	Y	female	18–49	no alcohol consumption	yes alcohol consumption	0.89 (0.55–1.43)
		South Africa (Harare)								3.13 (1.57–6.24)
		South Africa (Johannesburg)								1.27 (0.69–2.34)
Vandepitte et al., 2013	P-C	Uganda	Y	Women engaging in high-risk sexual behavior from redlight areas in Southern Kampala recruited from the Good Health for Women Project clinic	Y	female	13+	no alcohol use	yes alcohol use	3.36 (1.17–9.59)
Non-risky drinking vs. risky drinking										
Baliunas et al., 2010	MA	Australia, Jamaica, Tanzania, Thailand, Uganda, United States	Y	1. cohort, case-control, or nested case-control studies 2. alcohol consumption as exposure group with reference group as no alcohol consumption or lowest exposed category 3. outcome is HIV incidence among MSM, family clinic attendees, and military conscripts	Y	combined	15+	no binge drinking	binge drinking	2.20 (1.29–3.74)
								no alcohol in sexual context (alcohol prior to sex)	alcohol in sexual context (alcohol prior to sex)	1.87 (1.39–2.50)
Howe et al., 2011	P-C	United States (Baltimore, Maryland)	N	HIV- African American participants (majority male 72%) from the AIDS Link to Intravenous Experience (ALIVE) cohort	Y	combined	mean 37	no binge drinking	binge drinking	1.70 (1.22–2.37)
Kabapy et al., 2020	MA	Worldwide	Y	1. cohort studies 2. reporting ORs for alcohol consumption as a risk factor for HIV (relative risks or odds ratio) 3. outcome is HIV incidence	Y	combined	n/a	no alcoholism	alcoholism	1.77 (1.20–2.62)
Kagaayi et al., 2014	P-C	Uganda	Y	An open population-based prospective cohort in the community of Rakai limited to sexually active individuals who reported sexual intercourse in the previous 12 months	Y	male	15–49	no alcohol before sex, as reported by partner	alcohol before sex, as reported by partner	1.28 (0.96–1.71)
						female				1.44 (1.15–1.80)

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Table A2. Description of studies that compared alcohol consumption and risk of HIV incidence *(Continued)*

Koblin et al., 2006	P-C	United States (Boston, Massachusetts; Chicago, Illinois; New York, New York; San Francisco, California; Seattle, Washington)	N	High-risk MSM population without HIV antibodies, engaging in anal sex for the past year (72% white) recruited from the EXPLORE study from six US cities	Y	male	16+	none, light, or moderate alcohol use	heavy alcohol use	1.97 (1.32–2.96)‡
Liu et al., 2015	P-C	China	N	MSM living in Beijing, who are HIV and syphilis negative and have engaged in anal or oral sex in the past 4 months and recruited from respondent driven sampling and volunteer HIV texting and counseling clinics	Y	male	17+	no sex after drinking alcohol	sex after drinking alcohol	1.90 (1.10–4.20)
Seeley et al., 2012	P-C	Uganda	Y	HIV- participants who are 'at-risk' for HIV from Masaka, Wakiso, and Mukono districts	Y	combined	13–49	no sex under the influence	sex under the influence	2.10 (1.20–3.60)
No drinking vs. non-risky drinking and risky drinking										
Plankey et al., 2007	P-C	United States (Baltimore, Maryland; Washington, DC; Chicago, Illinois; Los Angeles, California; Pittsburgh, Pennsylvania)	N	HIV- MSM from the Multicenter AIDS Cohort Study (MACS)	Y	male	mean 33.4	abstain/low to moderate drinking	moderate to heavy drinking	1.18 (0.94–1.48)¶
									binge drinking	1.13 (0.81–1.56)¶
Vandepitte et al., 2013	P-C	Uganda	Y	Women engaging in high-risk sexual behavior from redlight areas in Southern Kampala recruited from the Good Health for Women Project clinic	Y	female	13+	not drinking	not problem drinking	1.65 (0.48–5.73)
									problem drinking	2.85 (0.99–8.17)
								nondrinker	never binge drinker	3.20 (1.10–9.31)
									ever binge drinker	3.87 (1.20–12.52)

Continued on next page

Table A2. Description of studies that compared alcohol consumption and risk of HIV incidence *(Continued)*

