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Trend of alcohol use disorder as a percentage of all-cause mortality in North America

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Abstract

Objective To evaluate the trend of alcohol use disorder (AUD) mortality as a percentage of all-cause mortality in Canada and the United States (US) between 2000 and 2019, by age group.

Results Joinpoint regression showed that AUD mortality as a percentage of all-cause mortality significantly increased between 2000 and 2019 in both countries, and across all age groups (i.e., young adults (20–34 years), middle-aged adults (35–49 years), and older adults (50 + years)). The trend has been levelling off, and even reversing in some cases, in recent years. The average annual percentage change differed across countries and between age groups, with a greater increase among Canadian adults aged 35–49 years and among adults aged 50 + years in the US. Over the past two decades, AUD mortality as a percentage of all-cause mortality has been increasing among all adults in both Canada and the US.

Keywords Alcohol-attributable harm, AUD, Joinpoint regression, Disease trends

Background

Recent studies suggest an increasing trend of certain conditions attributable to alcohol in North America [1, 2]. For instance, studies from both Canada and the United States (US) have found an increasing number of liver cirrhosis deaths during the past two decades [3, 4]. Most alarmingly, liver cirrhosis deaths appear to be occurring among younger cohorts than in the past [2]. Given the link between chronic liver disease and heavy alcohol use [5], it is reasonable to postulate that the rising trend of liver disease is mirrored by that of alcohol use disorder (AUD).

AUD is diagnosed according to criteria in the Diagnostic and Statistical Manual of Mental Disorder Fifth Edition (DSM-5). As per the World Mental Health Survey, AUD has an estimated lifetime prevalence of 13.8% in the US [6, 7]. In Canada it has been estimated that 21% of Canadians consume more alcohol than what is recommended in Canada's Guidance on Alcohol and Health [8, 9]. Consequently, AUD and alcohol-associated liver

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disease is on the rise in both Canada and the US, with the significant increases occurring in the last two decades [2, 10]. The life expectancy trends in both countries have demonstrated a gradual increase followed by some stagnation in the past decade [11], consequently it is important to look at the specific contributions of different causes of death to further understand what contributes to these trends. Moreover, AUD can be seen as an indicator of the contribution of alcohol as a risk factor, as it is linked to many disease and other causes of death [12, 13].

In this short report, we aimed to evaluate the trend of AUD mortality as a percentage of all-cause mortality in Canada and the US, by age group (young adults, 20–34 years; middle-aged adults, 35–49 years; and older adults, 50+years). It was hypothesized that AUD mortality as a percentage of all-cause mortality has been an increasing over time.

Methods

Data

We obtained AUD mortality and all-cause mortality for Canada and the US between 2000 and 2019, for both sexes, separated by 5-year age groups (e.g., 0–4 years, 5–9 years, 10–14 years, 15–19 years, etc.) from the Institute for Health Metrics and Evaluation (IHME). The IHME provides publicly available data as a part of the Global Burden of Disease Study {Global Burden of Disease Collaborative Network, 2019 #34} with estimated data for diseases, injuries and risk factors from 1990 to 2019. For the present study we wanted to focus on the trends in AUD as a part of all-cause mortality at the turn of the century (see also [1, 10]). Based on the GBD Study coding scheme, AUD as a cause of death is composed of a group of ICD codes which include: E24.4, F10, G31.2, G62.1, R78.0, X45-X45.9, X65-X65.9, Y15-Y15.9, Z81.1 [11]. Our primary measure of interest was AUD mortality rate as a percentage of all-cause mortality, as previous work has simply demonstrated that trends of alcohol-attributable deaths (such as liver cirrhosis) have increased. As a sensitivity analysis, we also analyzed the raw number of deaths due to AUD, and the trends in all-cause mortality (presented in Supplementary Material). To prepare comparable analyses for both countries (despite differences in legal drinking ages), we limited our analyses to those 20 years of age and older as the number of deaths provided were in 5-year age groups. As well, we aimed to distinguish trends in younger cohorts, thus, we collapsed the age categories into three age groups; 20–34 years (young adults), 35–49 years (middle-aged adults), and 50+years (older adults).

