APPENDIX

Table A1. Description of MCP Regular Service Days and Summer Event Days in 2014[a]

	Regular service days	**Summer event days**
Scope of service	Immunization, well-child check-up, illness evaluation, school and sports physical, urgent care, lab services, and immunization.	Immunization
Operational months	September – mid-July	Late July – August
Operational days in a week	Monday through Thursday	Irregularly but daily Monday through Thursday and Saturday
Operational days in 2014	185 days	25 days
Daily operating hours	4- 4.5 hours	3- 5 hours
Number of operating clinics/events in one day	Mostly 2	1 or 2
Staff involved per site	1 provider, 2 staff, 1 volunteer	2 providers, 3 staff, 2 volunteers
Data collection periods	Late spring (Apr 28- May 8) and early fall (Sep 2- 25, 2014)	Late summer (Aug 2-16, 2014)
Sample size	469 (208 from late Spring and 261 from early Fall)	836
Estimated daily visits in all sites	25	76
Information collected	Patient age, sex, language, insurance, visit info, services, travel time, transit and waiting time, and vaccines given.	Patient age, sex, event information, vaccines given

MCP= mobile clinic program.

[a] Information was provided by MCP. Sample information for regular service days was based on two time studies conducted in 2014. Sample information for summer event days was based on event records and vaccination records.

Table A2. MCP Patient Characteristics in the Regular Service Sample and the Summer Event Sample in 2014[a]

	Regular service sample (N=469)	Summer event sample (N=836)
Age, mean (SD), y	8.94 (4.51)	9.06 (4.87)
Male, %	54.09	49.5
No. vaccine doses given among vaccinated children, mean (SD)	3.14 (1.80)	3.15 (1.70)
Received 1 or more vaccines at visit, %	81.24	100.00
New patients, %	67.56	
Uninsured, %	89.85	
Primary language spoken, %		
English	34.76	
Spanish	62.66	
Other	2.58	
No. patients per family, %		
1	62.11	
2	26.43	
3	8.81	
4	2.64	

MCP= mobile clinic program. SD= standard deviation.

[a]The regular service sample was based on two time studies conducted in 2014. The summer event sample was retrospectively collected from event records and vaccination records. We tested differences for the first three variables (age, male, and vaccine doses given among vaccinated children) in the regular service sample versus the summer event sample. None of the differences were significant (p=0.66, 0.11, 0.89 respectively). Variables in the lower panel were only available in regular service sample, and we assumed patients in the summer event sample did not significantly differ in these variables.

Table A3. Data on Total Dose Counts, Percentages of Doses Given by Dose Order, Percentages of Benefit Contributed by Dose Order, and Coverage Rate by Dose Order in Sensitivity Analysis (1)

a. Data on Total Dose Counts, Percentages of Doses Given by Dose Order, and Benefit Contributed by Dose Order

Vaccine	Doses[a]	% of doses given as[b]					% benefit contributed by dose[c]					Ref[c]
		1st dose	2nd dose	3rd dose	4th dose	5th dose	1st dose	2nd dose	3rd dose	4th dose	5th dose	
DTaP	1,084	10	15	11	42	22	20	20	20	20	20	
Hep A	2,345	62	37	NA	NA	NA	95	5	NA	NA	NA	[10]
Hep B	1,257	28	38	26	NA	NA	32	42	26	NA	NA	[11]
Hib	442	19	26	13	42	NA	25	25	25	25	NA	
HPV												
Females	1,076	57	26	17	NA	NA	86	7	7	NA	NA	[12]
Males	1,075	57	26	17	NA	NA	86	7	7	NA	NA	[12]
Influenza	1,642	100	NA	NA	NA	NA	100	NA	NA	NA	NA	NA
IPV	1,970	21	22	18	21	NA	38	56	3	3	NA	[13]
MCV4	1,784	81	13	NA	NA	NA	50	50	NA	NA	NA	
MMR	1,772	38	61	NA	NA	NA	96	4	NA	NA	NA	[14]
PCV13	759	46	13	15	20	NA	32	32	4	32	NA	
Rota	77	58	33	8	NA	NA	64	33	3	NA	NA	[15]-[19]
Tdap	1,723	100	NA	NA	NA	NA	100	NA	NA	NA	NA	NA
Var	2,290	49	51	NA	NA	NA	91	9	NA	NA	NA	[9]

