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Current experience with school-located influenza vaccination programs in the United States

A review of the medical literature

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Abbreviations: LAIV, live attenuated influenza vaccine; NACCHO, National Association of City and County Health Officials; PTA, Parent Teacher Association; SLIV, school-located influenza vaccination; TIV, trivalent inactivated influenza vaccine; VFC, Vaccines for Children

In the United States, all children sic months through 18 years of age are recommended to be vaccinated against influenza annually. However, the existing pediatric immunization infrastructure does not have the capacity to vaccinate a high proportion of children each year. School-located influenza vaccination (SLIV) programs provide an opportunity to immunize large numbers of school-age children. We reviewed the medical literature in order to document the current US experience to benefit future SLIV programs. Published reports or abstracts for 36 SLIV programs were identified, some of which spanned multiple years. The programs immunized between 70–128,228 students. While most programs vaccinated 40–50% of students, coverage ranged from 7–73%. Higher percentages of elementary students were vaccinated compared with middle and high school students. While many programs offered only intranasal vaccine, several programs have successfully used both the intranasal and injectable vaccines. Faculty and staff were immunized in some programs and uptake in this group varied considerably. Students were vaccinated quickly during school hours. Costs, where reported, ranged from approximately $20–27 per dose delivered, including both vaccine and administration costs. The greatest need for future US SLIV program implementation is the development of a financially sustainable model that can be replicated annually on a national scale.

Introduction

One of the principal concerns with the Advisory Committee on Immunization Practices' 2008 recommendation that all children in the United States aged six months through 18 years of age be immunized against influenza annually has been the feasibility of immunizing so many children every year. Neither private practices nor public clinics have the capacity to vaccinate a high proportion of children between the time that influenza vaccine becomes available at the end of the summer and the peak of the influenza season in late winter or early spring of the following year.[1] Public health authorities are increasingly adopting school-located influenza vaccination (SLIV) programs as a cost-effective,[2] efficient approach for reaching large numbers of children. In the US, immunizing children against other infectious diseases at school has been used for outbreak control and to bring students into compliance with new vaccination requirements. However, such programs have generally been one-time events.[3] Because influenza and, consequently, influenza vaccines change every year, SLIV programs must become an institutionalized, standard part of each school year to be successful. In recent years, SLIV programs have been implemented in the US at the individual school, school district, county, and, recently, state levels. The national Parent Teacher Association (PTA) reports that 440 schools and communities in 47 states conducted some form of school-located influenza immunization during the 2008–2009 influenza season.[4] Subsequently, in response to H1N1 pandemic, H1N1 vaccinations were provided in some schools in approximately 40 states (Wortley P, CDC, personal communication). For the benefit of those planning future SLIV programs, we conducted a review of the available medical literature on SLIV programs in the US to summarize the collective experience regarding program outcomes and effectiveness.

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Results

Our review identified 13 published articles and 25 conference presentations/posters that described 36 SLIV programs, some of which were conducted over several years. SLIV programs ranged in size from 70 students vaccinated at a single school to statewide programs conducted by a state health department. Many of the early SLIV programs were formal studies or pilot demonstration programs, conducted with financial support and/or vaccine from MedImmune (Gaithersburg, MD). However, since 2006, with the exception of the multi-year study in Temple-Belton, TX, programs have taken place without manufacturer assistance. For

