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J Infect Dis. Author manuscript; available in PMC 2022 March 21.

Published in final edited form as:

J Infect Dis. 2019 October 31; 220(220 Suppl 4): S253–S262. doi:10.1093/infdis/jiz301.

Impact of 13-Valent Pneumococcal Conjugate Vaccine on Pneumococcal Meningitis, Burkina Faso, 2016–2017

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Abstract

Background.—In 2013, Burkina Faso introduced 13-valent pneumococcal conjugate vaccine (PCV13) into the routine childhood immunization program, to be administered to children at 8, 12, and 16 weeks of age. We evaluated the impact of PCV13 on pneumococcal meningitis.

Methods.—Using nationwide surveillance, we gathered demographic/clinical information and cerebrospinal fluid (CSF) results for meningitis cases. Pneumococcal cases were confirmed by culture, polymerase chain reaction (PCR), or latex agglutination; strains were serotyped using PCR. We compared annual incidence (cases per 100 000) 4 years after PCV13's introduction (2017) to average pre-PCV13 incidence (2011–2013). We adjusted incidence for age and proportion of cases with CSF tested at national laboratories.

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Supplementary Data

Supplementary materials are available at *The Journal of Infectious Diseases* online. Consisting of data provided by the authors to benefit the reader, the posted materials are not copyedited and are the sole responsibility of the authors, so questions or comments should be addressed to the corresponding author.

Potential conflicts of interest. All authors: No reported conflicts of interest. All authors have submitted the ICMJE Form for Disclosure of Potential Conflicts of Interest.

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Results.—In 2017, pneumococcal meningitis incidence was 2.7 overall and 10.5 (<1 year), 3.8 (1–4 years), 3.5 (5–14 years), and 1.4 (≥15 years) by age group. Compared to 2011–2013, PCV13-serotype incidence was significantly lower among all age groups, with the greatest decline among children aged <1 year (77%; 95% confidence interval [CI], 65%–84%). Among all ages, the drop in incidence was larger for PCV13 serotypes excluding serotype 1 (79%; 95% CI, 72%–84%) than for serotype 1 (52%; 95% CI, 44%–59%); incidence of non-PCV13 serotypes also declined (53%; 95% CI, 37%–65%). In 2017, 45% of serotyped cases among all ages were serotype 1 and 12% were other PCV13 serotypes.

Conclusions.—In Burkina Faso, meningitis caused by PCV13 serotypes continues to decrease, especially among young children. However, the concurrent decline in non-PCV13 serotypes and short pre-PCV13 observation period complicate evaluation of PCV13's impact. Efforts to improve control of serotype 1, such as switching from a 3 + 0 schedule to a 2 + 1 schedule, may improve overall control of pneumococcal meningitis in this setting.

Keywords

Burkina Faso; pneumococcal conjugate vaccine; pneumococcal meningitis; vaccine impact

Streptococcus pneumoniae is a leading infectious cause of global morbidity and mortality [1] and a primary etiology of bacterial meningitis, along with *Neisseria meningitidis* and *Haemophilus influenzae* [2]. In 2017, an estimated 445 000 cases of pneumococcal meningitis with 42 000 deaths occurred globally [3]. In the meningitis belt of sub-Saharan Africa, pneumococcal meningitis has a distinct seasonality similar to that of meningococcal meningitis, a high case fatality ratio (CFR), and a predominance of serotype 1 disease in persons aged >5 years [4-8].

Burkina Faso is a West African country that is located entirely within the meningitis belt and experiences hyperendemic rates of meningitis [9]. Historically, approximately 90% of meningitis cases during epidemics in Burkina Faso were due to *N meningitidis* serogroup A [10]. After the successful introductions of *H influenzae* serotype b (Hib) vaccine in 2006 [11] and meningococcal serogroup A conjugate vaccine ([MACV] MenAfriVac) in 2010 [10, 12], *S pneumoniae* became the predominant cause of bacterial meningitis in Burkina Faso. Therefore, the government of Burkina Faso introduced 13-valent pneumococcal conjugate vaccine (PCV13) into the routine childhood immunization program in October 2013 using a 3 + 0 schedule at 8, 12, and 16 weeks of age without a booster or catch-up campaign. Burkina Faso is one of the few African countries to both successfully implement nationwide case-based meningitis surveillance as part of the MenAfriNet Consortium [13] and to also routinely serotype all pneumococcal meningitis specimens, in an effort to evaluate PCV13 impact.

To date, 60 Gavi-eligible countries have introduced pneumococcal conjugate vaccines (PCVs) into routine immunization programs [14]. To help sustain these programs, evaluating the impact of PCV on pneumococcal disease and circulating serotypes is crucial. The introduction of PCV resulted in substantial decreases in invasive pneumococcal disease (IPD) and pneumonia among children globally, with dramatic decreases observed among young children targeted for vaccination [15-21]. In addition to direct effects on disease,

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widespread use of PCVs also reduces nasopharyngeal carriage of vaccinetype pneumococci among both vaccinated and unvaccinated individuals [16]. The resulting herd protection decreases PCV-type IPD incidence in unvaccinated children and adults [22, 23]. Data on PCV impact in Asia and West Africa are limited [19, 24].