DTaP= diphtheria and tetanus toxoids and acellular pertussis vaccine. HepA= hepatitis A vaccine. HepB: hepatitis B vaccine. Hib= *Haemophilus influenzae* type b conjugate vaccine. HPV= human papillomavirus vaccine. IPV= inactivated poliovirus vaccine. MCV4= quadrivalent meningococcal conjugate vaccine. MMR= measles, mumps, and rubella vaccine. PCV13= 13-valent pneumococcal

conjugate vaccine. Rota= rotavirus vaccine. Tdap= tetanus toxoid, reduced diphtheria toxoid and acellular pertussis vaccine. Var= varicella vaccine. NA=not applicable.
[a]Doses represent the total doses of each vaccine component. They were estimated based on time studies and summer event data.
[b] Percentages of doses given by dose order were estimated based on time studies and summer event data. For Hib vaccine, the 4-dose ActHIB® formulation was used. For HPV vaccines, assume the proportion of doses given as each dose and the benefits contributed by each dose do not vary by sex. For rotavirus vaccines, the 3-dose RotaTeq® formulation was used.
[c] Percentages of benefit contributed by dose were calculated based on efficacy/effectiveness data with the references listed in the last column. For vaccines that reliable efficacy data were not available (DTaP, Hib, MCV4, PCV13), we reviewed other evidence and made assumptions about their benefit of each dose accordingly. Single-dose vaccines (Influenza and Tdap) have benefit 100% attributable to the 1st (the only) dose.

b. Data on Coverage Rate by Dose Order in Sensitivity Analysis (1)[a]

Vaccine	Coverage rate by dose order in sensitivity analysis (1), %				
	1st dose	2nd dose	3rd dose	4th dose	5th dose
DTaP	93.9	93.9	93.9	82.8	80
Hep A	92.4	67.5	NA	NA	NA
Hep B	80.6	85	87.8 (0-3 yrs); 81.4 (4-12 yrs); 75 (13-18 yrs)	NA	NA
Hib	94.2	94.2	94.2	84.7	NA
HPV					
Females	73.4	66.5	61.5	NA	NA
Males	58.1	39	25	NA	NA
Influenza	74.5 (0-4 yrs); 65.6 (5-11 yrs); 50.0 (12-18 yrs)	NA	NA	NA	NA
IPV	92.6	92.6	92.6	80	NA
MCV4	85.1	28.5	NA	NA	NA
MMR	91.4	79.7	NA	NA	NA
PCV13	92.2	92.2	92.2	82.9	NA
Rota	67.8	67.8	67.8	NA	NA
Tdap	85.8	NA	NA	NA	NA
Var	91.4 (0-3 yrs); 86.3 (4-12 yrs); 81.2 (13-18 yrs)	81.2	NA	NA	NA

DTaP= diphtheria and tetanus toxoids and acellular pertussis vaccine. HepA= hepatitis A vaccine. HepB: hepatitis B vaccine. Hib= *Haemophilus influenzae* type b conjugate vaccine. HPV= human papillomavirus vaccine. IPV= inactivated poliovirus vaccine. MCV4= quadrivalent meningococcal conjugate vaccine. MMR= measles, mumps, and rubella vaccine. PCV13= 13-valent pneumococcal conjugate vaccine. Rota= rotavirus vaccine. Tdap= tetanus toxoid, reduced diphtheria toxoid and acellular pertussis vaccine. Var= varicella vaccine. NA=not applicable.
[a] Coverage rates by dose were based on National Immunization Survey (NIS) estimated vaccination coverage with individual vaccines and selected vaccination series among children aged 19-35 months and children 13-17 years old living below the poverty level for the City of Houston, 2014[12-13] and influenza vaccine coverage for Texas, 2014[14]. For some vaccines, NIS estimates

differentiate coverage rates by doses administered and by age groups. We then applied the coverage rate to the corresponding doses and to the closest age group. For vaccine doses or age groups that such coverage rates were not available, we made assumptions based on coverage rates for other doses or age groups of the same vaccine as well as coverage rates of other vaccines with similar schedules.

