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Developing a Topology of Syphilis in the United States

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Abstract

Background: In the United States, reported rates of syphilis continue to increase. Co-occurring epidemics of syphilis among men who have sex with men (MSM) and heterosexual populations create challenges for the prioritization of resources and the implementation of context-specific interventions.

Methods: State was the unit of analysis and was restricted to the 44 states with the most complete data of sex or sex partners for their reported adult syphilis cases. States were classified as high, medium, or low for reported congenital syphilis (CS) and MSM primary and secondary (P&S) syphilis rates. Average values of a range of ecologic state level variables were examined among the 9 categories created through the cross-tabulation of CS and MSM P&S syphilis rates. Patterns among ecologic factors were assessed across the 9 categories of states' syphilis rates.

Results: Among the 44 states categorized, 4 states had high rates of both CS and MSM P&S syphilis in 2015, whereas 12 states fell into the medium/medium category and 7 into the low category. Six states had high CS and medium MSM syphilis and 4 states had medium CS but high MSM syphilis. Several area-level factors, including violent crime, poverty, insurance status, household structure and income, showed qualitative patterns with higher rates of CS and MSM P&S syphilis. Higher proportions of urban population were found among states with higher CS rates; no trend was seen with respect to urbanity and MSM P&S syphilis.

Conclusions: Several area-level factors were associated with CS and MSM P&S syphilis in similar ways, whereas other ecologic factors functioned differently with respect to the 2 epidemics. Explorations of community and area-level factors may shed light on novel opportunities for population specific prevention of syphilis.

In the United States reported syphilis rates declined to historic lows in the 1990s. Less than 7000 cases of primary and secondary (P&S) syphilis were reported to the Centers for Disease Control and Prevention (CDC) in 1998 and over half of those case reports came from only 28 counties (<1% of all counties in the United States).[1] In an effort to take advantage of these unprecedented lows in reported morbidity, CDC embarked on an effort to

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eliminate syphilis in 1999.[1] Syphilis epidemics in the 1980s and 1990s in the United States were primarily focused in heterosexual populations, and associated with crack use and exchange of sex for drugs or money.[1,2] Soon after elimination efforts were initiated, P&S syphilis rates began to increase, driven largely by infections among men who have sex with men (MSM).[3–7] Primary and secondary syphilis rates have risen considerably since then and in 2016, 27,814 P&S syphilis cases were reported to the CDC[8] representing nearly a 300% increase in P&S syphilis cases since 1998. In 2016, 89% of the reported cases of P&S syphilis occurred among men. Among the 83% of P&S syphilis cases reported in 2016 with information about sex of sex partners, 63% were MSM, 7% were MSM and men who have sex with women, 17% were men who have sex with women only, and 13% were female.[8] Although heterosexual syphilis represents an increasingly smaller proportion of all reported syphilis, rates among females have been increasing, along with reported congenital syphilis (CS). Between 2012 and 2016, reported P&S syphilis cases among women of reproductive age increased from 1458 to 3049 (a 109% increase) and congenital cases increased from 334 to 628 (an 88% increase).[8]

Furthermore, the epidemiologic context of syphilis has changed greatly since the 1990s. Over the past 20 years, remarkable advancements in the care, treatment, and prevention of human immunodeficiency virus (HIV) has changed the landscape of MSM sexual health. No longer a death sentence but rather a manageable chronic infection, life expectancy of HIV-infected persons has increased significantly and rivals that of the HIV-uninfected.[9] Food and Drug Administration approval of, and increasing access to, HIV preexposure prophylaxis (PrEP) may impact sexually transmitted disease (STD) rates.[10] Increasing or maintaining the consistent use of condoms may be difficult in populations with high uptake of PrEP for HIV[11] because while PrEP is an effective HIV prevention tool, it is not effective for preventing other STDs. Additionally, the delivery of clinical care and public health interventions have changed in the 2010s. As a result, more STDs are being diagnosed and treated in the health care system rather than traditional STD clinics.[12,13] This increase in access to primary clinical care has coincided with a decline in available public health resources.[14] This reduction in resources has resulted in fewer STD clinics, reduced hours in clinics that did not close, and a smaller public health workforce prepared to prevent and control STDs.[15–17] These contextual changes require not just an eye towards individual level risk factors, but also social determinants of health.