The World Health Organization (WHO) currently recommends both PCV booster-containing schedules (2 primary doses and 1 booster dose at 9–12 months of age: 2 + 1) and nonbooster-containing schedules (3 primary doses: 3 + 0) [25]. Most Gavi-eligible countries and all African countries except South Africa use a 3 + 0 schedule, because WHO initially recommended the 3 + 0 schedule, with the 2 + 1 schedule being an acceptable alternative [26]. Many countries also implemented the 3 + 0 schedule due to logistical harmonization with other infant immunizations and to maximize vaccination coverage. However, more recent data indicate that the 2 + 1 PCV schedule induces higher antibody levels in the second year of life [25, 27]. Therefore, it is important to evaluate whether PCV delivered on the 3 + 0 or the 2 + 1 schedule can control disease in high-transmission settings, such as meningitis belt countries, as effectively as PCV programs in other settings.

Before PCV13's introduction in Burkina Faso, the highest pneumococcal meningitis incidence and mortality occurred among children aged <1 year, and 71% of cases were due to PCV13 serotypes [28]. In the first 2 years after PCV13's introduction, there was a substantial (32%) reduction in meningitis due to PCV13-serotypes, both among vaccinated age groups (children aged <1 year: 76% reduction) and among older age groups potentially benefitting from herd protection (persons aged ≥15 years: 20% reduction) [24]. These early data suggested impact of PCV13, but further effects on herd immunity and serotype 1 required continued monitoring.

In this study, we evaluate continued PCV13 impact 3 and 4 years after introduction, to guide discussions around a potential switch from the 3 + 0 schedule to a 2 + 1 schedule in an effort to better control pneumococcal meningitis in Burkina Faso.

METHODS

13-Valent Pneumococcal Conjugate Vaccination

The PCV13 was introduced into the routine immunization program nationwide on October 31, 2013, with doses administered to children aged 8, 12, and 16 weeks. The WHO-UNICEF estimate of vaccination coverage with 3 doses of PCV13 in Burkina Faso was 91% for 2014–2017, based on coverage reported by the national government [29]. In 2017, Burkina Faso had a total population of 19 632 147 and an estimated birth cohort of 762 074.

National Surveillance System

Burkina Faso has collected high-quality case-based meningitis surveillance data nationwide since 2010 and joined MenAfriNet in 2015 [13, 28, 30, 31]. Case-level demographic and clinical information, as well as cerebrospinal fluid (CSF) specimens, are collected from all suspected meningitis cases in all 70 districts using WHO and MenAfriNet instruments [28, 32] and tested at 5 national reference laboratories.

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According to WHO case definitions [33], a suspected meningitis case is sudden onset of fever ≥38.5°C with neck stiffness, altered consciousness, or other meningeal signs (including flaccid neck, bulging fontanel, or convulsions in young children). A laboratory-confirmed pneumococcal meningitis case is a suspected case with *S pneumoniae* isolated from CSF by culture or detected in CSF by real-time polymerase chain reaction (PCR) or latex agglutination, using laboratory methods previously described and supported by the MenAfriNet Consortium [28, 34]. In the case of discrepant results for case confirmation, methods were considered confirmatory in the following order: PCR, culture, and latex agglutination. Pneumococcal serotyping was performed using a multiplex real-time PCR approach; however, this method was unable to differentiate some genetically similar serotypes (eg, 12F/12A/12B/44/46) [35].

Statistical Methods

We analyzed meningitis cases diagnosed from January 1, 2011 to December 31, 2017. A pre-PCV13 period (2011–2013) and a post-PCV13 period (2014–2017) were defined, although this analysis primarily focuses on the third and fourth years post-PCV13 introduction (2016–2017). Cases in nonresidents of Burkina Faso (n = 56) were excluded from analyses.

Pneumococcal meningitis cases were categorized as due to PCV13 serotypes (1, 3, 4, 5, 6A/6B, 7F/7A, 9V/9A, 14, 18C/18F/18B/18A, 19A, 19F, or 23F), non-PCV13 serotypes, or nontypeable specimens. Annual incidences (cases per 100 000 persons) were calculated using age-stratified population census estimates projected from the 2006 census. Within each age stratum (<1 year, 1–4 years, 5–9 years, 10–14 years, and ≥15 years), the number of cases confirmed by culture or PCR as *S pneumoniae* was divided by the number of cases with CSF tested via culture or PCR at a national laboratory. This proportion was then applied to the number of suspected meningitis cases within that age stratum for which no diagnostic testing was performed; this number was then added to confirmed cases to calculate the adjusted incidence.

To calculate the annual incidence of PCV13, non-PCV13, and nontypeable pneumococcal meningitis, the adjusted pneumococcal meningitis incidence in each age group was multiplied by the proportion of serotyped cases in each category. Percentage change ([relative risk − 1] × 100) in incidence with 95% confidence intervals (CIs) was calculated using the mean incidence pre-PCV13 (2011–2013) compared with individual post-PCV13 years (2016 and 2017) and the Poisson distribution for incidence rates. As a sensitivity analysis, percentage changes were also calculated comparing the most recent pre-PCV13 year (2013) to the most recent post-PCV13 year (2017). The CFRs were calculated by dividing the number of reported deaths by the total number of cases.

Study Approval

This analysis was approved by Burkina Faso Ministry of Health ethical committee and was determined by the Centers for Disease Control and Prevention's (CDC) Human Research Protection Office to be public health nonresearch. Because this analysis involved routinely

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collected surveillance data, informed consent was not required. Surveillance data were anonymized to maintain patient privacy and confidentiality.

RESULTS

Data Completeness and Quality

From 2016 to 2017, 5167 suspected meningitis cases were reported; CSF was collected in almost all cases (98%) (Supplemental Table 1). Ninety-one percent of CSF specimens were tested by Gram stain, 16% were tested by latex, 8% were tested by culture, and 74% were tested by PCR. In total, 79% were tested by latex, culture, or PCR.