Frequency of alcohol consumption										
Downen et al., 2020	C-C	Ecuador	N	HIV+ patients from outpatient HIV clinics matched with controls from outpatient internal medicine clinics based on age, sex, and gender who are not mentally incapcitated	N	combined	18+	never	one or more times per month or per week or every day	0.60 (0.30–1.30)
									one or more times per year	0.30 (0.10–0.70)
									less then once per year	0.50 (0.30–0.95)
Geis et al., 2011	P-C	Tanzania	Y	Residents from Mbeya and Itende village who plan to stay for at least three years	N	combined	18–45	never	occasionally, less than weekly	1.83 (1.02–3.30)
									occasionally, weekly	1.64 (0.91–2.94)
									daily	2.01 (1.00–4.07)
Seeley et al., 2012	P-C	Uganda	Y	HIV- participants who are 'at-risk' for HIV from Masaka, Wakiso, and Mukono districts	Y	combined	13–49	never	rarely, at least once a month or less	1.18 (0.52–2.66)
									regularly, at least once a week	3.13 (1.62–6.06)
Vandepitte et al., 2013	P-C	Uganda	Y	Women engaging in high-risk sexual behavior from redlight areas in Southern Kampala recruited from the Good Health for Women Project clinic	Y	female	13+	not using	less than once a week	0.83 (0.09–7.60)
									at least once a week	2.72 (0.94–7.87)
									daily	2.58 (0.81–8.20)

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Table A2. Description of studies that compared alcohol consumption and risk of HIV incidence *(Continued)*

Volume of alcohol consumption										
Bedoya et al., 2012	P-C	United States (Boston, Massachusetts; Chicago, Illinois; Denver, Colorado; New York, New York; San Francisco, California; Seattle, Washington)	N	HIV- MSM participants in the past year and have not been in a monogamous relationship with HIV- males in the past 2 years	Y	male	18+	never (no drinks in past month)	light (< 3 drinks/day and less than 3 days/week)	3.20 (0.75–13.59)‡
									moderate (4–5 drinks/day and drinking less than 3 days/week; or 1–5 drinks/day and drinking 3–6 days/week; or 1–3 drinks/day and drinking 7 days/week)	2.91 (0.65–13.02)‡
									heavy (more than 4 drinks/day and drinking 7 days/week; or drinking more than 6 drinks/day)	4.28 (0.94–19.57)‡
Howe et al., 2011	P-C	United States	N	HIV- African American participants (majority male 72%) from the AIDS Link to Intravenous Experience (ALIVE) cohort	Y	combined	mean 37	0 drinks/week	1–5 drinks/week	1.09 (0.60–1.98)
									6–20 drinks/week	1.18 (0.66–2.09)
									21–50 drinks/week	1.66 (0.94–2.93)
									51–140 drinks/week	2.12 (1.15–3.90)
Sander et al., 2013	P-C	United States (Maryland/Washington, DC; Chicago, Illinois; Los Angeles, California; Pittsburgh, Pennsylvania)	N	Sexually active HIV- MSM from the Multicenter AIDS Cohort Study (MACS)	Y	male	mean 33.4	nondrinker	moderate drinker	1.10 (0.78–1.54)
									heavy drinker	1.61 (1.12–2.29)

* MA = meta-analysis, C-C = case-control, P-C = prospective cohort

† For meta-analyses the study inclusion criteria were described instead of the study population.

‡ Key populations include sex workers, men who have sex with men, people who inject drugs, transgender people, and incarcerated people.

§ Risk estimates are unadjusted estimates.

¶ Study combined no drinking and light-to-moderate drinking.

Table A3. Description of studies that compared alcohol consumption and risk of HIV mortality

