A Comparison of Liver Disease Mortality with HIV and Overdose Mortality Among Georgia Prisoners and Releases: A 2-Decade Cohort Study of Prisoners Incarcerated in 1991

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Drug use, incarceration, and mortality are intertwined: the use of illicit drugs can result in both incarceration and premature death. A 2010 international meta-analysis of prisoners’ survival after their release into the community emphasized mortality from overdose in the 2 weeks following discharge, possibly attributable to loss of opiate tolerance after forced sobriety in prison, but a more recent publication illustrates how this pattern may vary among subpopulations.

Long-term consequences of injection drug use include hepatitis C and HIV infection. In the United States, sexual exposure is the most common mode of HIV transmission, but the hepatitis C epidemic is mainly driven by the injection of drugs, even if the drug use is not sustained. HIV prevalence is 3 times as common among prisoners as among the general population, but hepatitis C prevalence is 13 times as high. Sequelae that could lead to death from hepatitis C typically occur 2 to 4 decades after injection drug use was initiated. Little is known about the long-term survival of inmates, particularly in the southeastern United States, where historical and recent patterns of drug use may differ from those in other regions.

In contrast with other studies that have examined cohorts of released inmates, we sought to assess long-term prisoner survival by retrospectively following a cohort composed of a cross section of all imprisoned persons in the state of Georgia on a single day in 1991. In a previous study, we did not observe significantly higher mortality among members of this cohort immediately after release from prison than in the subsequent postrelease period. Multiple sources suggest that heroin use is less common in Georgia than in other states. Between 2002 and 2012, consistently fewer than 6.5% of men jailed in Atlanta, the capital and largest city in Georgia, had evidence of heroin in their urine samples. The prevalence of opiate use in Atlanta was among the lowest for any city studied in the past decade by the Office of the National Drug Control Policy. In particular, heroin use was lower than in Washington State, site of a previous study of former inmate mortality. According to the Treatment Episode Data Set—Admissions for 1992 to 2010 from the Substance Abuse and Mental Health Services Administration, heroin addiction accounted for only 1.6% of admissions for drug rehabilitation in Georgia, but 9.7% in Washington State and 14.2% nationally.

In assessment of risk for hepatitis C, needle use—whether for heroin, cocaine, or another drug—is more important than what is injected. Needle use in Georgia is not uncommon. According to population-wide National Survey on Drug Use and Health data for 2002 to 2009, 1.1% of Georgians have ever used a needle to inject drugs, including cocaine—a moderate rate compared with the frequency in Washington State, where lifetime prevalence is 2.7%, and nationally, where prevalence is 1.6%. State-level data on needle use prior to 2002 are not publicly available from the Substance Abuse and Mental Health Services Administration.

The prevalence of hepatitis C in the Georgia general population is moderately high, especially in Atlanta. At Grady Memorial Hospital, the safety net charity hospital for Atlanta, the prevalence of hepatitis C among ambulatory primary care patients is 7%. A liver clinic established at this hospital saw 807 unique patients in its first 5 years of existence and was still receiving 60 new patient referrals each month through 2010. Three quarters of the patients were African American, and most patients were born between 1945 and

Objectives. We investigated whether eventual causes of death among a cohort of inmates imprisoned in the southeastern United States differed from those in previous prisoner studies.

Methods. We matched 23,510 prisoners in Georgia, a state with historically low levels of heroin consumption but moderate amounts of injection drug use, who were incarcerated on June 30, 1991, to death registries through 2010. Main exposure was 4-year time intervals over 2 decades of observation; main outcome was mortality from liver disease, HIV, and overdose.

Results. Although the HIV-related mortality rate exceeded that from liver-related conditions before 2003, liver disease subsequently surpassed HIV as a cause of death. Among 3863 deaths, 22 (0.6%) occurred within 2 weeks after release from prison. Of these, only 2 were caused by accidental poisoning (likely drug overdose). Cardiovascular disease and cancer were the most frequent causes of death in this aging cohort.

1965; 64% were former drug users, and only 4% were currently using.14 High prevalence of hepatitis C in this baby boomer birth cohort probably reflects time-limited parental drug use decades ago, perhaps as early as the Vietnam war era.15 Despite relatively low levels of heroin use in the state, we hypothesized that the prevalence of hepatitis C would be high among inmates in the Georgia prison system who were born between 1945 and 1965.