Pneumococcal Meningitis

In 2016–2017, 917 meningitis cases were laboratory-confirmed via latex, culture, or PCR as *S pneumoniae* (Table 1). The majority (857 of 875; 97.9%) of pneumococcal meningitis cases were confirmed using PCR, with or without another positive test (Supplemental Table 2). In total, 739 of 917 (81%) specimens could be serotyped (Supplemental Table 3). Among these, 540 (73%) had a serotype and 199 (27%) were nontypeable. The proportion of pneumococcal meningitis cases among all ages that were serotyped increased from 60% in 2011 to 86% in 2017. The CFR was 15% overall and was lowest among infants aged <1 year (8%). The CFR among all ages declined over time, from 28% in 2011 to 12% in 2017.

13-Valent Pneumococcal Conjugate Vaccine Impact

From pre-PCV13 baseline (2011–2013) to 2017, pneumococcal meningitis incidence among all ages decreased by 52% (95% CI, 46%–57%) from 5.6 to 2.7 cases per 100 000 (Table 2). The largest decline was observed among children aged <1 year (61%; 95% CI, 49%–70%; 26.9 to 10.5 cases per 100 000) (Figure 1).

By 2017, incidence of PCV13 serotype disease among all ages decreased by 62% (95% CI, 57%–67%), with significant decreases observed among all age groups: children aged <1 year (77%; 95% CI, 65%–84%), children aged 1–4 years (44%; 95% CI, 22%–60%), children aged 5–14 years (61%; 95% CI, 52%–69%), and persons aged ≥15 years (64%; 95% CI, 53%–72%) (Table 2, Figure 2). Incidence of non-PCV13 serotype disease also declined: 53% (95% CI, 37%–65%) among all ages and 68% (95% CI, 39%–84%) among children aged <1 year. However, the absolute decline in incidence was larger for PCV13 serotypes than for non-PCV13 serotypes: 2.5 vs 0.4 cases per 100 000 among all ages (13.3 vs 3.4 cases per 100 000 among children aged <1 year). A decrease in incidence among all ages was observed for the 12 PCV13 serotypes other than serotype 1 (79%; 95% CI, 72%–84%), with significant declines in all age groups and the largest decrease observed among children aged <1 year (87%; 95% CI, 78%–93%). Serotype 1 disease decreased by 52% overall, but the decrease was limited to children aged 5–14 years (58%; 95% CI, 47%–67%) and persons aged ≥15 years (62%; 95% CI, 49%–71%), with no significant change observed among children aged <5 years (Figures 3 and 4). Incidence of nontypeable disease did not significantly change (3%; 95% CI, −20% to 23%).

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In the sensitivity analysis comparing the most recent pre-PCV13 year (2013), which also had the lowest baseline pneumococcal meningitis incidence, to the most recent post-PCV13 year (2017), the decreases in incidence among all ages were more modest: a 23% decline (95% CI, 13%–31%) in pneumococcal meningitis and a 33% decline (95% CI, 22%–48%) in PCV13 serotypes (Supplemental Table 4). As with the primary analysis, the greatest decreases were observed among children aged <1 year; and decreases were observed among PCV13 serotypes other than serotype 1, but not among serotype 1.

Serotype Distribution

During the third and fourth years after introduction of PCV13 (2016–2017), the predominant disease serotypes within each age group were 1 (49%) and 12F/12A/12B/44/46 (11%) (Table 3). The proportion of cases due to serotype 1 increased with age, from 22% in children aged <1 year to 55% in persons aged ≥5 years. Serotype 1 accounted for 82% of PCV13 cases among all ages in 2016–2017, compared with 76% in 2014–2015 and 63% in 2011–2013 (Supplemental Table 3).

Among children aged <5 years, who would have been eligible to receive 3 doses of PCV13 by 2017, the proportion of serotyped cases caused by serotypes 3, 4, 5, 6A/6B, 7F/7A, and 14 was lower in 2016–2017 than in 2011–2013, whereas serotypes 19A, 19F, and 9V/9A disappeared, and the proportion of cases caused by serotypes 1, 18C/18F/18B/18A, and 23F increased (Supplemental Figure). Among children aged <5 years, 45% of cases in 2016–2017 were due to PCV13 serotypes; 16% were due to PCV13 serotypes other than serotype 1. In addition, for this age group, in each of the post-PCV13 years (2014, 2015, 2016, and 2017), the annual incidences of both PCV13 serotypes and PCV13 serotypes excluding serotype 1 were lower than in any of the pre-PCV13 years (2011, 2012, and 2013) (Figure 4).

DISCUSSION

Our findings suggest direct benefit from Burkina Faso’s infant PCV13 program; PCV13-serotype meningitis incidence among children aged <1 year was 77% lower in 2017 compared with pre-PCV13, equivalent to an absolute decline of 13.3 cases per 100 000. However, the observed decrease was primarily due to declines in PCV13 serotype disease excluding serotype 1. No significant decreases in serotype 1 disease were observed among the vaccine-eligible age groups by 4 years post-PCV13 introduction. By 2017, persons aged ≥5 years also had noticeable reductions in PCV13 serotype disease, including serotype 1 disease, although these age groups also experienced declines in meningitis due to non-PCV13 serotypes during this time period.