Author, year	Study design*	Location	High HIV prevalence *(Y/N)?*	Study population or study inclusions†	Key population‡ *(Y/N)?*	Sex	Age group *(years)*	Reference group	Alcohol exposure *(as defined by the study)*	Risk estimate (95% CI)
No drinking vs. any drinking										
Patsis et al., 2020	P-C	Kenya and Uganda	Y	HIV+ participants who are ART-naïve (have never received antiretroviral therapy) recruited from one of the five clinics within the East Africa International epidemiology Databases to Evaluate Aids (EA-IeDEA) consortium	N	combined	18+	non-alcohol consumers	alcohol consumers	1.16 (0.58–2.33)
Non-risky drinking vs. risky drinking										
DeLorenze et al., 2011	R-C	United States	N	HIV+ participants that received health care at Kaiser Permanente Northern California (KPNC)	N	combined	14+	none	alcohol only	1.65 (1.30–2.09)
Patsis et al., 2020	P-C	Kenya and Uganda	Y	HIV+ participants who are ART-naïve recruited from one of the 5 clinics within the East Africa International epidemiology Databases to Evaluate Aids (EA-IeDEA) consortium	N	combined	18+	non-hazardous drinking	hazardous drinking	1.73 (0.80–3.77)
								non-harmful drinking	harmful drinking	1.25 (0.46–3.35)
Peltzer et al., 2011	P-C	South Africa	Y	HIV+ patients who are ART-naïve recruited from three public hospitals in Uthukela health district in KwaZulu-Natal and about to start treatment (majority women 70%)	N	combined	18+	not hazardous or harmful alcohol use	hazardous or harmful alcohol use (AUDIT score ≥ 2)	1.32 (0.54–3.27)
No drinking vs. non-risky drinking and risky drinking										
Fairbairn et al., 2016	P-C	Russia (St. Petersburg)	N	HIV+ participants from the HIV's Evolution in Russia-Mitigating Infection Transmission and Alcoholism in a Growing Epidemic (HERMITAGE) randomized controlled trial enrolled people from inpatient and outpatient HIV and substance use patient care sites	N	combined	18+	no drinking	moderate < 14 drinks/week	0.95 (0.35–2.59)
									hazardous > 14 drinks/week	2.60 (1.24–5.44)

* MA = meta-analysis, P-C = prospective cohort, R-C = retrospective cohort

† For meta-analyses the study inclusion criteria were described instead of the study population.

‡ Key populations include sex workers, men who have sex with men, people who inject drugs, transgender people, and incarcerated people.

Table A4. Description of studies that compared alcohol consumption and risk of risky sexual behaviors

Author, year	Study design*	Location	High HIV prevalence *(Y/N)?*	Study population or study inclusions†	Key population‡ *(Y/N)?*	Sex	Age group *(years)*	Reference group	Alcohol exposure *(as defined by the study)*	Risk estimate (95% CI)
No drinking vs. any drinking										
Multiple sexual partners and unprotected sex										
Miller et al., 2023	P-C	South Africa (Gugulethu, Cape Town)	Y	HIV- pregnant women attending their first antenatal clinic visit	Y	female	16+	no alcohol use	alcohol use	1.33 (1.05–1.68)
Unprotected sex										
Przybyla et al., 2018	MA	France, South Africa, Switzerland, Thailand, Togo, United States	Y	1. cohort/longitudinal or cross-sectional studies 2. alcohol consumption as exposure group with reference group as no alcohol consumption or lowest exposed category 3. outcome is risky sexual behavior	Y	combined	n/a	no alcohol consumption	any alcohol consumption	1.64 (1.46–1.85)
Shuper et al., 2009	MA	Canada, France, Germany, Ivory Coast, South Africa, United States	Y	1. quantitative studies 2. alcohol consumption as exposure group with reference group as no alcohol consumption or lowest exposed category 3. outcome is risky sexual behavior	Y	combined	n/a	no alcohol use	any alcohol use	1.63 (1.39–1.91)
Non-risky drinking vs. risky drinking										
Unprotected sex										
Koblin et al., 2015	P-C	United States (Chicago, Illinois; New York, New York; Philadelphia, Pennsylvania)	N	HIV- women; not pregnant or intending to get pregnant; that engage in high-risk behavior such as unprotected sex, exchange of sex, or cocaine use; or having a male partner who has been incarcerated in the past year, injected drugs in the past year, or had concurrent sex with another partner in the last 6 months	Y	female	18–45	no heavy alcohol use	heavy alcohol use	1.50 (1.13–1.99)
Przybyla et al., 2018	MA	France, South Africa, Switzerland, Thailand, Togo, United States	Y	1. cohort/longitudinal or cross-sectional studies 2. alcohol consumption as exposure group with reference group as no alcohol consumption or lowest exposed category 3. outcome is risky sexual behavior	Y	combined	n/a	no binge/ problematic drinking	binge/ problematic drinking	1.65 (1.14–2.39)
								no alcohol in sexual context	alcohol in sexual context	2.88 (2.01–4.13)