Although reported MSM P&S syphilis morbidity is geographically diffuse,[18,19] reported CS is highly geographically focused[8] with only 3 states accounting for more than 50% of total national morbidity. Nearly three quarters of reported CS cases were born to nonwhite mothers, yet rates of CS increased among all racial/ethnic groups from 2015 to 2016.[8] Although white men make up the largest absolute number of MSM P&S syphilis case reports, rates of syphilis are highest among black MSM.[18] Over half of the MSM P&S syphilis cases reported in 2016 were HIV infected.[8] The co-occurring epidemics of CS and MSM syphilis in the United States illustrate the complexities of simply characterizing the epidemiology of syphilis.

Population-specific approaches to addressing the increasing rates of CS and MSM syphilis are critical. However, at the state and local level, many times these seemingly distinct

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epidemics are co-occurring and may be enmeshed in a complex epidemiology. A better understanding of the upstream factors that may influence these epidemics, independently and collectively, may inform approaches at the state and local level. Through social determinants of health lens, we developed a national topology of syphilis which explores the relationship between selected socioeconomic, demographic, and health care factors, and state level rates of CS and P&S syphilis among MSM. Our qualitative approach is intentionally simple and designed to help differentiate the areas where CS and MSM syphilis epidemics may diverge and align.

METHODS

State Syphilis Burden Rankings

We categorized states according to their reported rates of both CS and P&S syphilis among MSM in 2015. Data on syphilis cases were reported to the CDC as part of the National Notifiable Diseases Surveillance System. Congenital syphilis cases were those diagnosed in newborns and infants that were determined to have been transmitted from the mother in utero. Primary and secondary syphilis cases in MSM were identified using data on sex and sexual behavior; syphilis cases in adult men who reported having sex with men only or with both men and women in the past year were determined to be MSM.

To calculate rates, 2 sources of population denominators were used. For rates of CS, state CS case totals were divided by the number of live births reported to the National Center for Health Statistics through the Vital Statistics Cooperative Program. For P&S syphilis rates among MSM, the total number of P&S syphilis cases attributed to MSM were divided by state-specific estimates of MSM population sizes based on a published method.[20]

We restricted our analysis to 44 states for which at least 70% of adult P&S syphilis cases could be classified as MSM, men who had sex with women only, or women. We ranked these states independently according to their rates of CS and P&S syphilis among MSM, dividing them into 3 groups for each condition. For MSM syphilis, the 10 states with the highest reported rate of P&S syphilis among MSM were categorized as “high,” the ten states with the lowest reported rate of P&S syphilis among MSM were categorized as “low” and the remaining states were placed in the middle category. The same process was undertaken for CS, with one exception: 15 states had CS rates of 0, and all were categorized as “low.” We then used the cross-tabulation of the 2 rankings to classify the 44 states into 9 categories that described their joint ranking for P&S syphilis among MSM and CS.

Ecologic Variables

We selected state-level demographic, sociologic, and health data from several sources, including the America’s Health Rankings[21] (Table 1). Means, maxima, and minima were calculated for each variable according to the 9 syphilis burden categories. Due to the small sample size of 44, we did not conduct formal statistical tests to examine patterns. Instead, qualitative patterns between syphilis rankings and their means were used to examine relationships between the state-level ecologic factors and the relative burden of syphilis. Finally, we summarized results in conjunction with expert review and evidence from the

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literature in order to profile states and identify common and divergent factors associated with the 2 syphilis epidemics at the state level.