Compared to the previous early impact analysis in 2014–2015 [24], the 2016–2017 data showed that the overall annual incidence of pneumococcal meningitis and of meningitis due to PCV13 serotypes decreased each year since the introduction of PCV13 , from a 27% decline in all pneumococcal meningitis by 2014 to 52% decline by 2017, and from a 22% to 62% decline in meningitis caused by PCV13 serotypes. Decreases in PCV13 serotype disease incidence among children aged <1 year appeared to level off at a 76%–78% decrease in 2015–2017 (3.8–4.2 cases per 100 000), whereas disease trends among children aged 1–4

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years were inconsistent, with disease incidence increasing slightly in 2017. Possible herd effects among persons aged ≥5 years did not appear until 4 years post-PCV13 introduction, with 52%–57% declines in PCV13 serotype incidence in these older age groups by 2017. In addition, the yearly declines in disease due to PCV13 serotypes besides serotype 1 were greater than for serotype 1. Overall, these additional 2 years of data are encouraging and suggest continued PCV13 impact.

Serotype 1 continues to dominate as a cause of pneumococcal meningitis after PCV13 introduction, causing 49% of pneumococcal meningitis in all age groups and 55% of cases among those aged ≥5 years in 2016–2017. However, 84% of serotype 1 cases were in persons aged ≥5 years and, therefore, are not directly preventable by routine childhood immunization. Similar to meningococcal disease, pneumococcal serotype 1 disease demonstrates natural variations in incidence over time and can cause outbreaks when population immunity wanes [36]. In addition, serotype 1 transmission likely differs from that of other serotypes, because this serotype is not commonly found in pneumococcal carriage studies [37]. It is difficult to know what the natural trend of serotype 1 disease would have been in the absence of PCV13 introduction, making it difficult to assess PCV13 impact on serotype 1 disease in Burkina Faso. Although our data indicate decreases in disease caused by PCV13 serotypes excluding serotype 1, the 2016–2017 data show some changes in serotype 1 disease epidemiology compared with 2014–2015 [24]. First, children aged <1 year were the only age group to experience a significant decline in serotype 1 disease incidence (59% decrease) by 2015. By 2017, however, significant serotype 1 disease declines were only observed in persons aged ≥5 years (58% decrease in children aged 5–14 years and 62% decrease in persons aged ≥15 years). In addition, serotype 1 became the most common disease serotype among all age groups, including children aged <1 year; in fact, the highest incidence of serotype 1 disease in 2017 was among children aged <1 year (2.2 cases per 100 000).

The PCV13 given on a 3 + 0 schedule early in life may not be as effective at controlling disease caused by serotype 1 compared with that caused by other PCV13 serotypes circulating in Burkina Faso. In addition, Burkina Faso introduced PCV13 into the routine immunization program without a catch-up campaign, so full herd effects and control of serotype 1 disease may not be seen until more birth cohorts receive PCV13 or a booster dose is added to the schedule [27, 38, 39]. Switching to a 2 + 1 schedule involves removing 1 of the 3 primary doses (the middle dose, given at age 12 weeks) and adding a booster dose at the 9- to 12-month visit along with the first dose of measles-containing vaccine. Immunogenicity data show that expanding the interval between primary doses from 4 to 8 weeks improves the immune response [40]. In addition, a booster dose could lead to a longer duration of protection and improved effectiveness against serotype 1 disease [26], and it may help prevent PCV13-serotype pneumococcal carriage among toddlers, who are likely the primary source of pneumococcal transmission in the community [27]. Data from South Africa and elsewhere have demonstrated the 2 + 1 schedule’s effectiveness against all clinical endpoints and in reducing carriage of PCV13 serotypes [41, 42]. However, switching from a 3 + 0 schedule to a 2 + 1 schedule could have some challenges as well. A schedule switch would place PCV13 out of sync with other vaccines given at the 8, 12, and 16 week visits, including the pentavalent (diphtheria-tetanus-pertussis-Hib-hepatitis B) and rotavirus

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vaccines, which would complicate logistics and could lead to decreased PCV13 vaccination coverage; monitoring delivery of the third (9- to 12-month) dose would be important. In addition, a switch would require intensive communication efforts targeting both caregivers and immunization staff, as well as careful monitoring of circulating serotypes before and after the switch to estimate impact.

The reason for the decline in incidence of non-PCV13 serotype disease after PCV13 introduction is unclear, although several possible explanations have been proposed [24], including environmental conditions less conducive to invasion by bacterial organisms inhabiting the nasopharynx or that the years used as a pre-PCV13 baseline (2011–2013) could represent a natural high point in the cyclical nature of pneumococcal meningitis incidence. In the absence of more years of quality pre-PCV13 surveillance data, it is difficult to be fully confident in the true baseline level of disease. In addition, the proportion of pneumococcal meningitis specimens found to be nontypeable increased over time: from 15% in 2011–2013, to 16% in 2014–2015, to 27% in 2016–2017, despite ongoing use of both real-time PCR and conventional PCR methods. However, this increasing proportion could be an artifact of a decrease in disease due to PCV13 serotypes, because the incidence of nontypeable disease among all ages remained steady during these time periods: 0.9 cases per 100 000 in 2011–2013, 0.6 in 2014–2015, and 0.8 in 2016–2017. The relatively high proportion of nontypeable strains is consistent with previous studies in the region [7], and may reflect circulating serotypes not covered by existing serotyping methods or low antigen levels in the tested specimens, because the majority of serotyping was performed directly on CSF specimens rather than cultured isolates. The decreasing incidence of non-PCV13 serotypes and steady incidence of nontypeable disease suggest that serotype replacement is not likely occurring in Burkina Faso.