Analysis strategy

We conducted a joinpoint regression analysis using the joinpoint program of the National Cancer Institute [14]. Joinpoint regression uses an iterative method to model segmented linear trends in time series data; the number of inflection points or "joinpoints" is determined via successive permutations in which an additional point and linear segment is added, and retained only if it results in a lower Bayesian Information Criterion (BIC). As per the recommendations of the authors of the program, we set a maximum of three joinpoints based on our sample size [15]. The output of the program is the annual percentage change (APC) for each linear segment, as well as an overall average annual percentage change (AAPC). As well, to determine if the countries differed in trends, we conducted a moderated linear regression to test for interactions of country effects with year or age. The linear regression was conducted in R version 4.3.1 [16].

Results

In Canada, there were a total of 22,508 AUD deaths. The fewest number of AUD deaths occurred among young adults (1,196 deaths), followed by middle-aged adults (5,127 deaths), and the most deaths occurred among older adults (16,185 deaths). In the US, there were a total of 234,319 AUD deaths. Similar to Canada, the fewest number of AUD deaths in the US occurred among young adults (18,633 deaths), followed by middle-aged adults (74,395 deaths), and the most deaths occurred among older adults (141,292 deaths).

Overall, in Canada there was an increasing general trend for AUD mortality as a percentage of all-cause mortality for each age group (see Fig. 1 and see Table 1), with the largest average annual percentage increase in young adults (AAPC=1.87, 95% CI: 1.39, 2.36). As well, across all age groups there was a marked increase between the mid 2000s and the mid 2010s (young adults, APC (between 2005 and 13)=4.88, 95% CI: 4.42, 5.33; middle-aged adults, APC (between 2006 and 13)=3.55, 95% CI: 2.85, 4.26; and older adults, APC (between 2007 and 14=3.61, 95% CI: 3.33, 3.90), followed by a slight decline into 2019 (although the final segment of the youngest age group flattened out).

Similarly in the US, there was a general increase in AAPC in all age groups (see Table 1), with the largest average annual percentage increase in older adults (AAPC=2.33, 95% CI: 2.22, 2.44). In US data, there was a consistent increase in AUD deaths as a percentage of all-cause mortality from 2000 until the mid 2010s in young adults and older adults with no joinpoint (APC=4.46 (95% CI: 4.07, 4.84) and APC=3.11 (95% CI: 3.04, 3.17), respectively). Meanwhile in middle-aged adults there was a lower magnitude increase between 2001 and 2006 (APC=1.37, 95% CI: 1.03, 1.71) followed by a steeper increase between 2006 and 2011 (APC=2.12, 95% CI: 1.44, 2.80). AUD deaths as a percentage of all-cause mortality showed a decline into 2019 for all age groups.