We sought to describe the leading causes of death over 2 decades in a large cohort of all Georgians who were in state prisons on June 30, 1991, and to evaluate whether the immediate mortality following prison discharge was low, because Georgia is a state with low heroin use. In light of the moderate background rates of injection drug use in Georgia, we hypothesized that mortality from liver-related causes would rise over time as the cohort aged. Our first aim was to rank the causes of death and categorize which deaths occurred in prison, immediately after release, and subsequently. Second, we compared deaths from liver disease to those from HIV in 4-year intervals between 1991 and 2010.

METHODS

In our previous study, we assembled a cohort of 23,510 inmates residing in any prison facility under the jurisdiction of the Georgia Department of Corrections on June 30, 1991, and followed it through 2006.7 This represented a cross-section of everyone inside the prison (sometimes known as the stock population). We linked identities of all 23,510 prisoners to records in the National Death Index available through 2006.7

Data

In the study reported here, we assessed mortality outcomes. We obtained inmate administrative records from the Georgia Department of Corrections Planning and Strategic Management Section and abstracted demographic data, functional status, psychiatric classification, substance abuse record, complete incarceration history, and the result of every HIV test performed in prison. Although the Centers for Disease Control and Prevention and the World Health Organization recommend voluntary HIV screening for inmates, it has been mandatory upon each admission to the state prison system in Georgia since 1988.4,16-19

Subsequent to the first study, we obtained additional data on reincarcerations from the Georgia Department of Corrections through 2010. As with the previous study, we matched the identities of the members of the cohort first with the Georgia Death Registry, a listing of all deaths that is maintained by the Georgia Department of Public Health, and then, for those not appearing in the Georgia Death Registry, the National Death Index, a collection of death registries from all US states. The linkage to the death registries for the previous study provided data through December 31, 2006, and the more recent linkage provided data on deaths through December 31, 2010. Mortality data included the date of death and the International Classification of Diseases, Ninth (ICD-9) or 10th (ICD-10) Revision codes for the primary and secondary causes of death. We stripped personal identifiers after linkage and prior to any analyses.

First, we obtained frequency distributions of inmate characteristics: age in 1991, race/ethnicity, gender, educational level, preprison employment status, HIV status, incarceration history, and vital status. Next, we examined the primary cause of death in each of 4 periods—inside prison (either during the index incarceration or subsequent reincarceration), in the first 2 weeks after a release, in the second 2 weeks after a release, and more than 1 month after a release. We calculated the number of person-years of follow-up for the total cohort, as well as for each period of observation inside and outside prison.

Statistical Analysis

For analytic purposes, we defined liver disease–related deaths as any death from liver cirrhosis, viral hepatitis, hepatocellular carcinoma, alcohol-related liver disease, or “other, unknown, or unspecified” liver-associated conditions, because liver disease may have multiple, possibly overlapping etiologies. We categorized deaths in HIV-infected persons that occurred in the setting of other infectious or parasitic diseases and deaths coded as “HIV resulting in malignant neoplasms” as HIV infection–related deaths. The category cancer excluded liver cancer and malignant neoplasms resulting from HIV infection. We combined deaths coded as ill-defined or unknown into 1 category. The category of all other causes comprised deaths from any condition not in the top 10 categories. ICD-9 and ICD-10 codes used for each cause-of-death grouping are listed in Appendix A, Table A (available as a supplement to this article at http://www.ajph.org).

We then enumerated HIV infection–related and liver disease–related deaths in each of 5 periods of 4 years, from June 30, 1991, to December 31, 2010, as well as the number of person-years contributed by the cohort for each interval (Appendix A, Table B, available as a supplement to this article at http://www.ajph.org). For this final analysis, the category of other decedents comprised inmates who died from any cause other than HIV or a liver-related condition.

For each period, we first calculated the odds of dying from HIV infection–related conditions versus dying from all other causes (including liver disease–related conditions). Next, we obtained crude mortality odds ratios and their 95% confidence intervals, with the 2007 to 2010 period as the referent, because our previous study indicated that HIV-related deaths were decreasing over time.7 For ease of interpretation, we performed the same calculation for liver disease–related deaths, with 1991 to 1994 as the referent period, because we hypothesized that liver deaths were rising. Finally, we derived adjusted mortality odds ratios with their 95% confidence intervals by controlling for age in 1991, race/ethnicity, and gender. We used SAS version 9.3 (SAS Institute Inc, Cary, NC) for all analyses.