Because surveillance only captured meningitis cases, we were unable to estimate PCV13 impact on other clinical syndromes such as pneumonia and bacteremia, which may have a somewhat different serotype distribution. However, the decrease in pneumococcal meningitis incidence among children aged <5 years observed by 2017 (48%) was comparable to the decreases in IPD incidence reported in South Africa (79% among children aged <5 years by 6 years post-PCV13 introduction) and The Gambia (55% among children aged <2 years by 3 years postintroduction) [19, 43]. In addition, focusing exclusively on meningitis may preclude a full understanding of potential herd protection, because PCVs have been shown to decrease pneumonia among older age groups [18]. Preliminary analysis of pneumococcal carriage study findings in Burkina Faso show reduction in PCV13-serotype carriage after PCV13 introduction but little evidence of herd effects (CDC and Burkina Faso Ministry of Health, unpublished data), significantly less than the reduction of vaccine serotypes seen in carriage studies from countries that include a booster dose [44]. Monitoring changes in pneumococcal carriage in Burkina Faso will aid our understanding of PCV13 impact and pneumococcal transmission dynamics [37].

CONCLUSIONS

This analysis adds to the literature regarding pneumococcal meningitis and the impact of PCV13 in West Africa [8, 19, 24] using nationwide population-based surveillance data

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with routine pneumococcal serotyping. The data suggest a positive impact of PCV13 in Burkina Faso; however, the observed post-PCV13 decline in meningitis due to non-PCV13 serotypes and the absence of a longer prevaccination observation period make it difficult to attribute observed decreases in PCV13 serotype incidence directly and solely to the vaccine. Continued robust meningitis surveillance [13], real-time specimen tracking [45], high levels of laboratory confirmation [31, 34], and pneumococcal serotyping in Burkina Faso will allow monitoring of the medium- and long-term impact of PCV13, including changes in incidence among young children, herd protection among older age groups, impact on serotype 1 disease, and potential serotype replacement. Strong surveillance data can be used to evaluate a potential switch from a 3 + 0 schedule to a 2 + 1 schedule, and data such as these are currently being used to inform recommendations for the prevention and response to pneumococcal meningitis outbreaks in the meningitis belt. This evaluation of PCV13 impact shows encouraging results, and, if trends continue, PCV13 may build on the success of Hib and MACV vaccination programs in reducing the burden of bacterial meningitis in Burkina Faso and make progress towards the global goal of defeating meningitis by 2030 [46].

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

Acknowledgments.

We thank the Burkina Faso national health system, including the patients and their families, all participating health centers and laboratories, the Direction de la Protection de la Santé de la Population, and the Direction de Prévention par la Vaccination. We also appreciate colleagues in the US Centers for Disease Control and Prevention's Bacterial Meningitis Laboratory and Streptococcus Laboratory for their support and input.

Disclaimer.

The findings and conclusions in this report are those of the authors and do not necessarily represent the official position of the Centers for Disease Control and Prevention.

Financial support.

This work was funded by the MenAfriNet consortium (www.menafrinet.org) through a grant from the Bill & Melinda Gates Foundation (OPP1084298).

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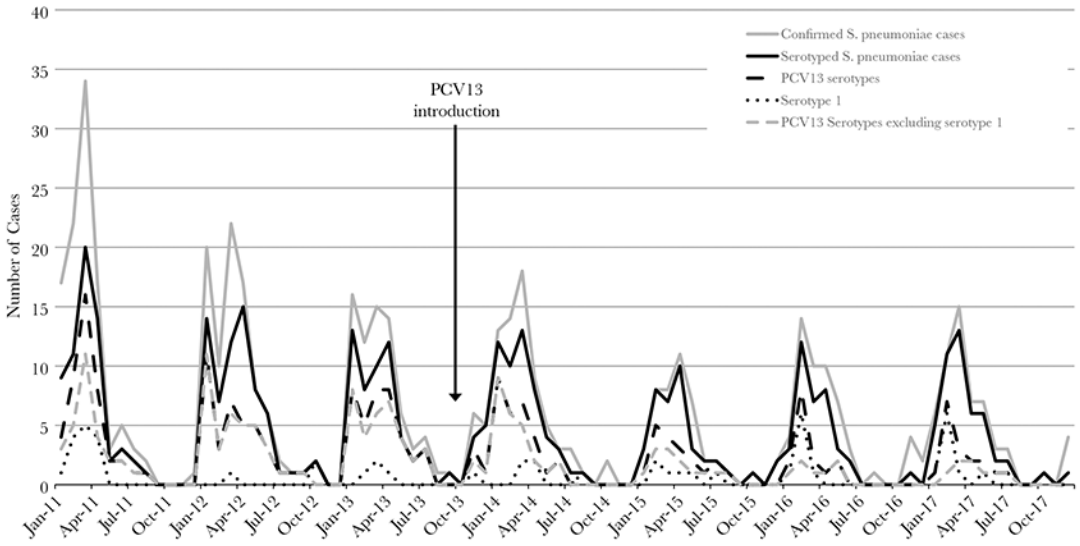

Figure 1.

Epidemic curve of confirmed pneumococcal meningitis cases, serotyped cases, 13-valent pneumococcal conjugate vaccine (PCV13) serotypes, serotype 1, and PCV13 serotypes excluding serotype 1 among children aged <1 year, by month, Burkina Faso, 2011–2017. *Streptococcus pneumoniae* isolated from cerebrospinal fluid (CSF) by culture or detected in CSF by real-time polymerase chain reaction or latex agglutination.