Table 1. US school-located influenza vaccination programs*

Geographic location	Year	Scope	Grades vaccinated**	Vaccine given to students	Number of children vaccinated	Students receiving ≥1 doses (%)	Students receiving second scheduled dose (% or n)
Carroll County, MD[47]	2003	1 School	K-5	LAIV	185	40%	61%
Fort Wayne, IN[23,31]	2004	2 Schools	K-5	LAIV	277	46%	NR
	2006, 2007	11 Schools	K-5	LAIV	4900 children over 2 years	NR	NR
Multi-State Study (WA, MN, TX, MD)[34]	2004	11 Schools	K-8	LAIV	2717	47%	95%
Carroll County, MD[48,49]	2005	1 County, 21 Schools	K-5	LAIV	5319	44%	3124
Knoxville, TN[11,46]	2005	1 County, 76 Schools	K-12	LAIV	24,198	45%	2945 (58%)
	2006	1 County	K-12	LAIV	29,408	48%	53%
San Bernardino, CA[50]	2005	16 Districts in 1 County, 244 Schools	K-12	LAIV	29,561	11.4%	NR
Pflugerville, TX[24]	2006	3 Schools	NR	LAIV	~300	NR	NR
	2007	10 Schools	NR	LAIV	~2200	NR	NR
Minnesota[29]	2006	3 Counties, 101 Schools	K-12	LAIV	15,453	41%	3321
Chicago, IL[16]	2006	1 School	6–10	LAIV/TIV	127	35%	NA
Alachua County, FL[51]	2006	1 County	K-8	LAIV	5198	25%	NR
Harford County, MD[32]	2006	44 Schools	K-5	LAIV	9003	50%	4255
Marion County, OR[30]	2006	1 School	K-12	LAIV	261	NR	NR
Los Angeles County, CA[24]	2007	3 Schools	K-8	LAIV	300	NR	NR
Hawaii[5]	2007	Statewide, 340 schools	K-8	LAIV/TIV	63,153	46%	18,173 (60%)
Temple-Belton, Texas[12-15]	2007	28 Schools	K-5	LAIV with TIV for those ineligible	5144	45%	Not offered at school clinics
	2008	50 Schools	K-12	LAIV with TIV for those ineligible	9007	39%	Not offered at school clinics
	2009	51 Schools	K-12	LAIV/TIV	11,998	50%	Not offered at school clinics
	2009	51 Schools	K-12	H1N1	7783	33%	1854 (58%)
St. Joseph County, IN[52]	2008	8 Schools	K-4	NR	2300	NR	NR
Pierce County, WA[53]	2007	2 Schools	K-6	LAIV/TIV	391	59%	114 (75%)
Aurora, CO[18]	2008	2 Schools	K-5	LAIV with TIV for those ineligible	872	NR	NR
Georgia[19,20]	2008	1 County, 2 Schools	6–12	LAIV with TIV for those ineligible	70	19%	NA
	2009	1 County, 2 Schools	6–12	LAIV with TIV for those ineligible	114	30%	NA
Kane County, IL[28]	2009	3 Schools	NR	H1N1	11,200	NR	2500
Clay County, FL[33]	2009	50 Schools	NR	H1N1	12,000	32%	NR
Arlington County, VA[33]	2009	35 Schools	NR	H1N1	>12,000	53%	NR
Maryland[28]	2009	Statewide	K-5	H1N1	NR	Up to 40% by school	NR
Wichita, KS[28]	2009	90 Schools	K-12	H1N1	NR	5–59%	NR
Maize, KS[28]	2009	NS	NR	H1N1	NR	20%	NR
Sedgwick County, KS[28]	2009	363 Schools, including 3 Universities	K-12, University	H1N1	>16,000 students & staff	NR	NR

*Programs are ordered by initiation date. **Programs described as "elementary" are presented as "K-5" unless other grades were noted in the publication. NR, not reported; NA, not applicable (e.g., second dose rate not applicable in children 10 years of age and older).

