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Cost Calculator for Mass Vaccination Response to a US College Campus Outbreak of Serogroup B Meningococcal Disease

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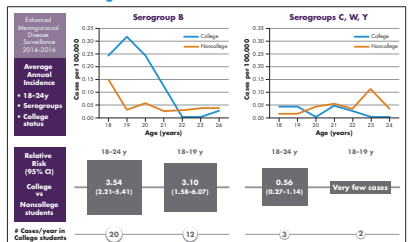
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INTRODUCTION

- Invasive meningococcal disease (IMD) is a life-threatening disease caused by the bacterium *Neisseria meningitidis*.
 - Despite receiving appropriate medical treatment, approximately 10% of people with IMD die.¹
 - Nearly 1 in 5 survivors may experience long-term consequences such as limb amputation, neurological impairment, or hearing impairment.²
- Meningococcal serogroup B (MenB) is the primary cause of IMD in the United States across all age groups, and is responsible for nearly 60% of IMD cases among individuals aged 16–23 years.³
- Between 2014 and 2016, 18- to 24-year-olds attending college had a higher average annual incidence and more cases of MenB disease than those not attending college (Figure 1).⁴

Figure 1. College Students Are at a ~3-Fold Higher Risk for MenB Disease Than Those Not Attending College, Particularly Those Aged 18–19 Years



- IMD outbreaks occur regularly (2–4/year) on US college campuses but can be difficult to predict and challenging to recognize in a timely manner.⁵
- Since 2011, MenB outbreaks on 10 US college campuses have resulted in 42 cases and 2 deaths (Table 1).⁶
- In February 2015, a MenB outbreak occurred at Providence College in Rhode Island; 2 cases were managed.⁷

Table 1. Meningococcal Serogroup B Outbreaks on College Campuses in the United States With CDC Consultation and MenB Vaccination, 2011–2018^{6,7}

School Location	US Campus Outbreaks				Mass Vaccination Response	
	Dates	Cases, n	Deaths, n	Under-graduates, n	Vaccinated With First Dose or Full Course, n	Doses in Vaccine Series, n
The Five College Consortium, Massachusetts ⁸	Oct 2017–Mar 2018	3	0	31,000	7700 (first dose)	NR
Oregon State University, Oregon	Nov 2016–Dec 2017	6	0	25,000	NR	2
University of Wisconsin–Madison, Wisconsin	Oct 2016	3	0	30,000	20,600 (first dose)	2
Rutgers University, New Jersey	Mar–Apr 2016	2	0	35,000	NR	3
Santa Clara University, California	Jan–Feb 2016	3	0	5,000	4921 (first dose)	2
University of Oregon, Oregon	Jan–June 2015	7	1	24,000	9193 (full course)	3
Providence College, Rhode Island	Feb 2015	2	0	4,000	2124 (full course)	3
UC Santa Barbara, California	Nov 2013	5	0	18,000	NR	NR
Prairie University, New Jersey	Mar 2013	9	1 ^a	5,000	NR	NR
Lehigh University, Pennsylvania	Nov 2011	2	0	5,000	NR	NR
Total		42	1	182,000		

CDC=Centers for Disease Control and Prevention; NR=not reported. ^aDeath of a student in a dormitory, University of Massachusetts at Amherst outbreak campus, Smith College. ^bMostly Hodge College, Amherst College, Massachusetts. ^cDeath of a student of neighboring Drexel University who was in contact with students at Prairie University.

INTRODUCTION (continued)

- Vaccines are available to help protect against IMD.
 - Current recommendations from the United States Advisory Committee on Immunization Practices (ACIP) for meningococcal vaccination are summarized in **Table 2**.⁸
 - MenB vaccine may be deployed to control campus outbreaks.⁹

Table 2. Advisory Committee on Immunization Practices (ACIP) Recommendations for Meningococcal Immunization⁸

Meningococcal Vaccine	ACIP Recommendation	Category of Recommendation
MenACWY	Routine vaccination for healthy adolescents aged 11–12 years, with booster dose at age 16 years	A
	Routine vaccination for individuals at increased risk ^a	A
MenB	Vaccination for healthy 16- to 23-year-olds (16–18 years preferred) in context of individual decision-making, in consultation with a healthcare provider	B

^aIncreased risk due to splenic complement deficiency or laboratory or outbreak exposure.