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Table A4. Description of studies that compared alcohol consumption and risk of risky sexual behaviors *(Continued)*

Shuper et al., 2009	MA	Canada, France, Germany, Ivory Coast, South Africa, United States	Y	1. cohort studies 2. alcohol consumption as exposure group with reference group as no alcohol consumption or lowest exposed category 3. outcome is risky sexual behavior	Y	combined	n/a	no drinking/ moderate drinking	problematic drinking	1.72 (1.41–2.10)
						male				1.88 (1.38–2.56)
						female				1.50 (1.00–2.25)
						combined		no alcohol in sexual context	alcohol in sexual context	1.98 (1.63–2.39)
Multiple sexual partners										
Koblin et al., 2015	P-C	United States (Chicago, Illinois; New York, New York; Philadelphia, Pennsylvania)	N	HIV- women; not pregnant or intending to get pregnant; that engage in high-risk behavior such as unprotected sex, exchange of sex, or cocaine use; or having a male partner who has been incarcerated in the past year, injected drugs in the past year, or had concurrent sex with another partner in the last 6 months	Y	female	18–45	no heavy alcohol use	heavy alcohol use	1.63 (1.24–2.12)
No drinking vs. non-risky drinking and risky drinking										
Unprotected sex										
Gordon et al., 2017	P-C	United States	N	HIV+ and HIV- group of men who have sex with men (MSM) reporting any sexual activity in the past year	Y	male	18+	not a current drinker	non-hazardous drinker	1.06 (0.88–1.28)
									hazardous drinker	1.53 (1.26–1.87)
									alcohol abuse	1.06 (0.82–1.37)
Multiple sexual partners										
Gordon et al., 2017	P-C	United States	N	HIV+ and HIV- group of MSM reporting any sexual activity in the past year	Y	male	18+	not a current drinker	non-hazardous drinker	1.05 (0.85–1.28)
									hazardous drinker	1.45 (1.19–1.77)
									alcohol abuse	1.66 (1.29–2.14)

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Table A4. Description of studies that compared alcohol consumption and risk of risky sexual behaviors *(Continued)*

Alcohol use before sex										
Gordon et al., 2017	P-C	United States	N	HIV+ and HIV- group of MSM reporting any sexual activity in the past year	Y	male	18+	not a current drinker	non-hazardous drinker	2.40 (1.81–3.19)
									hazardous drinker	7.49 (5.75–9.75)
									alcohol abuse	6.78 (5.07–9.06)
Volume of alcohol consumption										
Bedoya et al., 2012	P-C	United States (Boston, Massachusetts; Chicago, Illinois; Denver, Colorado; New York, New York; San Francisco, California; Seattle, Washington)	N	HIV- MSM participants in the past year and have not been in a monogamous relationship with HIV- males in the past 2 years	Y	male	18+	never (no drinks in past month)	light (< 3 drinks/day)	1.02 (0.71–1.46)
									moderate (4–5 drinks/day)	1.17 (0.80–1.72)
									heavy (> 6 drinks/day)	1.56 (1.03–2.36)
Woolf-king et al., 2013	P-C	United States (San Francisco, California)	N	MSM collected from the Urban Men's Health Study	Y	male	40+	no alcohol use	light/social drinkers (1–2 drinks on average)	1.83 (0.68–4.90)
									moderate drinkers (3–4 drinks on average)	1.43 (0.48–4.22)
									heavy/binge drinkers (5+ drinks on average)	3.68 (1.13–11.98)

* MA = meta-analysis, P-C = prospective cohort

† For meta-analyses the study inclusion criteria were described instead of the study population.

‡ Key populations include sex workers, men who have sex with men, people who inject drugs, transgender people, and incarcerated people.