c. Data on Uncertainty of Coverage Rate Estimates in Sensitivity Analysis (1)[a]

Vaccine component	95% confidence interval (±) of coverage rate estimates				
	1st dose	2nd dose	3rd dose	4th dose	5th dose
DTaP	5.0	5.0	5.0	8.6	5.7
Hep A	5.5	10.0	NA	NA	NA
Hep B	9.3	10.1	10.1	NA	NA
Hib	5.0	5.0	5.0	8.6	NA
HPV					
Female	14.8	15.4	15.7	NA	NA
Male	15.5	14.7	12.8	NA	NA
Influenza					
IIV: 6-23 mo	5.6	NA	NA	NA	NA
IIV: 2y	5.6	NA	NA	NA	NA
IIV: 3-4y	5.6	NA	NA	NA	NA
IIV: 5-11y	4.2	NA	NA	NA	NA
IIV: 12-17y	5.9	NA	NA	NA	NA
LAIV: 6-23 mo	5.6	NA	NA	NA	NA
LAIV: 2y	5.6	NA	NA	NA	NA
LAIV: 3-4y	5.6	NA	NA	NA	NA
LAIV: 5-11y	4.2	NA	NA	NA	NA
LAIV: 12-17y	5.9	NA	NA	NA	NA
IPV	5.5	5.5	5.5	5.7	NA
MCV4	8.1	2.8	NA	NA	NA
MMR	5.7	9.4	NA	NA	NA
PCV13	5.6	5.6	5.6	8.4	NA
Rota	11.6	11.6	1.6	NA	NA
Tdap	7.6	NA	NA	NA	NA
Var	8.3	10.1	NA	NA	NA

DTaP= diphtheria and tetanus toxoids and acellular pertussis vaccine. HepA= hepatitis A vaccine. HepB: hepatitis B vaccine. Hib= *Haemophilus influenzae* type b conjugate vaccine. HPV= human papillomavirus vaccine. IPV= inactivated poliovirus vaccine. MCV4= quadrivalent meningococcal conjugate vaccine. MMR= measles, mumps, and rubella vaccine. PCV13= 13-valent pneumococcal conjugate vaccine. Rota= rotavirus vaccine. Tdap= tetanus toxoid, reduced diphtheria toxoid and acellular pertussis vaccine. Var= varicella vaccine. NA=not applicable.

[a] The reported values are the 95% confidence intervals of vaccine-dose coverage rate estimates. They are based on the National Immunization Survey (NIS) estimated vaccination coverage with individual vaccines and selected vaccination series among children aged 19-35 months and children 13-17 years old living below the poverty level for the City of Houston, 2014[12-13] and influenza vaccine coverage for Texas, 2014[14]. For some vaccines, NIS estimates differentiate coverage rates by doses administered and by age groups. We then applied the coverage rate to the corresponding doses and to the closest age group. We used the widest confidence interval among related age groups coverage estimates for the dose. For vaccine doses or age groups

that such coverage rates were not available, we made assumptions based on coverage rates for other doses or age groups of the same vaccine as well as coverage rates of other vaccines with similar schedules.

Table A4. Benefit of Full-Series Vaccines and References

Vaccine component	Direct cost averted per series, 2014 $[a]	Societal cost averted per series, 2014 $[b]	Reference
DTaP	2,376	13,059	[8]
Hep A	21	41	[8]
Hep B	59	407	[8]
Hib	515	1,044	[8]
HPV			
Female	405	405	[20]
Male	151	151	[20]
Influenza	6	7	[21]
IPV	807	1,958	[8]
MCV4	5	18	[22]
MMR	1,497	3,253	[8]
PCV13	292	777	[8]
Rota	139	248	[8]
Tdap	21	33	[22]
Var	114	471	[8]

DTaP= diphtheria and tetanus toxoids and acellular pertussis vaccine. HepA= hepatitis A vaccine. HepB= hepatitis B vaccine. Hib= *Haemophilus influenzae* type b conjugate vaccine. HPV= human papillomavirus vaccine. IPV= inactivated poliovirus vaccine. MCV4= quadrivalent meningococcal conjugate vaccine. MMR= measles, mumps, and rubella vaccine. PCV13=13-valent pneumococcal conjugate vaccine. Rota= rotavirus vaccine. Tdap= tetanus toxoid, reduced diphtheria toxoid and acellular pertussis vaccine. Var= varicella vaccine.