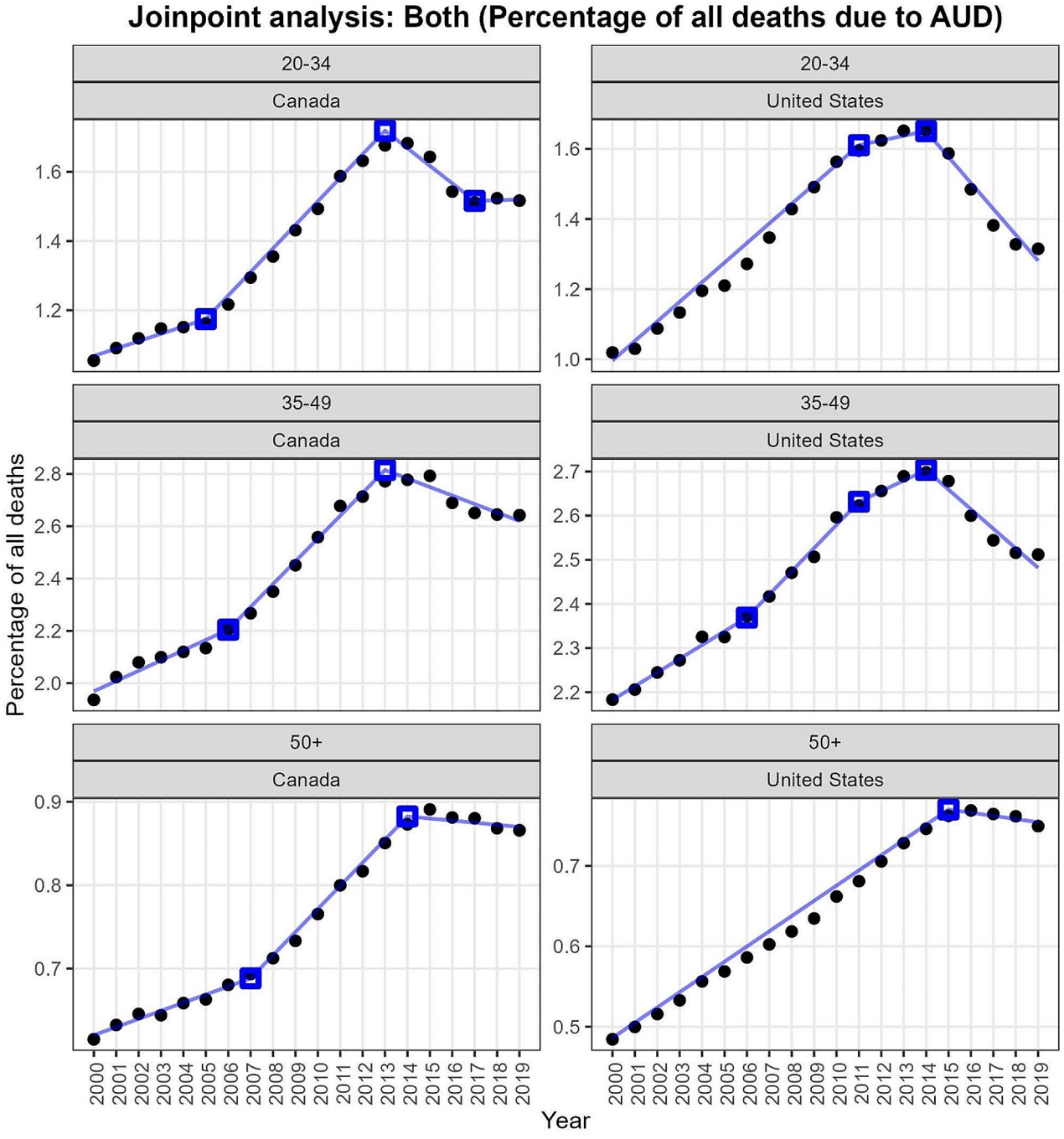

Fig. 1 Joinpoint regression analysis of percentage AUD of all-causes of mortality, raw data (black dots), with joinpoint model estimates (blue line) and joinpoints (blue squares) for both sexes across 3 age categories (20–34, 35–49, and 50+)

Comparing the AAPC between countries for each age group, there was no significant differences between slopes for young adults (overlapping CIs), however Canada demonstrated a higher AAPC for middle-aged adults (1.51 (95% CI: 1.16, 1.87), compared to 0.68 (95% CI: 0.26, 1.1) in the US), and in contrast, the US showed a higher AAPC for older adults (2.34 (95% CI: 2.23, 2.44), compared to 1.8 (95% CI: 1.65, 1.95) in Canada, see Table 1).