Table A5. Description of studies that compared alcohol consumption and risk of unfavorable HIV treatment outcomes

Author, year	Study design*	Location	High HIV prevalence *(Y/N)?*	Study population or study inclusions†	Key population‡ *(Y/N)?*	Sex	Age group *(years)*	Reference group	Alcohol exposure *(as defined by the study)*	Risk estimate (95% CI)§
No drinking vs. any drinking										
Non-adherence to treatment										
Dear et al., 2022	P-C	Kenya, Nigeria, Tanzania, Uganda	Y	PLWHIV not pregnant or have significant conditions receiving care at President's Emergency Plan for AIDS Relief (PEPFAR) clinics	N	combined	18+	no alcohol use	alcohol use	1.34 (1.05–1.70)
Non-response to treatment										
Miller et al., 2021	P-C	Uganda	Y	HIV+ patients (majority male 72%) from the Rakai Community Cohort Study (RCCS) surveyed from 34 communities in Rakai and neighboring districts	N	combined	15–49	no alcohol in past year	past year alcohol use	1.37 (1.15–1.61)
						male				1.27 (0.93–1.64)
						female				1.39 (1.12–1.72)
Loss to follow-up										
Kebede et al., 2021	MA	Chad, Democratic Republic of Congo, Ethiopia, Kenya, Malawi, Nigeria, South Africa, Uganda	Y	1. cohort/longitudinal, cross-sectional, or case-control studies 2. reporting ORs for alcohol consumption as a risk factor for HIV (relative risks, hazard ratios, or odds ratios) 3. outcome is unfavorable treatment outcome	N	combined	15+	never use alcohol	use alcohol	2.91 (1.93–4.37)
Non-risky drinking vs. risky drinking										
Non-adherence to treatment										
Cohn et al., 2011	P-C	United States	N	HIV+ patients (majority male 87%) without prior mycobacterium avium complex and with documented immune reconstitution	N	combined	mean 40	no heavy drinking	heavy drinking	1.19 (0.72–1.98)
								no binge drinking	binge drinking	1.53 (1.21–1.95)

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Table A5. Description of studies that compared alcohol consumption and risk of unfavorable HIV treatment outcomes *(Continued)*

Deiss et al., 2016	P-C	United States	N	HIV-infected (majority male 97%) military personnel and beneficiaries from The U.S. Military Natural History Study (NHS)	N	combined	18+	not at-risk drinking	at-risk drinking	2.28 (1.01–5.15)
Paolillo et al., 2017	P-C	United States	N	Adults (majority male 86%) enrolled in HIV Neurobehavioral Research Program receiving ART and reported drinking in past 30 days	N	combined	20–74	not at-risk drinking	at-risk drinking	1.56 (1.04–2.33)
Non-response to treatment										
Gross et al., 2017	P-C	Botswana	Y	HIV+ Botswana citizens of black African origin and initiating ART from 8 clinics in Gaborone and not currently pregnant	N	combined	21+	no hazardous alcohol use in prior year	hazardous alcohol use in prior year	1.40 (1.00–1.90)
Jones et al., 2021	P-C	England	N	HIV+ participants (majority male 80%) from the Royal Free Centre who were on ART at the time of questionnaire, and started ART 6 months prior to baseline viral load measurements	N	combined	18+	≤ 20 units/week	> 20 units/week	1.40 (0.72–2.74)
								no alcohol dependence	yes alcohol dependence	1.66 (1.03–2.66)
Kennedy et al., 2017‡	P-C	Canada (Vancouver)	N	HIV+ participants having used illicit drugs other than cannabis in the previous month	Y	combined	18+	no binge alcohol use	binge alcohol use	1.06 (0.66–1.69)‡
Loss to follow-up										
Kiriazova et al., 2014	P-C	Russia (St. Petersburg)	N	HIV+ patients who engaged in risky drinking and unprotected sex in the past 6 months were recruited from 4 inpatient and outpatient HIV and addiction clinics and from needle exchange programs	Y	combined	18+	no binge drinking	binge drinking	1.34 (0.75–2.37)
Peltzer et al., 2011	P-C	South Africa	Y	HIV+ patients who are treatment naïve recruited from three public hospitals in Uthukela health district in KwaZulu-Natal and about to start treatment (majority women 70%)	N	combined	18+	no harmful alcohol consumption	harmful alcohol consumption	1.17 (0.69–1.98)

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Table A5. Description of studies that compared alcohol consumption and risk of unfavorable HIV treatment outcomes *(Continued)*

