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# Testing trends and co-testing patterns for HIV, hepatitis C and sexually transmitted infections (STIs) in Emergency departments

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A B S T R A C T

*Background:* Many underserved populations use Emergency Department (EDs) as primary sources of care, representing an important opportunity to provide infectious disease testing and linkage to care. We explored national ED testing trends and co-testing patterns for HIV, hepatitis C, and sexually transmitted infections (STIs).
*Methods:* We used 2010–2019 Healthcare Cost and Utilization Project, Nationwide Emergency Department Sample data to estimate ED visit testing rates for HIV, hepatitis C, chlamydia, gonorrhea, and syphilis infections, identified by Current Procedural Terminology codes. Trends and co-testing (visit with tests for > 1 infection) patterns were analyzed by sociodemographic, hospital, and visit characteristics. Trends were evaluated as the average annual percentage change (AAPC) using the Joinpoint Regression.
*Results:* During 2010–2019, testing events per 1000 visits (AAPCs) increased for HIV from 1.3 to 4.2 (16.3 %), hepatitis C from 0.4 to 2.2 (25.1 %), chlamydia from 9.1 to 16.0 (6.6 %), gonorrhea from 8.4 to 15.7 (7.4 %), and syphilis from 0.7 to 2.0 (12.9 %). Rate increases varied by several characteristics across infections. The largest AAPC increases were among visits by groups with lower base rate testing in 2010, including persons aged ≥ 65 years (HIV: 36.4 %), with Medicaid (HIV: 43.8 %), in the lowest income quintile (hepatitis C: 36.9 %), living in the West (syphilis: 49.4 %) and with non-emergency diagnoses (hepatitis C: 44.1 %). Co-testing increased significantly for all infections except hepatitis C.
*Conclusions:* HIV, hepatitis C, and STI testing increased in EDs during 2010–2019; however, co-testing patterns were inconsistent. Co-testing may improve diagnosis and linkage to care, especially in areas experiencing higher rates of infection.

## 1. Introduction

HIV, hepatitis C, and sexually transmitted infections (STIs) including syphilis, chlamydia, and gonorrhea continue to be major public health concerns in the United States. Over 1.2 million people were living with HIV in the United States during 2019; an estimated 2.2 million people had current hepatitis C infection during January 2017-March 2020; and there were 53,567 cases of primary and secondary (P&S) syphilis, 1.6 million cases of chlamydia, and 710,151 cases of gonorrhea reported in 2021. (Hofmeister et al., 2019; CDC HIV Prevelance and Incidence, 2019; CDC Sexually Transmitted Disease Surveillance, 2021) These infections can be asymptomatic with no or mild symptoms for several weeks or even years. (World Health Organization 2024) Therefore, many people are unaware of their infection. An estimated 13 % of people with HIV and 45 % of people with hepatitis C in the United States are unaware of their infection, and a significant proportion of individuals are unaware of their syphilis, chlamydia, and gonorrhea infections. (Li et al., 2019; Cates Jr et al.,1999; Kim et al., 2019) This lack of awareness can have serious consequences for individuals and communities because these infections can lead to long-term serious health problems including cancer and death if left untreated, (Chhatwal et al., 2016; Dwyre et al., 2011; Kumar et al., 2021) as well as further transmission throughout communities. For example, approximately 38 % of new HIV infections are from persons who do not know they have HIV infection. (Li et al.,

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2019) Screening (i.e. testing an asymptomatic person based on patient characteristics) and testing (i.e. based on reported factors that may increase risk of infection) are critical for diagnosing individuals and providing them with appropriate treatment. Early diagnosis and treatment can prevent development of long-term complications, mitigate the spread of these infections, and improve public health outcomes.

Emergency Departments (EDs) play an important role in diagnosis and linkage to care for these infections. (O'Connell et al., 2016; Henriquez-Camacho et al., 2017; Stanford et al., 2021; Goyal et al., 2016) EDs are often safety net providers for underserved populations and a patient's first point of contact with the health care system, and they can be particularly important for individuals who lack access to primary care or other testing services. (CDC. FastStats - ED Visits, 2023; Weiss et al., 2011) Therefore, EDs provide a unique opportunity to screen individuals experiencing increased risk of infection who may not be reached through other care systems, and can support treatment as appropriate. (Pearson et al., 2023) Universal opt-out screening in EDs for HIV and hepatitis C has resulted in identification of new cases and linkage to care (O'Connell et al., 2016) and screening for syphilis, chlamydia, and gonorrhea has resulted in similar findings. (Stanford et al., 2021; Goyal et al., 2016) However, limited information exists on population-level testing trends in EDs across the United States with previous studies reporting variable ED testing rates with most focused on single or multiple regional EDs or a specific population. (O'Connell et al., 2016; Henriquez-Camacho et al., 2017; Galbraith et al., 2015; Barnes et al., 2019; Haukoos et al., 2021; Bi et al., 2022) Another important indication for testing in EDs is the capacity for co-testing; co-testing refers to simultaneous testing for multiple infections during a single visit, as opposed to testing for each infection separately. Since there is overlap in risk factors (e.g., injection drug use, sexual risk behaviors) and screening recommendations for HIV, hepatitis C, and STIs, co-testing in EDs is warranted; yet little is known about national level co-testing patterns in EDs. (CDC HIV Screening and Testing, 2024; CDC Hepatitis C guidelines, 2024) Understanding national-level ED testing trends and co-testing patterns is important to guide quality improvement efforts for testing and linkage-to-care services, especially for populations disproportionately affected and with less access to care. The objective of this study is to assess national ED testing trends and co-testing patterns for HIV, hepatitis C, syphilis, chlamydia, and gonorrhea overall, and by sociodemographic, hospital, and visit characteristics in the United States during 2010–2019.