RESULTS

The reported rates of MSM P&S syphilis in 2015 ranged from 73.1 to 748.3 per 100,000 MSM across the 44 states included in the analysis; the rates for CS ranged from 0.0 to 83.9 per 100,000 live births. Figure 1 illustrates how the 44 states examined break down with respect to CS and MSM P&S syphilis rates in 2015. The 3 CS categories are displayed on the x-axis and the 3 MSM P&S syphilis categories on the y axis. Four states (Arizona, Louisiana, Nevada, and Oklahoma) fell into the high rate category for both CS and MSM P&S rates. Hawaii, New Mexico, North Carolina, and South Carolina had the highest rates of MSM P&S syphilis, but fell into the medium group for CS syphilis. The medium/medium group included the largest number of states (n = 12) (middle cell in Fig. 1). Seven states had low/low reported rates of CS and MSM P&S syphilis in 2016 (Alaska, Maine, Montana, New Jersey, North Dakota, Utah, and Vermont).

The topologic relationships between urbanicity, the proportion of the population living in poverty, and syphilis, are shown in Figures 2 and 3, respectively. For each of the 9 cells in the figure, the data displayed is the state-specific value of the ecologic variable, and the red line represents the mean for that cell. In the figures, decreasing rates of CS are represented by the columns from left to right and decreasing rates of MSM P&S syphilis by the rows from top to bottom. The proportion of the population that is urban appears to decline as rates of CS decline (moving within rows from left to right); however, there is no pattern with respect to MSM syphilis (moving down columns from top to bottom) (Fig. 2). Fig. 3 illustrates the patterns with poverty. Here, there is not a pattern with respect to CS, yet as MSM P&S syphilis increases, so does the proportion of the population in poverty. The detailed data from the remaining 12 area-level characteristics are presented in the supplemental information (see Supplemental Figures, http://links.lww.com/OLQ/A250; Supplemental Titles, http://links.lww.com/OLQ/A251).

Nine of the examined area-level factors were seen to increase along with increasing rates of both CS and MSM P&S syphilis. These included the rate of violent crime (defined as the combined rate of murders, rapes, robberies, and aggravated assaults), the proportion of the population living in poverty, the proportion of children living in poverty, the underemployment rate, the unemployment rate, the percentage of the nonelderly population that is uninsured, the rate of unintended pregnancy, the proportion of households headed by a female, and the proportion of households headed by a single person. As mean value of state-specific median income decreased, rates of both CS and MSM P&S syphilis increased. A similar pattern was seen for per-capita health spending.

Other characteristics did not have consistent patterns between CS and MSM P&S syphilis. As the proportion of the state population that is urban increased, the rate of CS increased. Yet, no similar tendency was identified between proportion urban and MSM P&S syphilis. Conversely, no association was seen between state-level approval of same-sex marriage for CS, yet as MSM P&S syphilis rates increased, same-sex marriage approval decreased.

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Finally, no patterns were identified for either CS or MSM P&S syphilis with respect to the number of active primary care physicians per 100,000.

DISCUSSION

After nearly a decade of steady increases in reported syphilis in the United States, nationally overlapping epidemics among MSM and heterosexuals have been established. It is critical that state and local health departments, suffering from reduced availability of human and programmatic resources, explore the unique syphilis epidemiologies of their jurisdiction. Individual risk behaviors (eg, sexual and health care–seeking behaviors) occur within the greater context of the community in which individuals live, work, and play. Many state and local health departments are dealing with the challenges of resource allocation in a time of cooccurring epidemics. In our ecologic approach, among the 44 states included in our analysis, 4 (9.1%) had both the highest rates of CS and MSM P&S syphilis. Twelve states fell into the medium rate category for both CS and MSM syphilis. Our review of patterns in syphilis rates highlight the myriad area-level factors that may be operating at a macro level. Many area-level factors operated similarly with respect to increases in CS and MSM syphilis. Others seem to vary depending on the population at risk.