Discussion and limitations

An overall increasing trend in AUD mortality as a percentage of all-cause mortality from the year 2000 to 2019 is evident across all age groups in Canada and the US, with a steeper AAPC observed for middle-aged adults in Canada, and for older adults in the US. The rising rate of AUD mortality as a percentage of all-cause mortality may be viewed as an indicator of the rise in the heavy

Table 1 Joinpoint analysis of AUD as a percentage of all-cause mortality for both sexes (by age group and country)

	Age group	Segment number	Segment Years	APC [95%CI]	t-value	*p*-value	AAPC [95%CI]	t-value	*p*-value
Canada	20–34	0	2000–2005	1.92 [1.19,2.66]	5.94	< 0.0001	1.87 [1.39,2.36]	7.67	< 0.0001
		1	2005–2013	4.88 [4.42,5.33]	24.86	< 0.0001			
		2	2013–2017	-3.09 [-4.64,-1.51]	-4.40	0.002			
		3	2017–2019	0.12 [-3.05,3.39]	0.08	0.935			
	35–49	0	2000–2006	1.9 [1.21,2.59]	6.04	< 0.0001	1.51 [1.16,1.87]	8.33	< 0.0001
		1	2006–2013	3.55 [2.85,4.26]	11.22	< 0.0001			
		2	2013–2019	-1.19 [-1.86,-0.51]	-3.83	0.002			
	50+	0	2000–2007	1.5 [1.28,1.72]	14.95	< 0.0001	1.8 [1.65,1.95]	23.82	< 0.0001
		1	2007–2014	3.61 [3.33,3.9]	27.99	< 0.0001			
		2	2014–2019	-0.29 [-0.66,0.09]	-1.67	0.121			
USA	20–34	0	2000–2011	4.46 [4.08,4.84]	25.99	< 0.0001	1.33 [0.49,2.17]	3.13	0.002
		1	2011–2014	0.82 [-4.4,6.32]	0.34	0.743			
		2	2014–2019	-4.94 [-6.08,-3.79]	-9.15	< 0.0001			
	35–49	0	2000–2006	1.38 [1.03,1.72]	9.14	< 0.0001	0.68 [0.26,1.1]	3.19	0.001
		1	2006–2011	2.12 [1.45,2.8]	7.17	< 0.0001			
		2	2011–2014	0.9 [-1.73,3.6]	0.77	0.463			
		3	2014–2019	-1.7 [-2.15,-1.24]	-8.43	< 0.0001			
	50+	0	2000–2015	3.11 [3.05,3.18]	103.58	< 0.0001	2.34 [2.23,2.44]	42.96	< 0.0001
		1	2015–2019	-0.52 [-1.01,-0.03]	-2.28	0.038			

drinking and AUD incidence [17]. Under this premise, because AUD can cause chronic harm in the form of increased risk of cancers and liver disease, the increase in AUD mortality as a percentage of all-cause mortality among young adults is a particular point of concern. As well, when comparing the AUD deaths as a percentage of all-cause mortality to the trends in life expectancy, there is a clear stagnation of life expectancy in both countries beginning around 2010, meanwhile the AUD trend increased into the mid 2010s (see [11]). The fact that our measure of AUD trends continued to rise and precede the stagnation, could suggest that the AUD deaths had an impact on overall life expectancy. Interestingly we found a brief decline from 2015 onward across countries and age groups. We hesitate to speculate as to why this is the case, however based on the supplementary analysis of all deaths, there appears to be a declining trend in the raw number of deaths for both countries among young and middle-aged adults (but not older adults). This broader declining trend could in part explain the period of decline that was observed for AUD mortality as a percentage of all-cause mortality.

The limitations of this work include the fact that it is only a descriptive analysis, and captures a specific set of causes of death (grouped according to IHME) known to be attributable to AUD. We speculate that trends of certain 100% alcohol-attributable disease morbidity, such as alcohol-related liver cirrhosis, and AUD are similar, however, stronger causal evidence between rising AUD and other alcohol-related health conditions would indicate that alcohol consumption trends precede these mortality rates. As well, there is data only until 2019, and though there is a decline from peak levels, it is unclear how the slope has changed within the past 5 years, especially considering the impact of the COVID-19 pandemic and the increase in alcohol consumption seen in various countries [18]. As stated above, although a downward trend was observed toward the latter years, the levels remain much higher than in the 2000s. In some jurisdictions during the COVID-19 pandemic, AUD mortality rose quite substantially, while in others, there was a decrease in self-reported alcohol consumption [19–22].