## 2. Methods

### 2.1. Study design and data source

The Healthcare Cost and Utilization Project (HCUP) Nationwide Emergency Department Sample (NEDS) database for 2010–2019 was analyzed to investigate testing trends and co-testing patterns in EDs. The NEDS is the largest all-payer ED database in the United States, sponsored by the Agency for Healthcare Research and Quality. (AHRQ, 2019) The NEDS database was constructed using hospital-owned ED visit data from 28 to 41 geographically diverse states including over 28 million ED visits each year. (AHRQ. THE HCUP NATIONWIDE EMERGENCY DEPARTMENT SAMPLE NEDS, 2019) The data are visit level and contain patient-level information on demographic characteristics, primary payor status, Current Procedural Terminology (CPT) codes, International Classification of Diseases-Clinical Modification (ICD-CM) diagnosis and procedure codes, and admitting hospital information. For each visit, the NEDS database contains up to 15 CPT codes, 30 diagnosis codes, and 15 procedure codes. Data on hospital information and location were obtained from the American Hospital Association Survey. NEDS databases are de-identified under Health Insurance Portability and Accountability Act (HIPAA) standards; therefore, this analysis did not constitute human research and IRB approval was not required. Patients with missing age, discharges against medical advice, and cases of in-hospital mortality were excluded from the dataset.

### 2.2. Measures

The primary outcomes of interest, ED testing and co-testing events for the selected infections (HIV, hepatitis C, and STIs) were identified using a list of CPT codes from the American Medical Association and Health Resources and Services Administration (Appendix Table 1-5). For each infection, an ED testing event was defined as an ED visit with any test-related CPT code (e.g., antibody, antigen, nucleic acid) in any of the 15 listed CPT codes during the ED visit. A co-testing event was defined as an ED visit with a test-related CPT code for more than one selected infection (e.g., HIV and $>1$ other selected infection) in any of the 15 listed CPT codes during the ED visit. To identify each potential combination of tests, we iteratively designated tests for each selected infection as the 'primary' test, defined as having a test CPT code for that infection among any of the 15 potential CPT codes for that visit. Any other test CPT code(s) were considered the 'secondary' test(s) during that visit (e.g., any HIV test CPT code as the 'primary' test and any other infection test CPT code(s) as the 'secondary' test(s)). This designation of the 'primary' test was not influenced by the test's position within the list of potential CPT codes and does not imply the relative importance of the tests. Sociodemographic characteristics included age (<15, 15–24, 25–34, 35–54, 55–64, ≥65 years), sex (male, female), payor (Medicare, Medicaid, commercial, uninsured [Self-Pay/No Charge], other), median household income percentile (0-25th, 26-50th, 51-75th, 76-100th) for the patient's ZIP code, and urbanicity (metropolitan [city area with ≥ 50,000 people], micropolitan [area with ≥ 10,000 and ≤ 50,000 people], not metropolitan or micropolitan). Other payor types included Worker's Compensation, Civilian Health and Medical Program of the Uniformed Services (CHAMPUS), Civilian Health and Medical Program of the Department of Veterans Affairs (CHAMPVA), Title V, and other government programs. Hospital-level information included hospital type (trauma versus non-trauma) and Census region (Northeast, Midwest, South, West). Visit characteristics included weekday of visit (weekend, weekday), and medical urgency (emergent, preventable, and non-emergent), which was based on the previously validated NYU-ED Billing Algorithm developed by the New York University Center for Health and Public Service Research categorizing the primary ICD-CM diagnosis and procedures codes during the visit. (NYU Wagner 2023).

### 2.3. Statistical Analysis

Nationally representative estimates of ED testing events for each infection were calculated using NEDS survey sampling design and weight variables. ED testing events were calculated each year from 2010 through 2019 as the testing event rate per 1,000 ED visits. ED co-testing patterns were calculated, considering each infection as the primary test, as the proportion of testing events with co-testing for the secondary infection(s). Testing and co-testing trends were evaluated as the average annual percentage change (AAPC) using the Joinpoint Regression Program (IV. 4.8.0.1) (National Cancer Institute). (Joinpoint Regression Program, 2023) For each infection, ED testing events were also assessed by sociodemographic characteristics, hospital information, and visit characteristics. Because of substantial overlap (>90 %) in testing events for chlamydia and gonorrhea, co-testing event trends were analyzed for the combined chlamydia / gonorrhea testing event. (Pinto et al., 2021) All statistical analyses were performed using R studio, and a two-sided test with $P$-value $< 0.05$ was considered statistically significant.

## 3. Results

The analysis included 302,574,684 ED visits (unweighted) from January 1, 2010 to December 31, 2019, with average age 31 years and 53 % of visits among males. A total of 15,731,388 (52.0 per 1,000) visits involved at least one test for HIV, hepatitis C, or an STI. ED testing event

**Table 1**
Emergency department (ED) visits with HIV, hepatitis C and STI testing events, by select characteristics, United States, HCUP-NEDS 2010—2019.