- Planning for controlling an IMD outbreak at a college or university is a significant logistical challenge that requires accurate assessment of resources and labor/nonlabor costs.

OBJECTIVE

- To enumerate costs incurred during a point-of-dispersing (POD), mass vaccination response to a US campus MenB disease outbreak

OUTBREAK RESPONSE

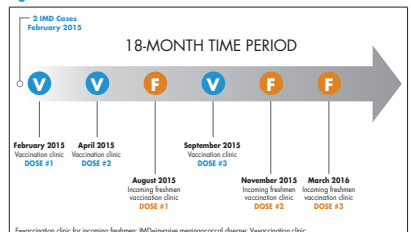
Mass Vaccination Campaign Characteristics

- In conjunction with the Centers for Disease Control and Prevention (CDC) and Rhode Island's State Medical Reserve Corps (MRC), Providence College implemented a mass vaccination campaign over 13 months using the MenB-FHbp vaccine (Trumenb[®], bivalent rLP2086; Pfizer Inc, Philadelphia, PA).⁷
- 3 mass vaccination events were held as large POD events.⁷
- Corresponding makeup PODs were held within 72 hours.
- 3 additional large on-campus PODs (with corresponding makeup PODs) were held for eligible incoming freshmen (Figure 2).

- Vaccine updates included
 - Existing students: Dose 1, 3525; Dose 2, 2988; Dose 3, 1670⁷
 - Incoming freshmen: Dose 1, 893; Dose 2, 543; Dose 3, 454

- The CDC covered acquisition costs for vaccine Dose 3 following Providence College's designation as an outbreak setting.

Figure 2. Timeline of Mass Vaccination and Events for Cost Calculator



V=Vaccination clinic for incoming freshmen; IMD=meningococcal disease; *Vaccination clinic.

METHODS

Cost Calculator Overview

- The MenB disease outbreak response at Providence College in 2015 was used as a case study.
- An Excel-based (Microsoft, Redmond, WA) cost calculator was developed to capture costs and resources associated with a MenB outbreak response. The calculator:
 - Includes user-modifiable inputs related to the vaccine-eligible population
 - Accounts for each vaccination event and vaccine dose (Figure 2)
 - Includes labor/nonlabor resource use inputs aligned with specific budgetary line items from Providence College's mass vaccination campaign
 - Modal assumptions were made in consultation with the Director of Emergency Management at Providence College
 - Estimates undiscounted direct medical and nonmedical costs (2016 US dollars) during the first 18 months postoutbreak
- Actual costs incurred were compared with potential/expected computed costs (assuming 100% vaccine coverage) using a ground-up or microcosting approach.

Input Parameters

- Population and outbreak characteristics
 - Target population at Providence College: 3745 then-current students and other eligible individuals to receive 3 doses of MenB-FHbp vaccine
 - Documented 2 cases of MenB disease, with 71 individuals receiving chemoprophylaxis (ie, 35.5 close contacts per case).^{7,9} consistent with the Providence College experience
- Labor resource and cost inputs
 - Reported labor costs were based on actual costs incurred by the college in 2015 and 2016 and reflect any labor received at reduced costs (eg, through MRC or volunteer efforts).
 - Staffing for one of the large PODs at Providence College included the Rhode Island MRC (n=93), the Rhode Island Department of Health (RIDOH; n=19), and Providence College (n=44, Figure 3).⁷
 - These data were used to estimate potential/expected labor resource use and associated costs by occupation and time period by applying mean national wages to the resources used (Table 3).
 - Providence College was assumed to bear the full cost of labor resources.