Volume of alcohol consumption										
Non-adherence to treatment										
Benning et al., 2020	P-C	United States (Bronx/ Manhatten, New York; Brooklyn, New York; Los Angeles/ Southern California/ Hawaii; San Francisco/ Bay Area, California; Chicago, Illinois; Washington, DC; Atlanta, Georgia; Chapel Hill, North Carolina; Miami, Florida; Birmingham, Alabama; Jackson, Mississippi	N	HIV+ women who were seen for at least 4 visits and reported using ART at least once from the Women's Interagency HIV Study (WIHS) cohort	N	female	18+	none	0–7 drinks/week	1.14 (1.03–1.27)
									7–12 drinks/ week	1.69 (1.37–2.13)
									> 12 drinks/ week	1.96 (1.67–2.33)
Conen et al., 2013	P-C	Switzerland	N	HIV+ adults from the Swiss HIV Cohort (SHCS) enrolled from 7 cohort centers, affiliated hospitals and private practices	N	male	16+	nondrinkers/ light risk (< 40 g/day)	moderate risk (40–60 g/day)	1.13 (0.72–1.76)
									Severe risk (> 60 g/day)	2.24 (1.42–3.52)
						female	16+	nondrinkers/ light risk (< 20 g/day)	moderate risk (20–40 g/day)	1.13 (0.72–1.76)
									Severe risk (> 40 g/day)	2.24 (1.42–3.52)

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Table A5. Description of studies that compared alcohol consumption and risk of unfavorable HIV treatment outcomes *(Continued)*

Non-response to treatment										
Benning et al., 2020	P-C	United States (Bronx/ Manhattan, New York; Brooklyn, New York; Los Angeles/ Southern California/ Hawaii; San Francisco/ Bay Area, California; Chicago, Illinois; Washington, DC; Atlanta, Georgia; Chapel Hill, North Carolina; Miami, Florida; Birmingham, Alabama; Jackson, Mississippi	N	HIV+ women who were seen for at least 4 visits and reported using ART at least once from the Women's Interagency HIV Study (WIHS) cohort	N	female	18+	none	0–7 drinks/week	1.05 (0.99–1.11)
									7–12 drinks/ week	1.35 (1.18–1.54)
									> 12 drinks/ week	1.45 (1.28–1.61)
Conen et al., 2013	P-C	Switzerland	N	HIV+ adults from the Swiss HIV Cohort (SHCS) enrolled from 7 cohort centers, affiliated hospitals and private practices	N	male	16+	nondrinkers/ light risk (< 40 g/day)	moderate risk (40–60 g/day)	0.52 (0.21–1.27)
									severe risk (> 60 g/day)	1.42 (0.65–3.07)
						female	16+	nondrinkers/ light risk (< 20 g/day)	moderate risk (20–40 g/day)	0.52 (0.21–1.27)
									severe risk (> 40 g/day)	1.42 (0.65–3.07)

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Table A5. Description of studies that compared alcohol consumption and risk of unfavorable HIV treatment outcomes *(Continued)*

Lesko et al., 2021	P-C	United States	N	HIV+ participants (majority male 83%) in HIV clinical care (defined as attending at least two clinic visits) at one of eight academic medical centers across the United States	N	combined	18+	nondrinkers	low-risk, no binge	1.09 (1.01–1.18)
									high-risk	1.24 (1.04–1.49)
									low-risk, binge	1.17 (1.07–1.28)
						male			low-risk, no binge (> 0 and < 14 drinks/week)	1.08 (0.99–1.18)
									high-risk (> 14 drinks/week)	1.22 (1.00–1.50)
									low-risk, binge (> 4 drinks on one occasion)	1.17 (1.06–1.29)
						female			low-risk, no binge (> 0 and < 7 drinks/week)	1.11 (0.94–1.32)
									high-risk (> 7 drinks/week)	1.33 (0.95–1.87)
									low-risk, binge (> 5 drinks on one occasion)	1.19 (0.98–1.44)
Loss to follow-up										
Howe et al., 2011	P-C	United States	N	HIV- African American participants (majority male 72%) from the AIDS Link to Intravenous Experience (ALIVE) cohort	Y	combined	mean 37	0 drinks/week	1–5 drinks/ week	0.92 (0.76–1.13)
									6–20 drinks/ week	0.83 (0.68–1.02)
									21–50 drinks/ week	0.87 (0.69–1.09)
									51–140 drinks/ week	0.80 (0.61–1.05)

* MA = meta-analysis, P-C = prospective cohort

† For meta-analyses the study inclusion criteria were described instead of the study population.

‡ Key populations include sex workers, men who have sex with men, people who inject drugs, transgender people, and incarcerated people.

§ Risk estimates are unadjusted estimates.