| | HIV | | | HCV | | | Syphilis | | | Chlamydia | | | Gonorrhea | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 2010 (per 1000 visits) | 2019 (per 1000 visits) | AAPC | 2010 (per 1000 visits) | 2019 (per 1000 visits) | AAPC | 2010 (per 1000 visits) | 2019 (per 1000 visits) | AAPC | 2010 (per 1000 visits) | 2019 (per 1000 visits) | AAPC | 2010 (per 1000 visits) | 2019 (per 1000 visits) | AAPC |
| Overall | 1.2 | 3.8 | 16.3 % | 0.4 | 2.2 | 25.1 % | 0.7 | 2.0 | 12.9 % | 9.2 | 16.0 | 6.6 % | 8.9 | 15.7 | 7.4 % |
| Age group | | | | | | | | | | | | | | | |
| <15 | 0.1 | 0.4 | 18.0 % | 0.1 | 0.2 | 18.7 % | 0.1 | 0.3 | 13.5 % | 0.6 | 1.3 | 10.6 % | 0.5 | 1.2 | 12.6 % |
| 15–24 | 2.1 | 7.0 | 16.4 % | 0.5 | 2.2 | 21.8 % | 1.5 | 4.1 | 13.7 % | 25.0 | 44.9 | 6.8 % | 23.1 | 43.9 | 7.6 % |
| 25–34 | 2.4 | 7.5 | 15.3 % | 0.8 | 3.2 | 21.1 % | 1.2 | 3.6 | 14.5 % | 17.6 | 35.7 | 8.4 % | 16.2 | 35.0 | 9.3 % |
| 35–44 | 1.8 | 5.8 | 16.7 % | 0.6 | 2.5 | 23.0 % | 0.8 | 2.3 | 13.3 % | 8.1 | 19.0 | 10.1 % | 7.5 | 18.5 | 10.9 % |
| 45–54 | 1.3 | 4.5 | 19.5 % | 0.5 | 2.5 | 27.0 % | 0.6 | 1.5 | 11.8 % | 3.2 | 7.7 | 10.3 % | 3.0 | 7.6 | 11.3 % |
| 55–64 | 0.8 | 3.7 | 23.9 % | 0.4 | 3.8 | 36.9 % | 0.5 | 1.3 | 14.6 % | 1.0 | 3.2 | 13.4 % | 0.9 | 3.1 | 14.8 % |
| 65 | 0.2 | 1.7 | 36.4 % | 0.1 | 2.1 | 36.7 % | 0.3 | 1.0 | 22.5 % | 0.2 | 0.7 | 13.3 % | 0.2 | 0.7 | 15.5 % |
| Sex | | | | | | | | | | | | | | | |
| Male | 1.2 | 4.2 | 17.5 % | 0.4 | 2.2 | 26.6 % | 0.8 | 2.0 | 12.4 % | 2.7 | 10.0 | 15.7 % | 2.6 | 9.9 | 16.5 % |
| Female | 1.4 | 4.3 | 15.5 % | 0.5 | 2.3 | 24.1 % | 0.7 | 2.0 | 13.4 % | 14.2 | 20.9 | 4.6 % | 13.0 | 20.3 | 5.4 % |
| Payor | | | | | | | | | | | | | | | |
| Medicare | 0.2 | 2.0 | 34.6 % | 0.1 | 2.2 | 41.2 % | 0.4 | 1.2 | 19.1 % | 1.6 | 2.9 | 6.1 % | 1.5 | 2.8 | 6.9 % |
| Medicaid | 0.6 | 4.3 | 43.8 % | 0.2 | 2.0 | 42.4 % | 0.6 | 2.6 | 15.3 % | 12.6 | 21.1 | 7.5 % | 11.6 | 20.7 | 8.2 % |
| Commercial | 1.3 | 3.2 | 12.8 % | 0.3 | 1.8 | 26.2 % | 0.7 | 1.4 | 9.5 % | 7.1 | 13.3 | 7.4 % | 6.6 | 13.0 | 8.1 % |
| Uninsured | 2.3 | 7.3 | 19.8 % | 0.3 | 1.9 | 34.0 % | 1.2 | 2.9 | 12.2 % | 14.0 | 29.8 | 9.1 % | 12.8 | 29.2 | 10.2 % |
| Others | 4.1 | 11.4 | 15.8 % | 3.6 | 8.9 | 14.1 % | 0.9 | 2.8 | 18.0 % | 6.9 | 11.8 | 10.3 % | 6.4 | 11.5 | 11.7 % |
| Household Income | | | | | | | | | | | | | | | |
| 0–25 | 1.9 | 5.2 | 15.2 % | 0.3 | 2.5 | 37.0 % | 0.9 | 2.6 | 13.9 % | 11.6 | 20.4 | 6.8 % | 10.7 | 19.7 | 7.5 % |
| 25–50 | 1.3 | 3.5 | 15.7 % | 0.4 | 1.9 | 23.3 % | 0.7 | 1.8 | 13.4 % | 8.9 | 16.3 | 7.1 % | 8.1 | 15.9 | 8.0 % |
| 50–75 | 0.8 | 3.3 | 20.7 % | 0.4 | 2.0 | 24.5 % | 0.6 | 1.4 | 12.4 % | 8.2 | 11.3 | 6.0 % | 7.7 | 11.3 | 6.7 % |
| 75–100 | 0.8 | 2.2 | 21.8 % | 0.7 | 1.3 | 16.5 % | 0.6 | 1.0 | 14.0 % | 5.9 | 6.3 | 6.3 % | 5.3 | 6.2 | 7.5 % |
| Urbanicity | | | | | | | | | | | | | | | |
| Metropolitan | 1.5 | 4.7 | 16.1 % | 0.4 | 2.5 | 27.3 % | 0.8 | 2.2 | 13.3 % | 10.5 | 17.3 | 5.9 % | 9.7 | 17.0 | 6.7 % |
| Micropolitan | 0.6 | 2.1 | 22.7 % | 0.4 | 1.2 | 13.8 % | 0.5 | 1.0 | 12.2 % | 4.3 | 11.8 | 12.5 % | 3.5 | 11.3 | 14.8 % |
| Not Metro or Micro | 0.6 | 1.8 | 14.8 % | 0.4 | 1.2 | 15.5 % | 0.6 | 0.9 | 8.5 % | 3.3 | 7.7 | 10.0 % | 3.1 | 7.3 | 10.5 % |
| Census region | | | | | | | | | | | | | | | |
| Northeast | 5.0 | 7.8 | 7.6 % | 1.3 | 5.6 | 20.4 % | 1.4 | 5.5 | 6.6 % | 11.4 | 18.5 | 6.2 % | 10.5 | 17.6 | 7.0 % |
| Midwest | 0.3 | 1.9 | 48.5 % | 0.2 | 1.0 | 26.3 % | 0.3 | 1.5 | 28.7 % | 7.9 | 18.8 | 12.1 % | 7.5 | 18.7 | 13.3 % |
| South | 0.5 | 4.6 | 36.1 % | 0.3 | 1.9 | 39.4 % | 0.7 | 1.9 | 13.4 % | 11.3 | 17.1 | 5.6 % | 10.5 | 16.9 | 6.5 % |
| West | 0.3 | 2.8 | 49.3 % | 0.2 | 1.4 | 43.3 % | 0.2 | 1.8 | 41.8 % | 3.4 | 8.1 | 11.8 % | 2.6 | 7.7 | 15.2 % |
| Days of ED visit | | | | | | | | | | | | | | | |
| Weekdays | 1.5 | 4.4 | 14.8 % | 0.4 | 2.3 | 25.5 % | 0.8 | 2.1 | 12.6 % | 9.5 | 16.3 | 6.3 % | 8.8 | 15.9 | 7.1 % |
| Weekends | 0.8 | 3.9 | 23.3 % | 0.4 | 2.0 | 24.8 % | 0.6 | 1.8 | 14.3 % | 8.1 | 15.4 | 7.5 % | 7.4 | 15.0 | 8.4 % |
| ED visit type | | | | | | | | | | | | | | | |
| Emergent | 1.3 | 4.6 | 17.6 % | 0.6 | 2.6 | 22.0 % | 0.7 | 2.0 | 14.1 % | 7.4 | 14.0 | 7.5 % | 6.8 | 13.7 | 8.4 % |
| Non-Emergent | 1.5 | 3.7 | 13.5 % | 0.2 | 1.6 | 44.1 % | 1.0 | 2.2 | 11.3 % | 15.4 | 25.3 | 5.8 % | 14.3 | 24.7 | 6.5 % |
| Preventable | 0.8 | 2.0 | 13.4 % | 0.1 | 1.0 | 41.4 % | 0.4 | 0.8 | 9.6 % | 3.0 | 6.1 | 8.5 % | 2.7 | 6.0 | 9.5 % |
| Hospital type | | | | | | | | | | | | | | | |
| Trauma | 0.8 | 3.5 | 14.6 % | 0.4 | 1.9 | 28.4 % | 0.7 | 1.9 | 15.7 % | 7.7 | 16.0 | 3.8 % | 7.1 | 15.8 | 4.6 % |
| Non-trauma | 2.1 | 5.1 | 26.2 % | 0.5 | 2.7 | 21.3 % | 0.8 | 2.1 | 13.4 % | 11.7 | 16.0 | 9.3 % | 10.8 | 15.6 | 10.6 % |