Figure 3. Labor Resources and Functions and Nonlabor Resources Used by Providence College During the 2015 Meningococcal Disease Outbreak



Table 3. Estimated Labor Resources and Unit Costs for Mass Vaccination at Providence College

Occupation	Mean Cost per Hour ^a	Preplanning Period		Each Mass Vaccination Event ^b		Year Following Mass Vaccination Event 3	
		Resources Used, n	Mean Hours per Resource	Resources Used, n	Mean Hours per Resource	Resources Used, n	Mean Hours per Resource
Clinical							
Family and general practitioners	98.54	2	2.0	5	6.6	2	20.0
Pharmacists	37.82	2	2.0	2	5.0	0	0
Nurse practitioners	49.30	0	0	12	6.0	0	0
Registered nurses	34.70	2	2.0	39	5.6	2	20.0
Licensed practical and licensed vocational nurses	21.58	0	0	3	7.2	0	0
Administrative							
Educational administrators, postsecondary	50.85	10	2.0	10	4.0	10	20.0
Emergency management directors	37.53	2	12.0	2	10.0	2	200.0
Public relations specialists	31.99	2	4.0	2	6.0	2	80.0
Health educators	27.84	0	0	4	6.0	0	0
Educational guidance, school, and vocational counselors	27.70	0	0	1	4.6	0	0
Social workers	24.38	0	0	2	5.7	0	0
Secretaries and administrative assistants, except legal, medical, and executive	17.38	2	2.0	5	4.0	2	10.0
Medical/technical assistance							
Epidemiologists	37.37	3	2.0	3	6.0	3	40.0
Medical records and health information technicians	19.93	0	0	5	4.0	0	0
Community health workers	19.80	0	0	1	9.7	0	0
Healthcare support workers, all other	18.13	0	0	7	4.0	0	0
Emergency medical technicians and paramedics	17.36	0	0	28	6.8	0	0
Medical secretaries	16.85	0	0	2	4.0	0	0
Other practical assistance							
Food service managers	26.93	2	2.0	2	4.0	0	0
Meeting, convention, and event planners	25.01	3	4.0	15	6.7	0	0
Bus drivers, school or special district	14.96	1	2.0	3	4.0	0	0
Janitors and cleaners, except maids and janitresses	12.99	0	0	2	4.0	0	0
Parking lot attendants	11.38	1	2.0	4	4.0	0	0

^aDefault number of resources used and mean hours per resource are presented for 1 mass vaccination event. These default values are equal for each of the 3 mass vaccination events because the target population for vaccination at Providence College was equal for each event. ^bMean cost per hour based on national occupational wage estimates in the United States in 2016 US dollars.

- Nonlabor resource and cost inputs
 - Default vaccine acquisition costs were based on the contracted price paid by Providence College (\$110 per dose for 3 doses).
 - Chemoprophylaxis costs were based on representative wholesale acquisition costs for ciprofloxacin (cost: \$0.30 per dose) and assumed that the full course of chemoprophylaxis was administered at the first large POD.

- The cost calculator provides additional details on nonlabor resources used at each large POD (ie, 55 tables, 400 chairs, 15 barriers, 4 refrigerators for vaccine storage; Figure 3).⁷

- Costs borne by other entities
 - The RIDOH planned and coordinated response efforts with the CDC and healthcare providers, and also disseminated public health concerns.¹⁰
 - Costs incurred by the local/state health departments were estimated based on the reviewed literature of measles and IMD outbreaks; on average cost of \$298 per close contact was assumed.
 - Costs of vaccine-related adverse events (AEs) were estimated based on probabilities and inflated costs of moderate and serious AEs from previous economic evaluations of meningococcal ACWY vaccination strategies.^{11,12}

METHODS (continued)

- Inputs were not included for costs associated with the following:
 - Treatment of AEs requiring hospitalization
 - Case identification and chemoprophylaxis efforts beyond those incurred by Providence College
 - Treatment of acute or long-term IMD cases
 - Productivity losses

Cost Calculator Outcomes

- Outcomes include the following:
 - Total number of individuals vaccinated with ≥1 dose
 - Total number and percentage vaccinated with all 3 doses
 - Actual and potential/expected costs (overall, labor/nonlabor costs paid by the university, and costs paid by other entities)
 - Actual and potential/expected costs per individual ever vaccinated, per individual fully vaccinated, and per IMD case

RESULTS

Calculator Outputs

- In all, 4418 individuals (92.1%) received ≥1 dose of the MenB-FHbp vaccine, and 2124 (44.3%) completed the 3-dose vaccine course.⁷
- Based on actual vaccinations received, the cost calculator computed \$1,350,963 in aggregate direct costs over the 18-month time period (\$805.79 per person receiving ≥1 vaccine dose, \$636.05 per person receiving all 3 vaccine doses, and \$675,481.50 per IMD case; Table 4).
- Providence College incurred 69.4% of these costs.