Table 1 (continued). US school-located influenza vaccination programs*

Geographic location	Year	Scope	Grades vaccinated**	Vaccine given to students	Number of children vaccinated	Students receiving ≥1 doses (%)	Students receiving second scheduled dose (% or n)
Minneapolis, MN[28]	2009–2010	7 Elementary Schools, 2 High Schools	<9 years in K-5, 9–12	H1N1	3410	NR	NR
New Mexico[10.17]	2008	11 Counties, 76 Schools	K-12	LAIV/TIV	10,991	35%	NR
	2009	145 Schools	K-12	LAIV/TIV	45,000	45%	NR
Bronx, NY[22]	2009	8 Schools	K-8	LAIV/TIV	854	16.5%	NR
Massachusetts[8]	2009	86 School Systems	K-12	LAIV, TIV, LAIV/TIV (varied by program)	>57,000	NR	NR
	2009	348 out of 351 Cities and Towns	K-12	H1N1	NR	NR	NR
Rhode Island[7,28]	2009	421 Schools	K-12	H1N1	120,930	73%	34,907 (75%)
New York, NY[6]	2009	1232 Schools	K-5	H1N1	128,228	22.4%	80,659
Louisville, KY[54]	2009	176 Schools	K-12	H1N1	>17,000 students and staff	NR	NR
Denver, CO[21]	2009	20 Schools	K-5	LAIV/TIV Seasonal, H1N1	2530 seasonal, 1633 H1N1	32.3% (either H1N1 or seasonal)	NR
Los Angeles County, CA[9]	2009	>120 Schools in 19 Districts	K-12	H1N1	104,036 doses	NR	NR
San Diego County, CA[27]	2009	143 Schools in 26 Districts	K-12 plus family members	H1N1	53,547 first doses (all ages)	NR	10,707 second doses (all ages)

*Programs are ordered by initiation date. **Programs described as "elementary" are presented as "K-5" unless other grades were noted in the publication. NR, not reported; NA, not applicable (e.g., second dose rate not applicable in children 10 years of age and older).

each program identified, available data regarding the location, number of students vaccinated and coverage achieved are outlined in **Table 1**. The number of programs has increased considerably since the initial pilot study in 2003, supported by the recommendation for annual vaccination of all children through 18 years of age in 2007–2008 and the H1N1 pandemic response in 2009–2010. The percentage of students receiving at least one dose of influenza vaccine in early programs ranged between 7–58% with most programs vaccinating 40–50% of students. The largest seasonal influenza vaccination program reported was conducted by the Hawaii Department of Health, which immunized 63,153 school children throughout the state against seasonal influenza in 2007–2008.[5] In response to the H1N1 pandemic, New York City reported the largest number of students vaccinated in SLIV programs (128,228),[6] but there were several other large programs. Rhode Island conducted a state-wide H1N1 program vaccinating 120,930 school children,[7] Massachusetts vaccinated children in schools in 348 of the state's 351 towns and cities (the number of children vaccinated was not reported),[8] Los Angeles administered 324,219 H1N1 doses to children 5–18 years of age, with 104,036 doses delivered through schools,[9] and New Mexico vaccinated approximately 45,000 children in 145 schools statewide.[10]

While many early programs vaccinated students in the elementary grades (K-5) only, the majority of recent programs have vaccinated children in grades K-12. Among programs reporting coverage by age or grade, coverage was higher among elementary students and lower in high school students (**Table 2**). Both Hawaii[5] and Tennessee[11] reported large variations in the percentage of students vaccinated per school. However vaccination rates were not correlated with school size. In Hawaii, there was no difference in coverage between public and private schools.[5] Vaccination rates were correlated with socioeconomic indicators in Tennessee; schools with a higher percentage of students participating in the National School Lunch Program had a lower proportion of students vaccinated.[11]

Many, but not all, programs conducted two rounds of clinics in elementary schools. These second clinics accomplished two purposes: providing a second dose to children less than nine years of age for whom two doses were indicated; and providing a second opportunity for vaccination for children who had been missed during the first clinic. Among children recommended to receive a second dose, 53–95% of these children actually received the second dose (**Table 1**). During the H1N1 response, New York City administered 80,659 second doses,[6] while in Rhode Island was able to administer 34,907 second doses, achieving a 75% two-dose compliance rate.[7]