AAPC: Average Annual Percentage change over 2010–2019 period. Household Income is based on the quartile classification of the estimated median household income of residents in the patient's ZIP Code.

rates varied by sociodemographic, hospital, and visit characteristics across infection (Table 1). In 2010, the highest ED testing event rates by sociodemographic characteristic were among visits by persons aged 25–34 years for HIV (2.4) and hepatitis C (0.8), and aged 15–24 years for syphilis (1.5), chlamydia (25.0) and gonorrhea (23.1); female patients for all infections, with the exception of syphilis for which there was no difference by sex; and persons in metropolitan areas for all infections. Testing event rates were highest among visits by persons with other payors for HIV (4.1) and hepatitis C (3.6), and uninsured for syphilis (1.2), chlamydia (14.0), and gonorrhea (12.8). Testing event rates were highest among visits by persons in ZIP codes with the 0-25th percentile median household income for all infections except hepatitis C, which was highest for the 75-100th percentile. By hospital characteristic, testing event rates were highest at non-trauma hospital EDs and hospitals in the Northeast for all infections. By visit characteristic, testing event rates were highest among visits during weekdays and with non-

**Table 2**
Trends of co-testing event combinations by infection type, NEDS 2010–2019.

| | **Secondary Tests** | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | HIV test | | | Hepatitis C test | | | Syphilis test | | | Chlamydia test | | | Gonorrhea test | | |
| **Primary test:** | 2010 | 2019 | AAPC | 2010 | 2019 | AAPC | 2010 | 2019 | AAPC | 2010 | 2019 | AAPC | 2010 | 2019 | AAPC |
| HIV test with any secondary test | | | | **12.3 %** | **29.9 %** | **16.2 %** | **6.7 %** | **21.6 %** | **17.6 %** | **11.4 %** | **22.0 %** | **8.6 %** | **10.5 %** | **21.8 %** | **11.3 %** |
| Hepatitis C test with any secondary test | **51.1 %** | **57.5 %** | 1.76 % | | | | **8.2 %** | **9.8 %** | **16.8 %** | **7.1 %** | **9.4 %** | **3.4 %** | **5.3 %** | **9.1 %** | **2.9 %** |
| Syphilis test with any secondary test | **18.8 %** | **52.5 %** | **13.8 %** | **5.6 %** | **12.4 %** | **12.4 %** | | | | **34.2 %** | **44.6 %** | **4.9 %** | **27.8 %** | **43.7 %** | **8.1 %** |
| Chlamydia test with any secondary test | **2.1 %** | **7.0 %** | **17.3 %** | **0.3 %** | **1.6 %** | **14.5 %** | **2.2 %** | **5.9 %** | **14.2 %** | | | | **91.7 %** | **95.3 %** | 0.5 % |
| Gonorrhea test with any secondary test | **2.1 %** | **7.2 %** | **20.9 %** | **0.3 %** | **1.6 %** | **28.0 %** | **1.6 %** | **5.9 %** | **17.3 %** | **99.3 %** | **98.1 %** | −0.1 % | | | |

AAPC: Average Annual Percentage change over 2010–2019 period; Bold AAPC value: significant for P-value < 0.05.

emergent diagnoses for all infections except hepatitis C.