RESULTS

Demographic characteristics of the study cohort are described in Table 1. Among our study population, 16,113 persons (69%) were born between 1945 and 1965. Only 10% of our study population remained continuously incarcerated over the observation period. The cohort contributed 424,524 person-years in total, with 158,481 person-years corresponding to time spent inside prison (Table 2).

In the cohort, 3,863 persons (16%) died between 1991 and 2010. Since 2006, the year of the last identity match with the National Death Index, we noted 1213 additional deaths...
The Georgia Death Registry identified 77% of all decedents; linkage with the National Death Index identified the remaining deaths. Table 2 summarizes the 10 leading causes of death, overall and stratified by whether individuals died inside prison or after release. The majority of deaths (83.0%) occurred in the community rather than the prison setting. The leading causes of death in this cohort were similar to those commonly observed in the general population: cancer and cardiovascular diseases. These were followed by HIV infection (13%), homicide (7%), and liver disease (6%). Of 237 liver disease–related deaths, 85 were from liver cirrhosis, 65 from viral hepatitis, 36 from liver cancer, 9 from alcohol-related liver disease (not including cirrhosis), and 42 from other, unknown, or unspecified conditions.

Two of the 3863 deaths observed (<1%) were caused by accidental poisoning in the immediate 14 days after release, yielding a rate ratio of 2.91 relative to later deaths from the same cause ($P= .19$). A comparison of the rate of death from overdose in the 30-day post-release period (5/3248 person-years) and after 30 days reached a commonly recognized level of statistical significance (rate ratio = 3.46; $P= .02$). However, the rate ratios for other intervals (e.g., before and after 3, 6, 7, and 8 weeks and beyond) were not significant. Of the 122 accidental poisoning deaths observed, 117 (98%) occurred more than 1 month after release from the Georgia prison system (Appendix A, Table D, available as a supplement to this article at http://www.ajph.org).

HIV infection–related deaths and liver disease–related deaths identified between 1991 and 2010 are summarized in Table 3, and the rates per 100 000 are graphed in Figure 1. Over time, the proportions of deaths related to HIV infection decreased and those from liver disease increased. After adjustment for age at study start, race/ethnicity, and gender, with the 2007 to 2010 period as the referent, the odds of dying from HIV infection–related conditions versus all other causes decreased.

By contrast, the adjusted mortality odds ratios from the early years of the study to recent years comparing liver disease–related deaths with all other causes became larger, suggesting that the odds of dying from liver disease–related causes increased significantly over time. The odds of dying from liver disease–related conditions between 2007 to 2010 and 2003 to 2006 were

| TABLE 1—Selected Demographic Characteristics of Cohort of Inmates Incarcerated in Georgia State Prisons on June 30, 1991, Followed Until December 31, 2010 |
| Characteristic | No. (%)
| --- | ---
| **Age at baseline, a, y** |  |
| ≤ 19 | 453 (2)
| 20–29 | 9 753 (41)
| 26–46 (1945–1965 birth cohort) | 16 113 (69)
| 30–39 | 8 665 (37)
| 40–49 | 3 407 (15)
| ≥ 50 | 1 232 (5)
| **Race/ethnicity** |  |
| Non-Hispanic African American | 15 493 (66)
| Non-Hispanic White | 7 746 (33)
| Otherb | 271 (1)
| **Gender** |  |
| Male | 22 208 (94)
| Female | 1 302 (6)
| **Education level at baseline** |  |
| < high school | 13 581 (58)
| High school or GED | 6 648 (28)
| Some college, associate degree, technical school | 1 762 (7)
| College, postgraduate, or professional school | 642 (3)
| Unknown | 877 (4)
| **Employment status before incarceration** |  |
| Employed full time or part time | 8 471 (36)
| Unemployed < 6 mo | 4 304 (18)
| Unemployed ≥ 6 mo | 7 136 (31)
| Otherc | 3 599 (15)
| **HIV status during study periodd** |  |
| Ever positive | 1 104 (5)
| Negative or unknowne | 22 406 (95)
| **Releases during study period, d no.** |  |
| 0 | 2 291 (10)
| 1 | 11 040 (47)
| 2 | 5 081 (22)
| 3 | 2 809 (12)
| 4 | 1 349 (6)
| ≥ 5 | 940 (4)
| **Deceased at study end** |  |
| Yes | 3 863 (16)
| No | 19 647 (84)