Seventeen SLIV programs offered only live attenuated influenza vaccine (LAIV) to students. Nine programs offered trivalent

Table 2. Reported vaccination rates for programs vaccinating elementary, middle, and high school students

	Vaccination coverage achieved		
Program (Year)	**Elementary**	**Middle School**	**High School**
Knoxville, TN (2005)[11]	56%	45%	30%
Knoxville, TN (2006)[46]	61%	45%	26%
San Bernardino, CA (2005)[50]	16%	8%	4%
Minnesota (2006)[29]	47%	33%*	
Temple-Belton, TX (2008)[12]	48%	28%	22%
Temple-Belton, TX (2009, seasonal)[15]	58%	51%	39%
Temple-Belton, TX (2009, H1N1)[14]	42%	32%	19%

*Combined rate for middle and high schools was reported.

Table 3. Vaccination of teachers and staff in SLIV programs*

Program	Vaccine offered to staff	Staff vaccinated	Children vaccinated	Staff vaccinated per 100 children vaccinated
Fort Wayne, IN (2004)[23]	LAIV	44	277	16
Carroll County, MD (2005)[49]	LAIV	295	5319	6
Harford County, MD (2006)[32]	LAIV	1734	9003	19
Marion County, OR (2006)[30]	LAIV	12	261	5
Knoxville, TN (2005)[11]	LAIV/TIV	3626	24,198	15
Hawaii (2007)[5]	LAIV and TIV	9306	63,153	15
New Mexico (2008)[17]	LAIV/TIV	>720	10,991	7
Temple-Belton, TX (2007)[13]	LAIV/TIV	887	5144	17
Temple-Belton, TX (2008)[12]	LAIV/TIV	1878	9007	21
Temple-Belton, TX (2009)[15]	LAIV/TIV	2373	11,998	20

*H1N1 programs are excluded because H1N1 administration to staff would have been affected by H1N1 vaccine prioritization guidelines.

inactivated vaccine (TIV) to students ineligible for LAIV or for those who preferred TIV.[5,12-22] Several programs that offered both TIV and LAIV reported the percentage of responding students that were medically-eligible for LAIV; this percentage was 68% in Chicago, IL,[16] 74% in New Mexico,[17] 83% in Fort Wayne, IN[23] and 85% and 77% in Temple-Belton, TX in 2007 and 2008.[12,13] In programs offering only LAIV, children who could not receive LAIV were referred to the regular health department influenza vaccination clinics or their private physicians to receive TIV.[24,25] The statewide program in Hawaii offered both LAIV and TIV.[5] Unless the child had a medical condition that precluded the use of live vaccine, parents could select LAIV or TIV, or indicate that either vaccine would be acceptable. Overall, 56% of parents chose TIV, 27% chose LAIV, and either vaccine was acceptable to 17% of parents. Preference for TIV increased with the age of the child.[5] In 2009, the Temple-Belton, TX program vaccinated children with either seasonal LAIV or TIV per parental choice, and 73% received LAIV.[15] During the H1N1 pandemic response, larger programs tended to offer both LAIV and inactivated vaccine to students.[6,8-10] Rhode Island used only inactivated vaccine for H1N1 vaccination in schools (Francesconi M, personal communication).

Eight programs reported vaccinating eligible teachers and staff at the SLIV clinics. Staff vaccination results are summarized in **Table 3**. Only two programs reported the percentage of staff vaccinated: 43% in Hawaii and 62% in Knoxville, TN. Some LAIV-only programs reported that many teachers and staff were not eligible to receive the vaccine.[23] When evaluating the number of staff vaccinated per 100 children vaccinated (as a marker of staff vaccination that corrects for the size of the school), results were similar for programs that offered LAIV-only and both LAIV and TIV. Two programs reported the proportions of LAIV and TIV use among staff. Of the staff vaccinated in the Knoxville, TN program, 60% received TIV.[11] In the Temple-Belton, TX program, 67% received LAIV in the elementary school program in 2007, but 67% and 71% received TIV in 2008 and 2009, respectively, when the program was expanded to include middle and high schools.[12,15,26] Some studies also vaccinated eligible parents and family members.[18,25,27]