In 2019, ED testing event rates were similarly highest for all infections among visits by females (except for syphilis), persons in ZIP codes with the 0-25th percentile median household income, in metropolitan areas, to non-trauma hospital EDs, and during weekdays. By age group, the highest testing event rates remained among visits by persons aged 15–24 years for syphilis, chlamydia and gonorrhea and 25–34 years for HIV, and among persons 55–64 years for hepatitis C. By payor, ED testing event rates remained highest among uninsured persons for syphilis, chlamydia and gonorrhea and persons with other payors for HIV and hepatitis C. Persons with commercial insurance had lower testing event rates than those uninsured or with Medicaid. The highest ED testing event rates remained among visits in the Northeast for HIV, hepatitis C, and syphilis, and shifted to the Midwest for chlamydia and gonorrhea. The highest testing event rates remained among non-emergent visits for syphilis, chlamydia and gonorrhea, but were highest among emergent type visits for HIV and hepatitis C.

ED testing event rates increased significantly for all infections ($P < 0.05$) from 2010 to 2019, with no significant decrease by any stratified group (Table 1). The annual ED testing event rate nearly tripled for HIV from 1.2 in 2010 to 3.8 in 2019 (AAPC 16.3 %) and nearly quintupled for hepatitis C from 0.4 to 2.2 (AAPC 25.1 %). From 2010 to 2019, ED testing event rates increased for syphilis from 0.7 to 2.0 (AAPC 12.9 %), chlamydia from 9.2 to 16.0 (AAPC 6.6 %), and gonorrhea from 8.9 to 15.7 (AAPC 7.4 %; Fig. 1). ED testing event trends varied by visit and hospital characteristics. For each infection, the highest AAPC increases were among visits by males for chlamydia (AAPC 15.7 %) and gonorrhea (AAPC 16.5 %); by persons in the West for HIV (AAPC 49.3 %) and syphilis (AAPC 41.8 %); and by persons with non-emergent visits for hepatitis C (AAPC 44.1 %). There were significant increases in ED testing event rates for each infection across all payor types, with the highest increases for HIV, hepatitis C, and syphilis among visits by persons with other payors, and for chlamydia and gonorrhea among uninsured (Fig. 2).

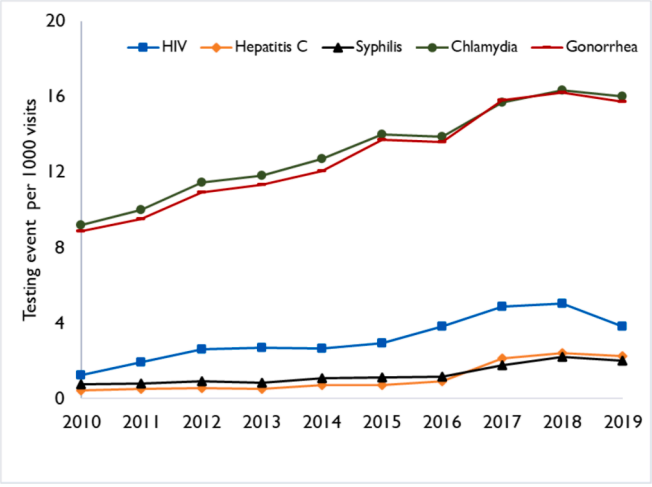


**Fig. 1.** Overall testing event trends in emergency departments, United States, Nationwide Emergency Department Sample (NEDS) 2010–2019. Annual testing event rates per 1,000 visits for HIV, hepatitis C, syphilis, chlamydia and gonorrhea.

Co-testing events and trends were also assessed among visits for HIV, hepatitis C, syphilis, and chlamydia/gonorrhea (Fig. 3). During 2010, 58.4 % of testing events for hepatitis C were co-testing events, which was higher than for HIV (35.2 %), syphilis (41.0 %) and chlamydia/gonorrhea (3.5 %). During 2019, similar co-testing event rates were observed for HIV (57.1 %), hepatitis C (63.5 %), and syphilis (66.4 %), with AAPCs for co-testing events significantly increasing for HIV (4.2 %), syphilis (3.2 %), and chlamydia/gonorrhea (5.5 %), but no significant increase for hepatitis C (0.7 %, $P = 0.26$).

Co-testing combinations were assessed by infection type (Table 2). From 2010 to 2019, primary HIV co-testing significantly increased with secondary tests for hepatitis C (from 12.3 % to 29.9 %), syphilis (from 6.7 % to 21.6 %), chlamydia (from 11.4 % to 22.0 %), and gonorrhea (from 10.5 % to 21.8 %). Primary hepatitis C co-testing significantly increased but remained less than 10 % with secondary tests for syphilis, chlamydia, and gonorrhea, while remaining stable with secondary tests for HIV (from 51.1 % to 57.5 %). Primary syphilis co-testing significantly increased with secondary tests for all other infections, with the highest AAPC with secondary HIV tests (13.8 %). More than 91 % of ED visits with a chlamydia or gonorrhea test were performed together and did not change significantly over time.

## 4. Discussion

Using nationally representative ED visit data, we found significant increases in testing rates for all infections and in co-testing rates for most infections during 2010–2019, indicating increased implementation of ED-based testing for HIV, hepatitis C, and STIs. These increases varied by sociodemographic, hospital, and visit characteristic. Significant increases in the AAPCs for multiple groups indicates increasing implementation of testing for more populations for whom screening is recommended. This study also provides a baseline for monitoring national testing trends and co-testing patterns for HIV, hepatitis C, and STIs in EDs. We found lower ED testing rates for most infections compared with prior studies, which is likely related to the place of receipt of services and purpose of the study, as the majority of prior published studies focused on testing for one infection within specific populations and clinical settings with specific screening interventions. (O'Connell et al., 2016; Henriquez-Camacho et al., 2017; Stanford et al., 2021; Barnes et al., 2019; Haukoos et al., 2021; Bi et al., 2022; Haukoos et al., 2013).