[a] The direct cost averted associated with a full series of each vaccine component is the net savings per child from averted doctor visits, hospitalizations, and death minus cost associated with adverse events of vaccination.

[b] The societal cost averted associated with a full series of each vaccine component is the direct cost averted plus productivity loss due to mortality and morbidity. For HPV vaccine, we were unable to recover a productivity cost estimate from the reference, thus the societal costs averted were the same as the direct costs averted. For influenza vaccine, we were only able to add productivity loss due to premature death of children; therefore, the societal costs averted are likely to be underestimated.

Table A5. Cost estimates for vaccination services received in office-based setting when MCP is not available

	Regular service days	Summer event days	Total
Direct Cost			
Administration cost			
Administration cost/dose, $/dose	22.6	22.6	22.6
No. doses	9034	4717	13751
Administration cost total, $	204,161	106,608	310,769
Vaccine purchase cost, $	427,661	242,623	670,285
Travel cost			
No. parents	2835	1328	4163
No. patients	2835	1328	4163
Round trip cost per person, $	5	5	5
Travel cost of parents and patients, $	28,355	13,276	41,631
Direct cost, $	660,177	362,508	1,022,685
Societal cost			
Direct cost, $	660,177	362,508	1,022,685
Time loss of parents			
Avg one-way travel time, min	30	30	30
Avg waiting time (total transit in a visit) spent by patient with, min	60	60	60
Total time spent on a visit by parents in hrs	2	2	2
Total time of all parents in 2014, hr	5,671	2,655	8,326
Value of time (hourly wage), $/hr	7.25	7.25	7.25
Opportunity cost of parents, $	41,114	19,251	60,365
Societal cost, $	701,292	381,758	1,083,050

Note: Provider's cost of vaccination in office-based setting is assumed to be covered by administration cost (limited to $22.06 per dose in Houston[28]). Patient count is determined assuming the number of vaccine components received per patient is the same in both mobile clinic and office-based setting. Each child, even from one family, was assumed to require a separate appointment for vaccination. Travel cost was assumed to be doubled the travel cost to MCP. Parents' time spent on commuting is assumed to be doubled of the time in MCP and the time spent on waiting in the office was assumed to be 1 hour.

Cost Estimates of Vaccination in a Mobile Clinic Setting

We first estimated the cost from the MCP's perspective. This cost is the portion of the total MCP program cost that is attributable to vaccination. The program cost, which covered all operating expenses (including overhead), was obtained from the MCP 2014 financial report. Two types of relevant costs were not included as a cost of the MCP. One was capital cost, covering the purchase cost of two mobile clinics (mobile vans with medical equipment). The other was the purchase cost of vaccines. These costs were excluded because capital costs were covered by donors while vaccine costs were covered by the Vaccines for Children (VFC) program (all vaccines administered by the MCP are acquired through the VFC program because all children served are either uninsured or Medicaid-eligible, thereby eligible for VFC vaccines).

Our direct cost estimate, reflecting the resources consumed in providing and receiving the vaccination services, included the cost of the MCP, capital cost, vaccine cost, as well as travel cost for patients and parents traveling to the mobile clinics. For capital cost, we used the annualized economic cost of two mobile clinics to reflect their value in 2014. The mobile clinics cost donors $400,000 (in 2000 dollars) each. We assumed the life years of the mobile clinics to be 10 years, which was also used in a study of mobile dental units,[31] and the discount rate to be 3%. The vaccine purchase cost was calculated using the number of doses given for each vaccine in 2014 (internal data from the MCP) multiplied by the vaccine purchase prices in the public sector (from the CDC Vaccine Price List[32]). These prices reflect the purchase cost of vaccines by immunization programs that receive CDC immunization grant funds (state health departments, certain large city immunization projects, and certain current and former U.S. territories). Travel costs were estimated based on the number of round-trips patients and parents made. We used a

Houston bus ticket fare as a proxy for the cost of a one-way trip to the site for each person ($1.25 per ride for local/METRORail area in 2014). We assumed one accompanying parent per family.