Table 4. Vaccination Coverage and Actual and Potential/Expected Direct Costs by Resource Category for Providence College^a

Outcome	Actual	Potential/Expected
Coverage outcomes		
People vaccinated with ≥1 dose, n	4418	4795
People vaccinated with all 3 doses, n	2124	4795
Completed full course, % of target population	44.3	100
Cost outcomes (college/university paid), \$		
Labor resource costs	91,418	153,702
Nonlabor resource costs	845,642	1,621,905
Medical supplies (including vaccine + chemoprophylaxis cost)	806,109	1,582,371
Supplies	1247	1247
Rentals	1426	1426
Food charges	28,065	28,065
Security chargebacks	611	611
Equipment – noncapital	6480	6480
Copy center	1693	1693
Copy center		
Medical supplies (CDC-covered vaccine costs)	391,600	21,158
Case identification (local health department paid)	21,158	21,158
Uncovered indirect adverse events		
Total costs, \$	1,350,963	1,798,399
College/university paid	937,060	1,775,607
Other entities paid	413,903	22,792
Total costs per person ever vaccinated ^b	305.79	375.06
Total costs per person fully vaccinated ^c	636.05	375.06
Total costs per IMD case	675,481.50	1891,950

CDC=Centers for Disease Control and Prevention; IMD=meningococcal disease; POD=point of dispersing. ^aActual and potential/expected costs are the same for some cost categories because the cost calculator does not include resource use estimates for these categories; the use of the scaling factor in the calculator to estimate the cost based on the target population size at Providence College planned for 3 large PODs in which 3745 then-current students and other eligible individuals would be vaccinated and 3 large PODs in which 1000 incoming freshmen would be vaccinated. Actual numbers of individuals vaccinated included 4418 individuals receiving the first dose, 2531 receiving the second dose, and 2124 receiving the third dose. ^bReceived 3 doses of vaccine. ^cReceived 3 doses of vaccine.

- Based on estimated total potential/expected costs, the cost calculator estimated \$1,798,399 for full vaccination of a planned target population of 4795 individuals (\$375.06 per person receiving all 3 vaccine doses; Table 4).
- Both analyses found that 88%–89% of costs were for medical supplies, 7%–9% were for labor resources, and 1%–2% were for food charges.

CONCLUSIONS

- This cost calculator quantifies the direct cost of a mass vaccination response to a MenB outbreak on 1 campus.
- Estimated costs exceeded both the average cost for a “large” outbreak containment strategy (\$579,851; range: \$105,484–\$1,081,627) and the average cost per IMD case reported in a recent systematic review.¹⁶

- Experiences at other US colleges/universities and in other noncollege/nonuniversity settings may vary substantially.
- Because it is difficult to forecast how quickly a government entity will declare an IMD outbreak and provide assistance, universities have to budget for the complete fiscal cost of outbreak containment for their entire at-risk student population.

- The variance between estimated and actual total costs at Providence College largely resulted from the CDC's decision to cover all costs for the third vaccine dose for then-current students and all doses for incoming freshmen.

- The calculator likely underestimates the true costs of a meningococcal outbreak, because

- It does not include costs appropriate for a full economic analysis (eg, costs related to treatment of acute or long-term IMD cases).
- It does not account for productivity losses related to the time required to implement a mass vaccination campaign.

- This outbreak response cost calculator suggests a need to shift the public health response from outbreak control to prevention by proactive, prescriptive vaccination using available licensed meningococcal vaccines.

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