AUD carries a heavy burden on society, especially since treatment rates are notoriously low due in part to the stigma around AUD. As well, the capacity to identify those suffering from AUD is also a challenge. The rising trend of AUD mortality as a percentage of all-cause mortality, equally across age groups, suggests that alcohol control policy must be updated. Alcohol control policies are meant to attenuate or invert rising trends in alcohol-attributable disease, however based on our results the current policies in North America are ineffective. Future research should be aimed at understanding why these trends continue to rise, especially among young adults, given that many of the harms of even light to moderate alcohol use have come to light [9, 23, 24]. Efforts should be made to increase the provision of resources and treatment for those affected by this disorder, as well as alcohol-control measures which limit the overall consumption in society, as level of consumption and AUD are highly associated [25–27].

Supplementary Information

The online version contains supplementary material available at https://doi.org/10.1186/s13104-024-06882-w.

Supplementary Material 1

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Author contributions
AT conceived of the study design, obtained and analyzed the data, and wrote the drafts of the manuscript. HJ, SL, and JR contributed to interpretation of the analyses, and edited all versions of the manuscript. The final version was approved by all authors.

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Data availability
This was study based on anonymized data and obtained from publically available sources (Institute for Health Metrics) https://vizhub.healthdata.org/gbd-compare/.

Declarations

Ethics approval and consent to participate
All study methods were carried out in accordance with the International Ethical Guidelines for Health-related Research Involving Humans (Council for International Organizations of Medical Sciences (CIOMS)). The Research Ethics Board at CAMH has confirmed that no ethical approval was required for this study and approved a waiver of informed consent. CAMH Research Ethics Board (REB) provided approval of analyses as conducted per protocol: #050/2020.

Consent for publication
Not applicable.

Competing interests
The authors declare no competing interests.