Significant increases in ED testing rates are encouraging and point to

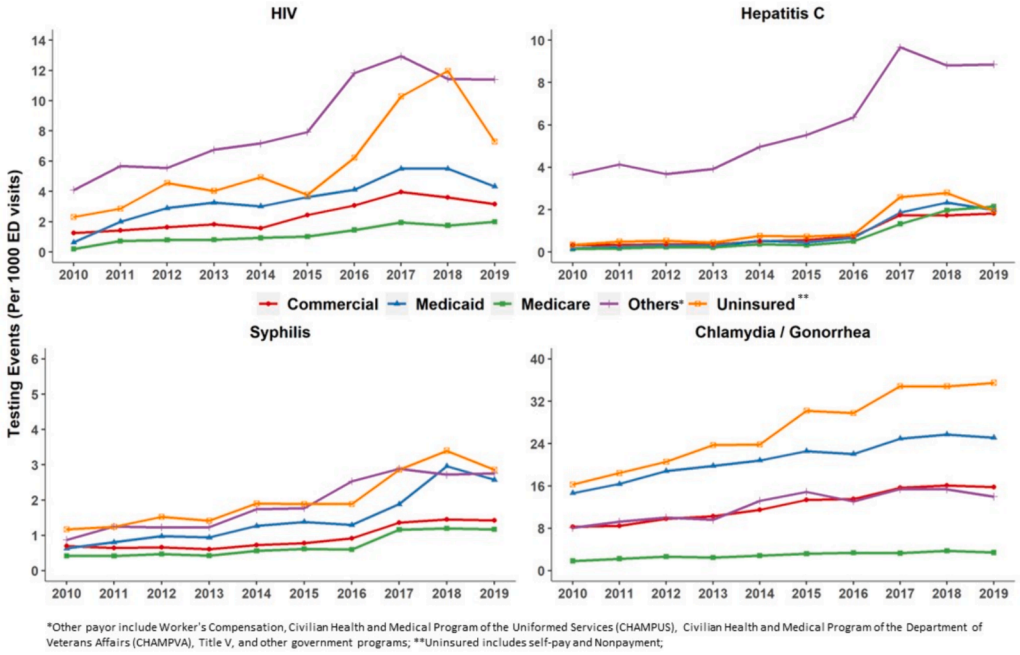


**Fig. 2.** Testing event trends by payor, United States, NEDS 2010–2019. Annual testing event rate per 1,000 Emergency Department visits 2010 through 2019 for HIV, hepatitis C, syphilis, and chlamydia/gonorrhea by payor. Uninsured includes self-pay and Nonpayment. Other payor includes Worker's Compensation, Civilian Health and Medical Program of the Uniformed Services (CHAMPUS), Civilian Health and Medical Program of the Department of Veterans Affairs (CHAMPVA), Title V, and other government programs.

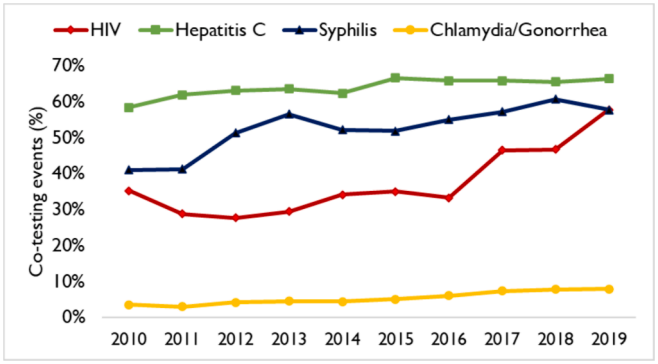


**Fig. 3.** Percentage of Visits with Co-Testing for HIV, Hepatitis C, Syphilis, and Chlamydia/Gonorrhea in the United States: NEDS 2010–2019.

several changes during this time period including increased access to preventive care and changes in testing and screening guidelines. In 2012, the passage of the Affordable Care Act (ACA) led to increased coverage for preventive care services, mitigating financial barriers and providing individuals with more opportunities to seek and receive health care services. (Agirdas and Holding, 2018; Menon et al., 2021; CDC ACA and HIV, 2024) Additionally, new policies that require testing, or screening guidelines that recommend testing for these infections likely also contributed to increased testing in EDs. (Barocas et al., 2017; Witzel et al., 2020; CDC. STI Screening Recommendations, 2021) In 2006, the Centers for Disease Control and Prevention (CDC) updated their HIV testing recommendations to include routine opt-out HIV screening for all patients aged 13–64 years in health care settings. (CDC HIV Guidelines, 2023) The United States Preventive Services Task Force (USPSTF) followed in 2012 with guidelines recommending one-time HIV screening for all persons aged 15–65 years. (United States Preventive Services Task Force, 2013) Similarly, between 2012 and 2013, CDC and USPSTF updated hepatitis C testing recommendations to include one-time testing for all individuals born between 1945 and 1965 (Baby Boomers), likely leading to higher hepatitis C testing rates among persons aged 55–65 years. (United States Preventive Services Task Force, 2013; 2012).

By median household income group, in 2010, the higher testing rates for hepatitis C among persons in the 75-100th percentile compared to the 0-25th percentile, is likely due to focused screening efforts for Baby Boomers who have had more time to accumulate wealth compared to younger groups. (United States Census Bureau, 2023) However, the consistent inverse relationship between area household income and testing rates indicates testing rates may still be driven by healthcare providers' perceptions of and actual risk factors rather than screening recommendations.

Screening recommendations for STIs have evolved to include more routine screening for sexually active individuals and specific groups. (United States Preventive Services Task Force, 2020; CDC. Sexually Transmitted Diseases Treatment Guidelines, 2010; 2021) Increased testing for chlamydia and gonorrhea among males may be related to CDC's 2015 recommendations for chlamydia and gonorrhea screening among all sexually active MSM that were followed in 2019 by USPSTF recommendations for screening men at increased risk. (United States Preventive Services Task Force, 2020; CDC. Sexually Transmitted Diseases Treatment Guidelines, 2010) The increased chlamydia and gonorrhea testing rates we observed are consistent with Pearson et al (2017) that used data from the National Hospital Ambulatory Medical Care Survey-Emergency Department component. (Pearson et al., 2017).