Lastly, we estimated total societal cost, which is direct costs plus time loss or opportunity costs of parents and volunteers. The opportunity cost of parents' time spent taking children to the clinic or summer event included (1) travel time and (2) waiting time during the entire visit. Opportunity costs of volunteers were calculated based on service hours. The time of parents and volunteers was valued using the minimum hourly wage in Texas. When the professional title of volunteers was known, median hourly wage of the corresponding occupation (from the Bureau of Labor Statistics, BLS) in Texas in 2014 was applied. In the sensitivity analysis, we considered higher opportunity costs for parents and volunteers without titles to account for potential underestimation.

Benefit Estimates of Full Series of Vaccines

The benefit of receiving full series of each vaccine is measured by direct and societal cost averted. The direct cost averted is the net saving per child from averted doctor visits, hospitalizations, and death, minus cost associated with adverse events of vaccination. The societal cost averted is the direct cost averted plus productivity loss averted due to mortality and morbidity. The benefit estimates were based on vaccine components. Combination vaccines, such as measles, mumps, rubella, and varicella vaccine (MMRV), were broken down into one dose of each component vaccine, i.e. measles, mumps, and rubella vaccine (MMR) and Var, respectively. The vaccines included in the study were diphtheria and tetanus toxoids and acellular pertussis vaccine (DTaP), *Haemophilus influenzae* type b conjugate vaccine (Hib), hepatitis A vaccine (HepA), hepatitis B vaccine (HepB), human papillomavirus vaccine (HPV),

influenza vaccine, inactivated poliovirus vaccine (IPV), quadrivalent meningococcal conjugate vaccine (MCV4), MMR, 13-valent pneumococcal conjugate vaccine (PCV13), rotavirus vaccine (Rota), tetanus toxoid, reduced diphtheria toxoid and acellular pertussis vaccine (Tdap), and Var. Tetanus and diphtheria toxoid vaccine (Td) was provided by the MCP but excluded from benefit analysis, because there was a lack of reliable benefit estimate of Td, and Td was administered much less frequently than Tdap.

The analytic horizon for the cost averted estimation was from the recommended vaccination time to death. For influenza and HPV vaccines, information was not found for productivity loss.[20, 21] The societal costs averted for these two vaccines would, therefore, be underestimated.

In addition, for HPV vaccines, we further distinguished cost averted by sex, since females and males benefit differently from HPV vaccines. Among those who received HPV vaccines in our samples, the percentage of males was not different from 50% ($p=0.79$ and 0.21 in the regular service sample and the summer event sample, respectively), we thus assumed half of all HPV vaccines in 2014 were given to males. For influenza vaccines, two types (live attenuated influenza vaccine, LAIV, and inactivated influenza vaccine, IIV) were used in 2014. We distinguished the benefit estimates of the two[21] and the targeted age groups of the two (LAIV was used for children aged 2 years and above, and IIVs were used for children aged 6 months or above).[23] To account for the seasonality of influenza severity and vaccine effectiveness, we also incorporated uncertainties in the benefit of influenza vaccines in the sensitivity analyses.

All benefit estimates were adjusted to 2014 dollars by using general and medical Consumer Price Indices (from BLS).

Vaccination Coverage Rates Used to Estimate Benefit of Vaccination in Office-based Settings

We assume the probability that a vaccine was administered by other providers when the MCP was not available equals to the coverage rate of that vaccine. We obtained coverage estimates by vaccine component from the National Immunization Survey (NIS) among children living below the poverty level in the City of Houston[24-25] (except influenza vaccines). Since children served by the MCP were mostly uninsured and Medicaid-eligible from low-income families, we believe these estimates were close to real coverage rate among the served population. And also because the data were for the City of Houston, the survey sample would be similar to the served population in terms of race/ethnicity mix and other demographic characteristics. Nevertheless, it may still overestimate the chance of receiving vaccines in other settings because the coverage rates were reached given the existence of the MCP. As a result, the added benefit of the MCP could be underestimated.