Note. GED = general educational development. The sample size was n = 23 510.

aMean (SD) = 32 (9); median = 31; range = 13–91.
bHispanics, n = 218; unknown, n = 53.
cIncapable of work, n = 908; capable nonstudents but never worked, n = 481; students, n = 49; unknown, n = 2161.
dData available through September 2, 2010.
eHIV negative, n = 21 292; indeterminate result, n = 15; unknown, n = 1099.
almost twice the liver-related mortality odds during 1991 to 1994, after adjustment for inmates’ demographic characteristics. In 2003, mortality from liver disease first exceeded that from HIV (Figure 1).

**DISCUSSION**

In our previously assembled cohort of persons imprisoned in Georgia, liver disease first surpassed HIV as a cause of death in 2003, reminiscent of the way that the nationwide age-adjusted mortality rate of hepatitis C surpassed that of HIV by 2007.22 We showed that mortality from HIV declined as our cohort aged. Many of those infected with HIV died years ago, prior to the advent of highly active antiretroviral therapy. Future studies of cohorts assembled in the antiretroviral era may show an even lower contribution of AIDS to mortality.

Although our results clearly indicated that death from liver disease increased in this cohort, we were unable to discern how the relative contribution of alcohol use, chronic hepatitis B, and chronic hepatitis C affected liver disease–related mortality; many persons may have multiple factors that contribute to development of liver failure. Because the majority of the inmates were born between 1945 and 1965, the birth cohort with highest rates of hepatitis C,15 we expect that a large portion of the liver disease in our study population was attributable to the hepatitis C virus. Indeed, 79% of all liver-related deaths occurred among those born between 1945 and 1965. Although

### TABLE 2—Leading Causes of Death Among a Cohort of Inmates Incarcerated in Georgia State Prisons on June 30, 1991, Followed Until December 31, 2010

<table>
<thead>
<tr>
<th>Cause of Death</th>
<th>Total (n = 3863, Person-Years = 424,524), No. (%)</th>
<th>Inside Prison (n = 655, Person-Years = 158,481), No. (%)</th>
<th>≤ 14 Days After Any Release, a (n = 22, Person-Years = 1515), No. (%)</th>
<th>15–30 Days After Any Release, b (n = 18, Person-Years = 1733), No. (%)</th>
<th>&gt; 30 Days After Any Release, c (n = 3133, Person-Years = 262,795), No. (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cardiovascular diseases</td>
<td>877 (23)</td>
<td>148 (23)</td>
<td>1 (5)</td>
<td>3 (17)</td>
<td>718 (23)</td>
</tr>
<tr>
<td>Unknown or other</td>
<td>820 (21)</td>
<td>133 (20)</td>
<td>4 (18)</td>
<td>2 (11)</td>
<td>672 (21)</td>
</tr>
<tr>
<td>Cancer</td>
<td>611 (16)</td>
<td>143 (22)</td>
<td>1 (5)</td>
<td>2 (11)</td>
<td>459 (15)</td>
</tr>
<tr>
<td>HIV infection</td>
<td>499 (13)</td>
<td>136 (21)</td>
<td>3 (14)</td>
<td>0 (0)</td>
<td>353 (11)</td>
</tr>
<tr>
<td>Homicide</td>
<td>273 (7)</td>
<td>6 (1)</td>
<td>4 (18)</td>
<td>6 (32)</td>
<td>254 (8)</td>
</tr>
<tr>
<td>Liver disease</td>
<td>237 (6)</td>
<td>48 (7)</td>
<td>1 (5)</td>
<td>0 (0)</td>
<td>187 (6)</td>
</tr>
<tr>
<td>Transportation injuries</td>
<td>184 (5)</td>
<td>1 (0)</td>
<td>3 (14)</td>
<td>1 (6)</td>
<td>178 (6)</td>
</tr>
<tr>
<td>Chronic respiratory diseases</td>
<td>133 (3)</td>
<td>20 (3)</td>
<td>1 (5)</td>
<td>0 (0)</td>
<td>111 (3)</td>
</tr>
<tr>
<td>Accidental poisoning</td>
<td>123 (3)</td>
<td>1 (0)</td>
<td>2 (9)</td>
<td>3 (17)</td>
<td>117 (4)</td>
</tr>
<tr>
<td>Suicide</td>
<td>106 (3)</td>
<td>19 (3)</td>
<td>2 (9)</td>
<td>1 (6)</td>
<td>84 (3)</td>
</tr>
</tbody>
</table>