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References

1. Spillane S, Shiels MS, Best AF, Haozous EA, Withrow DR, Chen Y, et al. Trends in alcohol-induced deaths in the United States, 2000–2016. JAMA Netw open. 2020;3(2):e1921451–e.
2. Lee E, Navadurong H, Liangpunsakul S. Epidemiology and trends of alcohol use disorder and alcohol-associated liver disease. Clin Liver Disease. 2023;22(3):99–102.
3. Doycheva I, Watt KD, Rifai G, Abou Mrad R, Lopez R, Zein NN, et al. Increasing burden of chronic liver disease among adolescents and young adults in the USA: a silent epidemic. Dig Dis Sci. 2017;62:1373–80.
4. Flemming JA, Dewit Y, Mah JM, Saperia J, Groome PA, Booth CM. Incidence of cirrhosis in young birth cohorts in Canada from 1997 to 2016: a retrospective population-based study. Lancet Gastroenterol Hepatol. 2019;4(3):217–26.
5. Rehm J, Dawson D, Frick U, Gmel G, Roerecke M, Shield KD et al. Burden of disease associated with alcohol use disorders in the United States. Alcoholism: Clinical and Experimental Research. 2014;38(4):1068-77.
6. Glantz MD, Bharat C, Degenhardt L, Sampson NA, Scott KM, Lim CC, et al. The epidemiology of alcohol use disorders cross-nationally: findings from the World Mental Health surveys. Addict Behav. 2020;102:106128.
7. American Psychiatric Association D-TF. Diagnostic and statistical manual of mental disorders: DSM-5. 5th ed. American Psychiatric Publishing, Inc; 2013.
8. Canadian Alcohol and Drugs Survey (CADS). summary of results 2019. [Internet]. 2019 [cited December 2023]. https://www.canada.ca/en/health-canada/services/canadian-alcohol-drugs-survey/2019-summary/detailed-tables.html
9. Paradis C, Butt P, Shield K, Poole N, Wells S, Naimi T, Sherk A. Canada's Guidance on Alcohol and Health: final report. Ottawa ON: Canadian Centre on Substance Use and Addiction.; 2023.
10. Maleki N, Yunusa I, Karaye IM. Alcohol-induced mortality in the USA: trends from 1999 to 2020. Int J Mental Health Addict. 2023:1–13.
11. Institute for Health Metrics and Evaluation (IHME). GBD Compare Data Visualization. Seattle, WA: IHME, University of Washington2020 [cited 2020. http://vizhub.healthdata.org/gbd-compare
12. Samokhvalov AV, Popova S, Room R, Ramonas M, Rehm J. Disability associated with alcohol abuse and dependence. Alcoholism: Clinical and Experimental Research. 2010;34(11):1871-8.
13. Rehm J, Shield K, Gmel G, Rehm M, Frick U. Modeling the impact of alcohol dependence on mortality burden and the effect of available treatment interventions in the European Union. Eur Neuropsychopharmacol. 2013;23(2):89–97.
14. National Cancer Institute. Joinpoint Regression Software, Version 4.9.0.1. Statistical Research and Applications Branch. National Cancer Institute; 2022.
15. National Cancer Institute. Joinpoint Regression: Number of Joinpoints: Statistical Methodology and Applications Branch, Surveillance Research Program, National Cancer Institute., 2022 [https://surveillance.cancer.gov/help/joinpoint/setting-parameters/method-and-parameters-tab/number-of-joinpoints
16. R Development Core Team. R: a language and environment for statistical computing. 4.3.1 ed. Vienna. Austria: R Foundation for Statistical Computing; 2023.
17. Rehm J, Marmet S, Anderson P, Gual A, Kraus L, Nutt D, et al. Defining substance use disorders: do we really need more than heavy use? Alcohol Alcohol. 2013;48(6):633–40.
18. Barbosa C, Cowell AJ, Dowd WN. Alcohol consumption in response to the COVID-19 pandemic in the United States. J Addict Med. 2021;15(4):341.
19. Kilian C, Carr S, Schulte B, Manthey J. Increased alcohol-specific mortality in Germany during COVID-19: state-level trends from 2010 to 2020. Drug Alcohol Rev. 2023;42(3):633–40.
20. Kilian C, Neufeld M, Manthey J, Alavidze S, Bobrova A, Baron-Epel O, et al. Self-reported changes in alcohol and tobacco use during COVID-19: findings from the eastern part of WHO European Region. Eur J Pub Health. 2022;32(3):474–80.
21. Kilian C, Rehm J, Allebeck P, Braddick F, Gual A, Barták M, et al. Alcohol consumption during the COVID-19 pandemic in Europe: a large-scale cross-sectional study in 21 countries. Addiction. 2021;116(12):3369–80.
22. National Institute on Alcohol Abuse and Alcoholism. Alcohol-related deaths, which increased during the first year of the COVID-19 pandemic, continued to rise in 2021. 2023.
23. Rumgay H, Murphy N, Ferrari P, Soerjomataram I. Alcohol and cancer: epidemiology and biological mechanisms. Nutrients. 2021;13(9):3173.
24. Anderson BO, Berdzuli N, Ilbawi A, Kestel D, Kluge HP, Krech R, et al. Health and cancer risks associated with low levels of alcohol consumption. Lancet Public Health. 2023;8(1):e6–7.
25. Cook PJ, Skog O-J. Alcool, alcoolisme, aloolisation. Alcohol Health Res World. 1995;19(1):30.
26. Carvalho AF, Heilig M, Perez A, Probst C, Rehm J. Alcohol use disorders. Lancet. 2019;394(10200):781–92.
27. Ledermann S. Alcool, alcoolisme, alcoolisation: données scientifiques de caractère physiologique, économique et social. Presses universitaires de France; 1956.

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