Increased education and interventions focused on knowledge and behavior change in certain populations are likely to have resulted in increasing testing rates for specific populations. As one would expect, persons aged 15–24 years accounted for the largest proportion of reported cases of chlamydia, gonorrhea, and syphilis in 2020 and had the highest ED testing rates for these infections during 2010–2019. (CDC. AtlasPlus, 2015) Youth Risk Behavior Survey data indicate that since 2011 some sexual risk behaviors are decreasing among adolescents (e.g., ever had sex), while other protective sexual behaviors (e.g., condom use) are declining. (CDC Youth Risk Behavior Survey, 2019) Increasing awareness of need for testing by patients and providers may have

contributed to high rates of screening for younger persons in EDs. (Jafari et al., 2021; CDC Adolescents and Young Adults STD Prevention, 2023; Department of Health and Human Services, 2023) Health care providers may be more likely to offer STI testing to younger patients as part of routine visits or sexual health screenings, especially chlamydia screening to sexually active females aged 15–24 years, because it has been a Health Plan Employer Data and Information Set (HEDIS) measure since 2000. (NCQA 2023) Interventions by specific programs and organizations were also likely to have contributed to increased testing and diagnosis for HIV and hepatitis C; Indian Health Service programs, Veterans Affairs, and Bureau of Prisons have implemented successful HIV and hepatitis C testing initiatives in recent years. (Halloran et al., 2012; Park et al., 2018; Federal Bureau of Prisons, 2021; Indian Health, 2015).

While ED testing event rates remained highest in metropolitan areas and in the Northeast for most infections during 2010–2019, the significant increases in testing among micropolitan areas for HIV, chlamydia, and gonorrhea, and in the Midwest and West for all infections, likely reflects changing geographic distributions, as well as broader implementation of testing. The West now has the highest rate of P&S syphilis and second highest rate of HIV, while the South and Midwest have the highest rates of gonorrhea. (CDC Viral Hepatitis Surveillance Report, 2020; CDC Sexually Transmitted Disease Survielance Report, 2021).

Significant increases in co-testing event rates were observed for each infection except hepatitis C. However, there was substantially more co-testing with hepatitis C in 2010 and co-testing rates remained high, with the second highest co-testing rate in 2019. The broader screening recommendations issued by CDC and USPSTF during 2010–2019 resulted in large overlaps in populations recommended to receive multiple infectious disease screenings. (CDC HIV Screening and Testing, 2024; CDC Hepatitis C guidelines, 2024) In particular, age-based recommendations for HIV and hepatitis C testing largely overlap. However, a substantial proportion of tests for HIV, hepatitis C, and syphilis infections in EDs were conducted as standalone tests, which suggests a need to increase awareness of recommendations and the disproportionate risk of infection and co-infection among certain populations. (Jichlinski et al., 2018; Haukoos et al., 2011; Arbelaez et al., 2012) Co-testing for chlamydia and gonorrhea was especially high due to the common practice of the use of a combination test for both pathogens with a single specimen. (Pinto et al., 2021) Co-testing for chlamydia or gonorrhea with the other infections remained low (<10 %), which is concerning given people with an STI are at increased risk of HIV and also a missed opportunity to assess testing for hepatitis C and syphilis. (Bala et al., 2011; CDC HIV/AIDS & STDs, 2024).

This study has several limitations. First, the HCUP database is an administrative claims dataset that uses ICD and CPT codes to classify patients' medical diagnoses, procedures, and outcomes. The possibility of coding inaccuracy or incorrect information cannot be dismissed. Second, to identify potential test combinations, we iteratively designated tests for each selected infection as the "primary" test. The HCUP NEDS database does not designate any CPT code as the primary service/procedure. Therefore, the "primary" test designation was not based on order of the test within the up to 15 potential CPT codes and is not an indication of which test was considered more important; it is solely to be able to characterize all possible test combinations during a visit. Third, NEDS does not include ED visits that resulted in inpatient hospital admissions, meaning these findings may not be representative of testing among persons with increased disease severity/morbidity. (Weiss and Jiang, 2018) Fourth, the HCUP NED database excludes non-community hospitals (e.g., federal, VA, and Indian Health Service hospitals), potentially limiting its representativeness for the VA and Indian Health Services populations. However, federal health insurance users may still be present in NEDS datasets when utilizing health benefits in community hospital EDs. Finally, NEDS collects data for the visit level, not the individual level; thus, stratified analyses by demographic characteristics may over represent people with multiple ED visits in a year.

This is the first study to our knowledge that analyzed national ED testing trends and identified significant increases in ED testing event rates and co-testing in the United States. Syndemics are not only characterized by co-occurring conditions but can illuminate enhanced disease transmission and disease progression that ultimately exacerbates the severity of future negative health outcomes. Identification and awareness of syndemics raises important questions about the need to identify best practices in ED settings for the simultaneous treatment of interlocked infectious diseases among population cohorts and specific geographic regions. Although the testing rate in 2019 increased from 2010, it remains low, suggesting that guidelines for screening are not being adequately implemented. In addition, the slight decline in testing for all infections from 2018 to 2019 underscores the necessity for continued vigilance and increased testing efforts, particularly in underserved communities. These findings can be used to evaluate and inform public health efforts to increase screening in the places and populations most in need and identify opportunities to improve screening for multiple infections at the same visit. Increasing testing for HIV, hepatitis C, and STIs in EDs is critical for providing comprehensive care to persons disproportionately at risk for these infections who may not access care elsewhere. Screening in EDs requires a multidisciplinary approach and the cooperation of health care providers, administrators, and policymakers. (Gardner and Haukoos, 2015; Anderson et al., 2017) Effective programs must also address the limited linkage to care for individuals diagnosed in prior ED studies. (Jichlinski et al., 2018; Anderson et al., 2017; Houri et al., 2020) EDs have addressed challenges through streamlined protocols, integrating screening into existing workflows, and strengthening partnerships with local health departments and other community organizations to support linkage to care. (Gutman et al., 2020; Negoita et al., 2018; Hoenigl et al., 2019) For ED screening programs nationwide to provide holistic care to patients and realize the public health benefits of testing, steps must be taken to increase testing, linkage to care and all diagnosed individuals, and referral to prevention services for those at risk.