Note. Of 3208 deaths that occurred outside prison, the relative time between release and death could not be ascertained for 35 former inmates.

aIncludes 261 with lung cancer. Excludes 36 with liver cancer and 15 with malignant neoplasms resulting from HIV infection.
bIncludes 137 where HIV resulted in infectious or parasitic diseases, 15 where HIV resulted in malignant neoplasms, and 347 with other, unknown, or unspecified conditions.
cIncludes 65 with liver cirrhosis, 65 with viral hepatitis, 36 with liver cancer, 9 with alcohol-related liver disease (not including cirrhosis), and 42 with other, unknown, or unspecified conditions.
dIncludes 17 with chronic obstructive pulmonary disease.


<table>
<thead>
<tr>
<th>Time</th>
<th>HIV Infection–Related Deaths</th>
<th>Liver Disease–Related Deaths</th>
</tr>
</thead>
<tbody>
<tr>
<td>1991-1994</td>
<td>Crude MOR (95% CI)</td>
<td>Adjusted MOR (95% CI)</td>
</tr>
<tr>
<td>1995-1998</td>
<td>Crude MOR (95% CI)</td>
<td>Adjusted MOR (95% CI)</td>
</tr>
<tr>
<td>1999-2002</td>
<td>Crude MOR (95% CI)</td>
<td>Adjusted MOR (95% CI)</td>
</tr>
<tr>
<td>2003-2006</td>
<td>Crude MOR (95% CI)</td>
<td>Adjusted MOR (95% CI)</td>
</tr>
<tr>
<td>2007-2010</td>
<td>Crude MOR (95% CI)</td>
<td>Adjusted MOR (95% CI)</td>
</tr>
</tbody>
</table>

Note. CI = confidence interval; MOR = mortality odds ratio. Total deaths during study period, n = 3863.

aIncludes death from cardiovascular diseases, cancer (excluding liver cancer and malignant neoplasms resulting from HIV infection), homicide, transportation injuries, chronic respiratory diseases, accidental poisoning, suicide, and unknown or other causes.
bAdjusted for age at study start, race/ethnicity, and gender.
cThis epoch spans June 30, 1991, to December 31, 1994. All other epochs span January to December.
The rareness of overdose deaths may explain the relative safety of the postrelease period. Individuals who survive earlier episodes of transition to the community may be less likely to overdose in their later years. Our findings help justify screening for later sequelae of injection drug use, such as hepatitis C, among correctional populations and emphasize interventions to promote liver health, such as alcohol treatment and access to medications that can cure viral hepatitis.

**Limitations**

Our findings on overdose mortality within 14 and 30 days of release should be interpreted cautiously because of the small absolute number of deaths observed, but they have several implications. The degree to which immediate postrelease overdose mortality rates are elevated can vary over time and geography, according to evolving drug use patterns in the jurisdiction studied. Furthermore, rates of death observed may vary by methodology used and the analyses conducted, as reviewed by Kinner et al.24 Bird and Hutchinson,25 following Seaman et al.,26 described heightenened rates of drug-related deaths in the fortnight after release from prison. Our results, derived from different methodology, suggest that rates of overdose that are higher within 2 weeks than later may not be a universal phenomenon. Immediate drug-related deaths are common among those released to areas where heroin is plentiful.30,31 Heroin use was not highly prevalent in Georgia during the study period, although heroin and pharmaceutical opioid use may have risen since then. Our findings suggest that public health investments to address the needs of released inmates should be tailored to current local conditions, including drug use patterns. For example, where heroin use is prevalent, interventions to prevent deaths from overdose, such as the take-home naloxone program piloted in Scottish prisons,30,31 could be appropriate.