The urban environment creates structures, such as increased population density and sexual network density, which may increase population levels of disease. Geographic proximity and density may facilitate more complex and larger sexual networks.[22–24] Health care access and cultural competencies may vary by levels of urbanicity. In our analysis, states with higher rates of CS tended to have higher proportions of urban populations. However, no similar tendency was seen for MSM P&S syphilis rates. This suggests that the urban environment may impact syphilis risk populations in different ways. Furthermore, the lack of a pattern with respect to urbanicity for MSM P&S syphilis also illustrates that MSM at high risk may not always live in urban centers, areas previously thought to have higher concentrations of gay and bisexual men.[20,25]

Chesson et al[26] explored overall rates of gonorrhea and syphilis and found positive correlations for both diseases and violent crime. In this context, higher crime rates are likely correlated with a range of other factors, including drug arrests, socioeconomic status, and neighborhood disorder.[27–30] State-level approval of same-sex marriage and laws related to discrimination in the lesbian, gay, bisexual and transgender community vary widely in the United States and are evolving. Cramer et al[31] reviewed laws across the United States in 2013 and found that 31% of states had laws preventing discrimination against employees based on sexual orientation. Although same-sex marriage approval was not associated with CS rates, states with higher rates of MSM P&S syphilis had lower levels of same-sex marriage approval. Men who have sex with men in states with lower community support may have (real or perceived) barriers to culturally competent health care.[32,33] Although likely confounded by region and other factors, it is not clear how lower community support for same-sex marriage may influence risk of syphilis among MSM.

Income is one of the most important socioeconomic indicators. We explored a number of income and employment data and found that higher rates of both CS and MSM syphilis

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occurred in states with lower income, higher poverty rates, and higher unemployment. The challenges of poverty and lack of employment seem to influence both populations in the same way. This relationship between morbidity and economic health has been demonstrated for other conditions.[34,35] Interventions occurring at the economic level (such as changes in living wage laws, paid sick leave, stable housing) may have positive impacts on rates of syphilis, irrespective of risk group.

In the United States in 2016, less than a quarter of all reported syphilis was diagnosed in a categorical STD clinic.[8] Health care reform and changes in insurance status of many at risk populations have precipitated changes in how STD services are provided.[12,16] Furthermore, local and state health departments have seen reductions and gaps in critical services related to STD prevention and care.[15] We explored one factor related to availability (primary care physicians) and 2 factors related to accessibility (un-insured nonelderly population, and per capita health spending). No pattern was seen with respect to primary care physicians and either CS or MSM P&S syphilis, suggesting that availability of services may be less important than access. The relationship of CS and MSM P&S syphilis with respect to insurance and per capita spending were similar—higher rates of syphilis were found in states with less spending and more uninsured.

Finally, we examined factors related to family structure. The rate of unintended pregnancy, percentage of female head-of-household, and percentage of single head-of-household were all seen to be higher in states with higher rates of CS or MSM P&S syphilis. Teenage pregnancies continue to decline in the United States,[36] yet are associated with a range of socioeconomic factors, such as underemployment, lower income, and percentage of population living in poverty.[37,38] A more thorough understanding of how family structure may influence syphilis rates may help inform structural level prevention interventions in the future.

Our ecologic analysis of CS and MSM syphilis rates has a number of important limitations. Given the small sample size, we intentionally did not attempt to describe trends and associations through a lens of statistical significance. Instead, we evaluated the general direction of the relationships between the factors explored and the outcomes of CS and MSM syphilis rates. Furthermore, we did not explore confounding and many of the factors examined likely have a complex relationship; our simple analysis is not able to determine independent factors that may modify syphilis rates in the United States. Also, because the data examined are ecologic, we cannot ascribe any relationship between factors and risk of syphilis at the individual level. We analyzed only 1 year of syphilis data, and it is possible that the associations found would differ in different years. Additionally, not all of the area-level factor data were collected in 2015. Finally, not all states had consistently collected gender of sex partner data for reported adult syphilis; therefore, some states were excluded from this analysis.

With numerous dynamic aspects influencing population-level risk of syphilis, innovative approaches to addressing increases in reported syphilis are urgently needed. Individual-level risk behaviors occur within a broader social and community context; a better understanding of how individual and higher-level factors may protect or increase risk of infection may hold

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promise to informing novel prevention interventions. Our proposed topology is designed to be the beginning, and not the end, of a discussion of the area-level factors that may be fruitful prevention levers. Although our approach has many limitations and was not designed to be comprehensive, the topology provides insights into social and community constructs that may be associated with both MSM and heterosexual syphilis risks and illustrates how all states might look at the community context of syphilis epidemics.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