Disclaimer: The findings and conclusions in this report are those of the authors and do not necessarily represent the views of the US Centers for Disease Control and Prevention.

## CRediT authorship contribution statement

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## Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

## Data availability

Healthcare Cost and Utilization Project (HCUP) Nationwide Emergency Department Sample (NEDS) data was used. HCUP NEDS data can be requested through https://hcup-us.ahrq.gov/tech_assist/centdist.jsp.

## Appendix

**Table A1**
CPT codes to identify **HIV** screening test.

| CPT Code | AMA list | HRSA BPHC UDS | Description |
|---|---|---|---|
| 80081 | | | Obstetric panel; hepatitis B surface antigen test, a single–result test for HIV–1 antigens and antibodies for HIV–1 and HIV–2, a rubella antibody test, a qualitative nontreponemal syphilis test, a red blood cell antibody screen, ABO blood typing, and Rh typing |
| 86689 | X | X | Antibody; HTLV or HIV antibody, confirmatory test |
| 86701 | X | X | Antibody; HIV-1 |
| 86702 | X | X | Antibody; HIV-2 |
| 86703 | X | X | Antibody; HIV-1 and HIV-2, single assay. |
| 87389 | X | X | Antigen, HIV-1 and Antibody; HIV-1 and HIV-2 |
| 87390 | X | X | Antigen, HIV-1 |
| 87391 | X | X | Antigen, HIV-2 |
| 87534 | X | X | HIV-1, Direct probe technique. Nucleic acid (DNA or RNA) |
| 87535 | X | X | HIV-1, Amplified probe technique. Nucleic acid (DNA or RNA) |
| 87536 | X | X | HIV-1, quantification. Nucleic acid (DNA or RNA) |
| 87537 | X | X | HIV-2, Direct probe technique. Nucleic acid (DNA or RNA) |
| 57538 | X | X | HIV-2, Amplified probe technique. Nucleic acid (DNA or RNA) |
| 87539 | X | X | HIV-2, quantification. Nucleic acid (DNA or RNA) |
| 87806 | X | X | Tests to identify the presence of HIV type 1 or type 2 strain |
| G0432 | | | Antibody, EIA HIV-1/HIV-2 screen* |
| G0433 | | | Antibody, ELISA HIV-1/HIV-2 screen* |
| G0435 | | | Oral HIV-1/HIV-2 screen* |

* Medicare enrollee, for an individual at high risk and other covered indication(s)

**Table A2**
CPT codes to identify **Hepatitis C** screening test.

| CPT Code | AMA list | HRSA BPHC UDS | Description |
|---|---|---|---|
| 80074 | | X | Acute hepatitis panel: must include tests for hepatitis A IgM antibody, hepatitis B core IgM antibody, hepatitis B surface antigen, and hepatitis C antibody |
| 86803 | X | X | Antibody, Hepatitis C |
| 86804 | | X | Antibody, Hepatitis C confirmatory test (e.g., immunoblot). |
| 87520 | X | X | Hepatitis C, Direct probe technique. Nucleic acid (DNA or RNA) |
| 87521 | X | X | Hepatitis C, Amplified probe technique. Nucleic acid (DNA or RNA) |
| 87522 | X | X | Hepatitis C, Quantification. Nucleic acid (DNA or RNA) |
| 87902 | | X | Hepatitis C, Genotype test |
| G0472 | | | Hepatitis C antibody screening, for an individual at high risk and other covered indication(s) (instead of 86803) * |
| 3266F | | | Hepatitis C, genotype test* |

* Medicare enrollee, for an individual at high risk and other covered indication(s)

**Table A3**
CPT codes to identify **Chlamydia** screening test.

| CPT Code | AMA list | Description |
|---|---|---|
| 86631 | X | Antibody, Chlamydia |
| 86632 | X | Antibody, Chlamydia, IgM. Indicating recent infection |
| 87110 | X | Culture and identifies any Chlamydia species |
| 87270 | X | Antigen, Chlamydia, Direct fluorescent antibody technique |
| 87320 | X | Antigen, Chlamydia, Multiple step method, enzyme immunoassay technique, qualitative or semiquantitative |
| 87490 | X | Chlamydia, direct probe technique. Nucleic acid (DNA or RNA); |
| 87491 | X | Chlamydia, Amplified probe technique, Nucleic acid (DNA or RNA) |
| 87810 | X | Chlamydia, Immunoassay with direct optical observation |

**Table A4**
CPT codes to identify **Gonorrhea** screening test.

| CPT Code | AMA list | Description |
|---|---|---|
| 87590 | X | Neisseria gonorrhoeae, Direct nucleic acid probe technique |
| 87591 | X | Neisseria gonorrhoeae, Amplified probe technique, Nucleic acid (DNA or RNA) |
| 87592 | X | Neisseria gonorrhoeae, Quantification, Nucleic acid (DNA or RNA) |
| 87850 | X | Neisseria gonorrhoeae, Immunoassay with direct optical observation |

**Table A5**
CPT codes to identify **Syphilis** screening test.

| CPT Code | AMA list | Description |
|---|---|---|
| 80055 | X | Obstetric panel; Hepatitis B surface antigen, a rubella antibody, a qualitative non treponemal syphilis test, a red blood cell antibody screen, ABO blood typing, and Rh typing |
| 80081 | X | Obstetric panel; hepatitis B surface antigen test, a single–result test for HIV–1 antigens and antibodies for HIV–1 and HIV–2, a rubella antibody test, a qualitative nontreponemal syphilis test, a red blood cell antibody screen, ABO blood typing, and Rh typing |
| 86592 | X | Syphilis, Qualitative (e.g., VDRL, RPR, ART) |
| 86593 | X | Syphilis, Quantitative |
| 86780 | X | Antibody, Syphilis |

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