We matched identities from custody data and death registries with probabilistic algorithms that in rare instances misclassify a match or nonmatch. Deaths of individuals who entered other state prison systems, jails, or the Federal Bureau of Prisons after their Georgia incarceration were not captured, which may have caused us to miss some postrelease deaths in our cohort.

We obtained causes of mortality from death certificates of the prisoners and released inmates that were filled out by physicians or county coroners. Unlike many other states, Georgia does not mandate autopsy for deaths in custody. The cause of death might not have been recorded accurately, thereby introducing the potential for misclassification. The relative contributions of hepatitis B, hepatitis C, and alcoholism to the pathogenesis of liver disease in this cohort is unknown.

The percentage of deaths attributed to unknown disease (2%) was high, but perhaps predictable. For persons previously or currently involved in the criminal justice system (including under community supervision, i.e., probation and parole), the chief focus of a coroner may be to rule whether a person died from unnatural causes (necessitating a criminal investigation) or natural causes.

**Conclusions**

Despite the limitations involved in a retrospective study of mortality, we believe our results show that hepatitis C accounts for a rising proportion of deaths among persons who have been involved in the criminal justice system in Georgia; however, an examination of deaths among more recent cohorts of inmates would be required to confirm that this finding persists. Alcohol use may be contributing to
mortality, and substance abuse treatment is warranted, but this should be coupled with prevention and treatment of viral hepatitis. Nationally, a tsunami of cases of decompensated cirrhosis and hepatocellular cancer is predicted over the next few decades both outside and inside correctional facilities.8,32 Even states such as Georgia, without a high current prevalence of injection heroin use, could face this epidemic. However, antiviral therapy for hepatitis C has rapidly improved and could mitigate the impact of previous injection drug use by the baby boom generation.

Although prison-based interventions for tobacco cessation beyond in-facility smoking bans are warranted to lower mortality from the leading causes (heart disease and cancer),33 attention should also be directed to conditions that are now curable, such as hepatitis C. Oral regimens of direct-acting antivirals for hepatitis C offer a nearly universal cure with few side effects.34–37 Partnerships between the prison system and community health systems could be developed to help coordinate the treatment of individuals leaving prison. Other issues, such as high homicide rates in the impoverished communities to which released inmates return, merit attention. In our cohort, deaths from homicide exceeded those from liver disease for the first decade after initial release (Table 3). How to diminish homicides among released inmates needs further study.

Complementing the advent of improved therapy for hepatitis C, the Centers for Disease Control and Prevention revised its hepatitis C screening guidelines in 2012, recommending that all persons born between 1945 and 1965 receive a hepatitis C antibody test.38 A simulated economic model showed that in this birth cohort, screening followed by treatment is cost effective.39 The US Preventive Services Task Force recommends voluntary hepatitis C screening for persons who have been incarcerated.40 A recent study demonstrated that use of direct-acting agents in prison populations is cost effective from a societal standpoint.41

Combining enhanced identification of undiagnosed hepatitis C in this high-prevalence population with thoughtful medical management can significantly temper the expected surge in cases of hepatitis C–related liver disease and death. Our study suggests that because current and former prisoners live long enough to experience sequelae of liver disease, they need better long-term treatments; many persons who have been prisoners will be appropriate candidates for efficacious and cost-effective antiviral treatment.37

About the Authors
At the time of the study, Anne C. Spaulding, Lauren C. Messina, and Maria Zlotorzynska were with and Akshay Sharma was a doctoral student in the Department of Epidemiology, Rollins School of Public Health, and Lesley Miller was with the Division of General Medicine, School of Medicine, Emory University, Atlanta, GA. Ingrid A. Binswanger is with the University of Colorado School of Medicine, Aurora.

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Contributors
A. C. Spaulding led the study design, article preparation, and editing. A. Sharma led the data analysis and helped draft the article. L. C. Messina and M. Zlotorzynska helped analyze and interpret the data. L. Miller and I. A. Binswanger helped design the study and contextualize the findings. All authors revised the article.

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Ethical approval was granted to this no-contact study by the Emory University institutional review board and the Georgia Department of Public Health.

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