For some vaccines, NIS estimates differentiate coverage rates by doses administered and by age groups. We applied the coverage rates to the corresponding doses and to the closest age groups. For vaccine doses or age groups that coverage rates were not available, we made assumptions based on coverage rates for other doses or age groups of the same vaccine and coverage rates of other vaccines with similar schedules. For influenza vaccines, data for children living below the poverty level in the City of Houston were not available for 2014 and we used 2014 state-level influenza coverage estimates for Texas[26] as a proxy. According to a study of influenza vaccination coverage of VFC-entitled versus privately insured children in 2011-2013,[27] the coverage for VFC-entitled children did not significantly differ from that for privately insured

children in Texas. However, these estimates were also likely to overestimate the probabilities for our purpose since Houston generally had lower coverage rate compared to other areas in Texas.

Cost of Vaccination in Office-Based Settings

When calculating incremental cost, we assumed provider's cost of vaccination in office-based setting was covered by administration cost (limited to $22.06 per dose in Houston[28]). We used dose counts administered in office-based setting that estimated above multiplying by $22.06 as the per dose administration fee to derive the total administration cost. We also adjusted for combination vaccine doses (based on percentages of combination doses observed in our sample for each vaccine component) since there would be fewer doses when combination vaccines were given. Travel cost was assumed to be doubled due to generally longer commute to an office-based provider than to the MCP that came to the community. Each child, even from one family, was assumed to require a separate appointment for vaccination (single trip accompanied by one parent for each child). The number of patients that would visit another provider had the MCP not existed is unknown, and this number would be less than the dose counts since one patient could receive more than one vaccine component at a visit. We derived the patient count assuming the number of vaccine components received per patient is the same in both mobile clinic and office-based setting. Parents' time spent on commuting was assumed to be doubled and parent's time spent in the office during the entire visit was assumed to be 1 hour.

Sensitivity Analyses

Given uncertainties in various parameters in the model, we conducted a series of probabilistic and one-way sensitivity analyses. Sensitivity analyses (1) to (4) assessed the impact

of uncertainties in benefit estimation and (5) to (8) addressed the uncertainties in cost estimation. Sensitivity analysis (9) presents the raw, rather than incremental, cost-benefit estimates from the baseline model.

In sensitivity analysis (1), we varied vaccine coverage rate estimates. Using the 95% confidence intervals that reported along with the coverage rate estimates from the references (Table A3.c), we assumed the coverage rates vary within the 95% confidence intervals following truncated normal distributions. Sensitivity analysis (2) let the estimates of non-influenza vaccine benefits (direct/societal costs averted) fluctuate 20% below and above the baseline. For influenza vaccines, additional uncertainty arose due to antigen-match, influenza severity, and other seasonal factors. We varied the benefit estimates of IIV from 50% to 150% of the baseline and that of LAIV from 0 to 110% of baseline. The downward (upward) variation of LAIV was set to be greater (lower) than that of IIV because there was evidence that LAIV was less effective than what estimated in prior studies.[29,30] Sensitivity analysis (3) varied the percentage of benefit attributable to the n^{th} dose. We assumed the percentages fluctuate 20% below or above the baseline (but within 0-100%) starting from the dose that contributed most to the ones that contributed less, the dose(s) that contributed the least were set equal to the complimentary percentages to sum up to 100%. Sensitivity analysis (4) assumed the percentages of doses given as the n^{th} dose vary from 20% below to 20% above the baseline (except the last dose(s), since it was set to be the complimentary percentage to sum up to 100%).

In sensitivity analyses (5)-(8), we considered alternative specifications in the cost analysis in the following scenarios: (5) the proportion of resources consumed attributable to vaccination during regular service days varies from 10 percentage points below to 10 percentage

points above the baseline (65% to 85%); (6) life years of mobile clinics vary from 5 to 20 years; (7) parents' opportunity cost per hour varies from the minimum hourly wage to the average hourly wage in Houston. We also increased the opportunity cost per hour for volunteers that served during regular service days (mostly medical students) from the minimum wage to the average hourly wage (no change for summer event days, since we knew the professional titles of those volunteers and used corresponding wages instead); (8) travel cost varies from 20% below to 20% above the baseline. For (7), We did not consider opportunity cost per hour higher than average hourly wage, given the fact that most children served by the MCP were uninsured or Medicaid-eligible, with low family income.

In sensitivity analysis (9), we showed cost-benefit estimates relative to no vaccination, which means children would forgo vaccination had MCP not existed.