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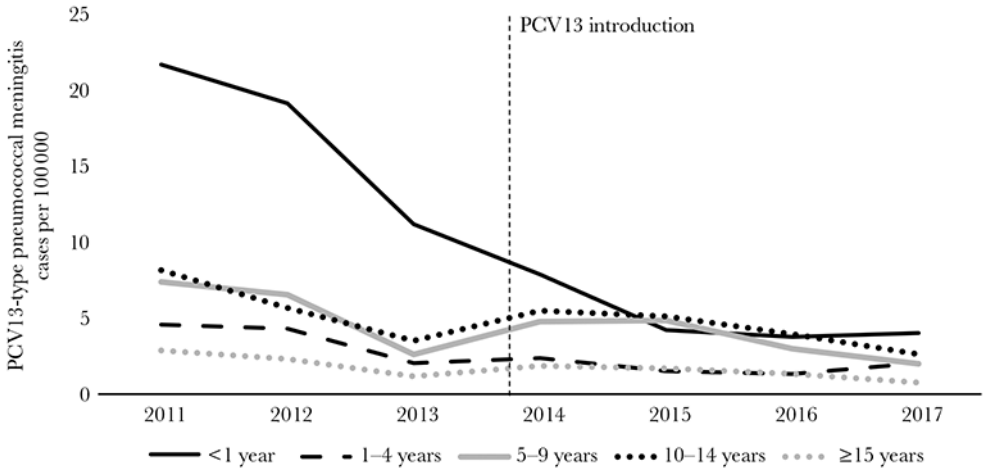

Figure 2.

Annual incidence of pneumococcal meningitis caused by 13-valent pneumococcal conjugate vaccine (PCV13) serotypes, by patient age group, Burkina Faso, 2011–2017.

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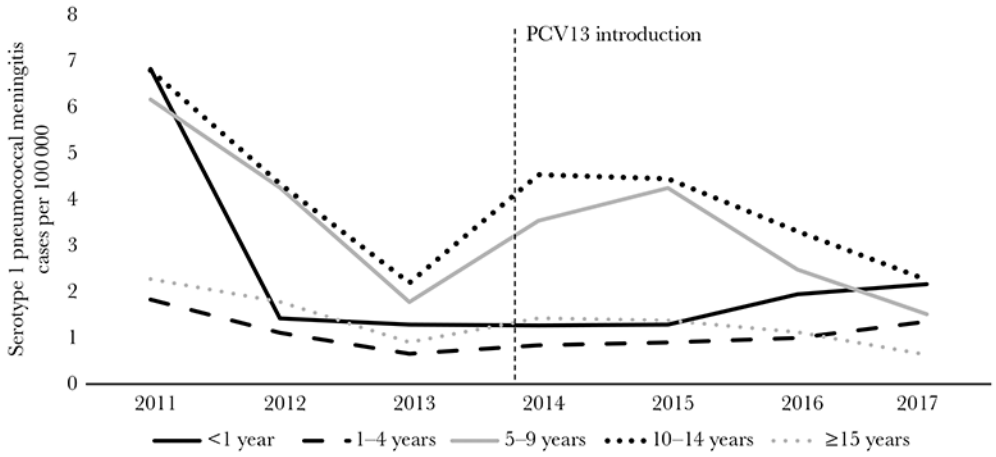

Figure 3.

Annual incidence of serotype 1 pneumococcal meningitis, by patient age group, Burkina Faso, 2011–2017. PCV13, 13-valent pneumococcal conjugate vaccine.

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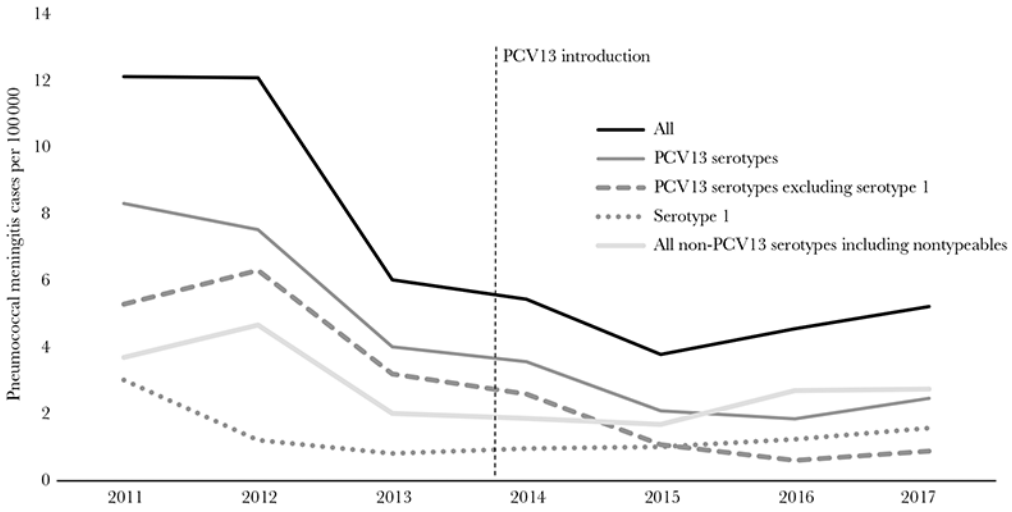

Figure 4.

Annual incidence of pneumococcal meningitis among children aged <5 years, by serotype category, Burkina Faso, 2011–2017. PCV13, 13-valent pneumococcal conjugate vaccine.

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Table 1.