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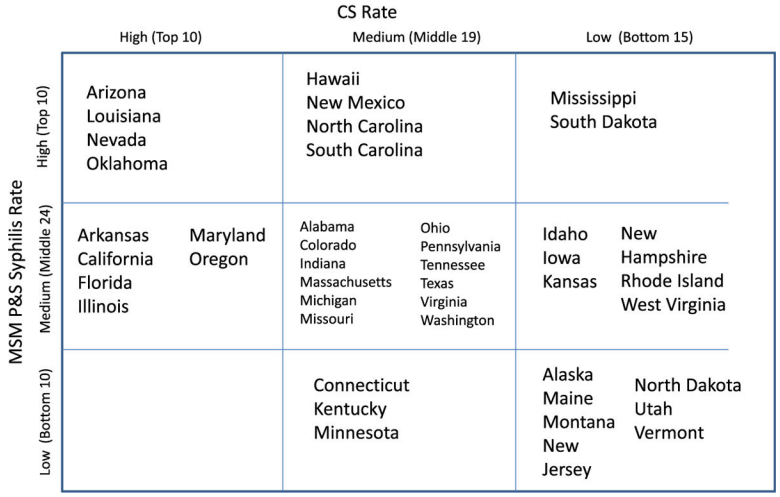

Figure 1.

Reported rates of CS and primary and secondary syphilis among men who have sex with men 44 states, 2015.

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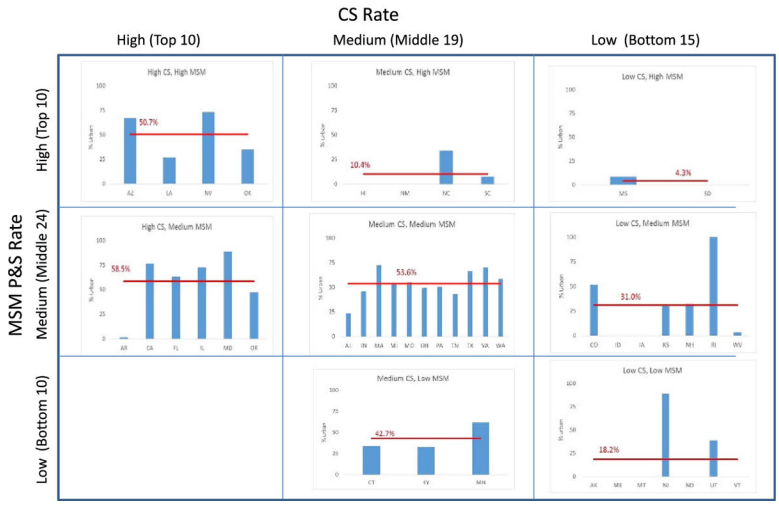

Figure 2.

Proportion of the state population residing in an urban county (2015) by state-level categorization of reported CS and MSM P&S Syphilis Rates (2015). *Horizontal line represents mean. Proportion urban—The percentage of the state population that resides in urban counties according to the 5-year summary file data from the American Community Survey (2011–2015) and the 2013 Urban-rural Classification Scheme for Counties from National Center for Health Statistics. CS rates classified as High represent the 10 states with the highest reported CS rate in 2015; Medium, the 19 states with the highest rates of reported CS syphilis in 2015 after the 10 High States; Low, the 15 states with no reported CS in 2015. MSM P&S syphilis rates were classified as High for the 10 states with the highest reported MSM P&S Syphilis Rates in 2015, medium—for the 24 states with the next highest MSM P&S syphilis rates in 2015, and Low for the 10 states with the lowest reported MSM P&S syphilis rates in 2015. AL, Alabama; AK, Alaska; AZ, Arizona; AR, Arkansas; CA, California; CT, Connecticut; CO, Colorado; FL, Florida; HI, Hawaii; ID, Idaho; IA, Iowa; IL, Illinois; IN, Indiana; KS, Kansas; KY, Kentucky; LA, Louisiana; MA, Massachusetts; MD, Maryland; ME, Maine; MI, Michigan; MN, Minnesota; MO, Missouri; MS, Mississippi; MT, Montana; NH, New Hampshire; NJ, New Jersey; ND, North Dakota; NM, New Mexico; NC, North Carolina; NV, Nevada; OK, Oklahoma; OH, Ohio; OR, Oregon; PA, Pennsylvania; RI, Rhode Island; SC, South Carolina; SD, South Dakota; TN, Tennessee; TX, Texas; UT, Utah; VA, Virginia; VT, Vermont; WA, Washington; WV, West Virginia.

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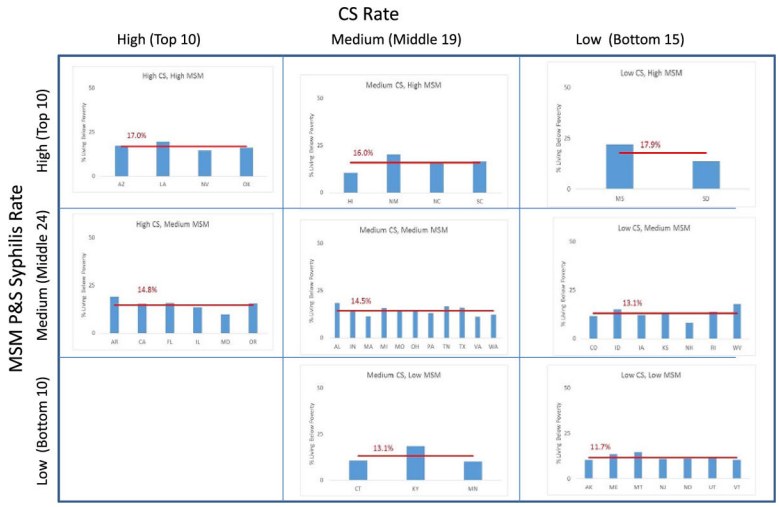

Figure 3.

Proportion of the state population living in poverty (2015) by state-level categorization of reported CS and MSM P&S Syphilis Rates (2015). *Horizontal line represents mean. Proportion poverty—the percentage of the population living in households at or below the poverty threshold. CS rates classified as High represent the 10 states with the highest reported CS rate in 2015; medium, the 19 states with the highest rates of reported CS syphilis in 2015 after the 10 High States; Low, the 15 states with no reported CS in 2015. MSM P&S syphilis rates were classified as High for the 10 states with the highest reported MSM P&S Syphilis Rates in 2015, medium—for the 24 states with the next highest MSM P&S syphilis rates in 2015, and Low for the 10 states with the lowest reported MSM P&S syphilis rates in 2015.

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TABLE 1.

State-level Ecologic Factors, Including Description and Source

Measures	Source
Urbanicity and community safety	
Percent population in central counties of large metropolitan areas, 2015	American Community Survey 5-year Summary File, 2011–2015
No. deaths due to drug injury of any intent (unintentional, suicide, homicide, or undetermined) per 100,000 population, 2012–2014	National Vital Statistics System
No. murders, rapes, robberies, and aggravated assaults per 100,000 population, 2015	Federal Bureau of Investigation
Percent who favor allowing gay and lesbian couples to marry legally, 2015	American Values Atlas
Income	
Median household income, 2015	American Community Survey
Percent of people below poverty level, 2015	American Community Survey
Percentage of children younger than 18 y who live in households at or below the poverty threshold	Current Population Survey
Percentage of the civilian labor force that is unemployed, plus all marginally attached workers, plus the total employed part-time for economic reasons, 2015	US Bureau of Labor Statistics
Percentage of the civilian labor force that is unemployed, 2015	US Bureau of Labor Statistics
Health care access and availability	
Health care expenditures per capita	Centers for Medicare and Medicaid Services
No. active primary care physicians per 100,000 population, 2016	American Medical Association
Percent uninsured persons aged 0–64 y (nonelderly), 2015	Current Population Survey
Family structure	
Unintended pregnancy rate per 100,000 women aged 14—44 y, 2010	PRAMS and other surveys
Percent female head of household, 2015	American Community Survey 1-year Summary File, 2015
Percent single head of household, 2015	American Community Survey 1-year Summary File, 2015