Pneumococcal Meningitis Cases: Burkina Faso, 2011–2017

	2011	2012	2013	Pre-PCV13 2011–2013	2014	2015	2016	2017	Post-PCV13 2014–2017	Total
Pneumococcal meningitis cases	**N (%)**	**N (%)**	**N (%)**	**N (%)**	**N (%)**	**N (%)**	**N (%)**	**N (%)**	**N (%)**	**N (%)**
Laboratory-confirmed pneumococcal meningitis cases[a]	642	462	424	1528	502	551	520	397	1970	3498
Patient age group[b]										
<1 year	104 (16)	89 (19)	83 (20)	276 (18)	68 (14)	45 (8)	55 (11)	57 (14)	225 (11)	501 (14)
1 year	19 (3)	25 (5)	21 (5)	65 (4)	17 (3)	9 (2)	22 (4)	24 (6)	72 (4)	137 (4)
2–4 years	54 (8)	46 (10)	37 (9)	137 (9)	34 (7)	39 (7)	51 (10)	54 (14)	178 (9)	315 (9)
5–9 years	134 (21)	97 (21)	81 (19)	312 (20)	113 (23)	141 (26)	119 (23)	74 (19)	447 (23)	759 (22)
10–14 years	125 (20)	81 (18)	81 (19)	287 (19)	113 (23)	124 (23)	122 (23)	80 (20)	439 (22)	726 (21)
15–29 years	114 (18)	68 (15)	71 (17)	253 (17)	83 (17)	120 (22)	87 (17)	68 (17)	358 (18)	611 (18)
≥30 years	92 (14)	56 (12)	50 (12)	198 (13)	74 (15)	73 (13)	62 (12)	40 (10)	249 (13)	447 (13)
Reported deaths	179 (28)	94 (20)	84 (20)	357 (23)	99 (20)	101 (18)	90 (17)	49 (12)	339 (17)	696 (20)

Abbreviations: CSF, cerebrospinal fluid; PCV13, 13-valent pneumococcal conjugate vaccine.

[a] *Streptococcus pneumoniae* isolated from CSF by culture or detected in CSF by real-time polymerase chain reaction or latex agglutination.

[b] Two cases missing age in 2016.

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Table 2.

Annual Incidence (Cases per 100 000 Persons) of Pneumococcal Meningitis[a,b] by Serotype Groups and Patient Age, Burkina Faso, 2011–2017

Serotype group and patient age category	Pre-PCV13 2011–2013	2014	2015	2016	2017	Percentage Change (95% Confidence Interval)	
						2016 Only vs 2011–2013	2017 Only vs 2011–2013
All pneumococcal meningitis cases	5.6	4.1	3.9	3.4	2.7	−39% (−45% to −33%)	−52% (−57% to −46%)
<1 year	26.9	13.7	8.7	9.0	10.5	−66% (−74% to −56%)	−61% (−70% to −49%)
1–4 years	5.4	3.2	2.4	3.3	3.8	−39% (−53% to −20%)	−30% (−46% to −10%)
5–14 years	7.2	6.2	6.5	5.2	3.5	−27% (−38% to −15%)	−52% (−59% to −43%)
≥15 years	3.0	2.5	2.6	1.9	1.4	−36% (−47% to −23%)	−54% (−63% to −44%)
PCV13 serotypes	4.0	3.1	2.7	2.0	1.5	−49% (−55% to −42%)	−62% (−67% to −57%)
<1 year	17.3	7.9	4.2	3.8	4.0	−78% (−86% to −67%)	−77% (−84% to −65%)
1–4 years	3.6	2.4	1.5	1.3	2.0	−63% (−75% to −46%)	−44% (−60% to −22%)
5–14 years	5.3	4.8	4.5	3.6	2.1	−33% (−44% to −19%)	−61% (−69% to −52%)
≥15 years	2.1	1.9	1.7	1.3	0.8	−37% (−49% to −21%)	−64% (−72% to −53%)
Non-PCV13 serotypes	0.7	0.6	0.4	0.5	0.3	−27% (−44% to −5%)	−53% (−65% to −37%)
<1 year	5.0	4.2	1.6	2.8	1.6	−44% (−68% to −4%)	−68% (−84% to −39%)
1–4 years	0.6	0.3	0.1	0.7	0.4	21% (−38% to 135%)	−29% (−67% to 50%)
5–14 years	0.9	0.7	0.8	0.6	0.4	−39% (−61% to −4%)	−57% (−74% to −30%)
≥15 years	0.4	0.2	0.4	0.3	0.2	−35% (−60% to 5%)	−52% (−72% to −19%)
Nontypeable specimens	0.9	0.4	0.8	0.8	0.8	−6% (−25% to 18%)	−3% (−23% to 20%)
<1 year	4.6	1.6	2.9	2.5	4.9	−45% (−69% to −3%)	7% (−33% to 71%)
1–4 years	1.2	0.5	0.9	1.3	1.3	8% (−34% to 77%)	11% (−32% to 81%)
5–14 years	0.9	0.7	1.1	1.1	1.0	18% (−20% to 72%)	8% (−26% to 59%)
≥15 years	0.5	0.4	0.4	0.3	0.4	−31% (−56% to 8%)	−13% (−43% to 33%)
PCV13 serotypes excluding serotype 1	1.5	1.0	0.5	0.3	0.3	−78% (−83% to −71%)	−79% (−84% to −72%)
<1 year	14.0	6.6	2.9	1.8	1.8	−87% (−93% to −78%)	−87% (−93% to −78%)
1–4 years	2.4	1.5	0.6	0.3	0.6	−88% (−94% to −74%)	−73% (−84% to −54%)
5–14 years	1.1	0.9	0.6	0.5	0.3	−56% (−72% to −29%)	−76% (−86% to −56%)
≥15 years	0.4	0.4	0.3	0.2	0.1	−58% (−76% to −26%)	−75% (−87% to −50%)
Serotype 1	2.5	2.2	2.2	1.7	1.2	−31% (−41% to −21%)	−52% (−59% to −44%)
<1 year	3.3	1.3	1.3	2.0	2.2	−39% (−68% to 17%)	−32% (−74% to 27%)

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Serotype group and patient age category	Pre-PCV13 2011–2013	2014	2015	2016	2017	Percentage Change (95% Confidence Interval)	
						2016 Only vs 2011–2013	2017 Only vs 2011–2013
1–4 years	1.2	0.9	0.9	1.0	1.4	−17% (−50% to 39%)	13% (−30% to 80%)
5–14 years	4.2	4.0	3.9	3.1	1.8	−27% (−40% to −11%)	−58% (−67% to −47%)
≥15 years	1.7	1.5	1.4	1.2	0.7	−32% (−47% to −14%)	−62% (−71% to −49%)

Abbreviations: CSF, cerebrospinal fluid; PCV13, 13-valent pneumococcal conjugate vaccine.

[a] Streptococcus pneumoniae isolated from CSF by culture or detected in CSF by real-time polymerase chain reaction or latex agglutination.

[b] Incidence adjusted for the proportion of cases with CSF tested at a national laboratory.

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Table 3.

Distribution of Pneumococcal Serotypes By Patient Age, Burkina Faso, 2016–2017

	<1 Year		1 Year		2 Years		3–4 Years		≥5 Years		Total	
Pneumococcal Serotype	**N (%)**		**N (%)**		**N (%)**		**N (%)**		**N (%)**		**N (%)**	
PCV13 serotypes	33	(40)	18	(50)	11	(38)	28	(55)	348	(65)	438	(59)
1	18	(22)	11	(31)	8	(28)	22	(43)	299	(55)	358	(49)
3	1	(1)	1	(3)	0	(0)	0	(0)	7	(1)	9	(1)
4	1	(1)	0	(0)	0	(0)	0	(0)	4	(1)	5	(1)
5	3	(4)	2	(6)	1	(4)	1	(2)	7	(1)	14	(2)
6A/6B	3	(4)	2	(6)	0	(0)	1	(2)	5	(1)	11	(1)
7F/7A	0	(0)	0	(0)	1	(3)	0	(0)	4	(1)	5	(1)
9V/9A	0	(0)	0	(0)	0	(0)	0	(0)	1	(0.2)	1	(0.1)
14	1	(1)	0	(0)	0	(0)	0	(0)	7	(1)	8	(1)
18C/18F/18B/18A	4	(5)	1	(3)	1	(3)	3	(6)	9	(2)	18	(2)
19A	0	(0)	0	(0)	0	(0)	0	(0)	0	(0)	0	(0)
19F	0	(0)	0	(0)	0	(0)	0	(0)	0	(0)	0	(0)
23F	2	(2)	1	(3)	0	(0)	1	(2)	5	(1)	9	(1)
Non-PCV13 serotypes	18	(22)	8	(22)	6	(21)	4	(8)	66	(12)	102	(14)
2	6	(7)	0	(0)	0	(0)	0	(0)	4	(1)	10	(1)
8	0	(0)	0	(0)	0	(0)	0	(0)	1	(0.2)	1	(0.1)
9N/9L	0	(0)	0	(0)	0	(0)	0	(0)	1	(0.2)	1	(0.1)
10A	0	(0)	0	(0)	1	(3)	0	(0)	2	(0.4)	3	(0.4)
10F/10C/33C	1	(1)	0	(0)	0	(0)	0	(0)	0	(0)	1	(0.1)
12F/12A/12B/44/46	8	(10)	7	(19)	5	(17)	4	(8)	55	(10)	79	(11)
13	1	(1)	0	(0)	0	(0)	0	(0)	0	(0)	0	(0.1)
16F	0	(0)	0	(0)	0	(0)	0	(0)	1	(0.2)	1	(0.1)
22F/22A	1	(1)	0	(0)	0	(0)	0	(0)	0	(0)	1	(0.1)
25F/25A/38	0	(0)	1	(3)	0	(0)	0	(0)	1	(0.2)	2	(0.3)
34	1	(1)	0	(0)	0	(0)	0	(0)	0	(0)	1	(0.1)
35B	0	(0)	0	(0)	0	(0)	0	(0)	1	(0.2)	1	(0.1)
Nontypeable specimens	32	(39)	10	(28)	12	(41)	19	(37)	126	(23)	199	(27)

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Pneumococcal Serotype	<1 Year N (%)		1 Year N (%)		2 Years N (%)		3–4 Years N (%)		≥5 Years N (%)		Total N (%)	
Total serotyped	83	(74)	36	(78)	29	(88)	51	(69)	540	(83)	739	(81)
Missing serotype[a]	29	(26)	10	(22)	4	(12)	23	(31)	112	(17)	178	(19)
Total	112		46		33		74		652		917	

Abbreviations: CSF, cerebrospinal fluid; PCR, polymerase chain reaction.

[a]Fifty-one cases were only positive via latex and could not be serotyped: 25 from 2016 and 26 from 2017 Serotype results were unavailable for 127 culture- and/or PCR-positive cases: 98 from 2016 and 29 from 2017