For programs that provided a description of the vaccination process, clinics were generally conducted in a large, central room at the school during school hours. Some smaller programs vaccinated after school, particularly if parents were required to be present at the time of vaccination.[24,25] Maize, KS vaccinated children against H1N1 after school hours so that parents could be present.[28] Some school districts in San Diego offered H1N1 vaccinations at after-school and Saturday clinics.[27] New York City chose to vaccinate high school students on the weekend.[6] One SLIV program reported vaccinating home-schooled students at a church in addition to schools to help increase access for this population.[12]

Vaccination was accomplished rapidly. Clinics in Minnesota could immunize 30–40 children per hour.[29] An early program in Oregon administered 273 doses in 2.5 hours.[30] By the third year of the program in Ft. Wayne, IN, 300 children could be vaccinated per hour.[31] In Pflugerville, TX, 50 children could be vaccinated per hour, but that number dropped to 15 per hour at times when parents were present.[24] Harford County, MD administered up to 981 immunizations per hour in their school-located preparedness exercise.[32] Kane County, IL was able to vaccinate 11,200 students against H1N1 in three clinics held over a 5-hour period on a single day.[28] In Hawaii, the median time for a child to be vaccinated was four minutes, and 90% of children spent less than 10 minutes in the clinic.[5] During the H1N1 SLIV programs in San Diego, students missed less than 20 minutes of class time.[27] Vaccinations were most often administered by health department staff and school nurses. Temporary staff were used by many health departments.[5,6] In some smaller programs, physician office staff were utilized as vaccinators.[25] Student nurses have also been used as vaccinators.[12] Commercial vaccinators were used to administer H1N1 vaccine in the statewide program in Rhode Island,[7,28] in Los Angeles[9] and San Diego counties,[27] and in a limited number of schools in Minneapolis.[28] Commercial vaccinators have also been used for seasonal SLIV programs.[24,25] Research nurses provided additional support in the Temple-Belton, TX program.[12,13,15]

Permission to vaccinate was generally obtained by sending consent forms with health screening questions and vaccine information statements home with the students. However, some programs found that parents could sign consent forms on site at after-school clinics.[33] Typically, forms needed to be provided in multiple languages. Forms were collected by the schools and screened for contraindications and completeness by public health or school nurses in advance or at the time of the clinic. To ensure that the correct child was being vaccinated, teachers handed the correct permission slip to each child. Some programs have had teachers place name tags on each child to help avoid administration errors.[30] Children were screened for acute illness at the time of the clinic by the nurse administering the vaccination.

Other than the typical adverse events (rhinorrhea and low grade fever for LAIV; redness/soreness at the injection site and low grade fever for TIV), there were few adverse events reported with SLIV programs. No hospitalizations were reported in the week after immunization among the 2717 children vaccinated in the multistate program conducted by King et al.[34] Of four adverse events reported by physicians, three were judged to be not related to vaccination. One episode of bronchospasm was thought to be possibly related to vaccination.[34] In Minnesota, no serious adverse events were reported among the 15,453 children vaccinated.[29] In Hawaii, physicians reported three non-serious adverse events among the 63,153 children vaccinated. Three additional syncope events were associated with vaccination, and one other unspecified, non-serious event was reported to the health department.[5] In Tennessee, no severe adverse reactions were reported to the health department or schools among the 24,198 students vaccinated.[11]

Most SLIV programs vaccinated children without charge. Many health departments were able to provide free vaccination to all children during their H1N1 campaigns as a result of federal funding.[6,28,33] Small SLIV programs organized by private physicians have required payment in advance of the clinic.[25] The SLIV program in Pfluegerville, Texas charged $25 in advance but was also a designated Vaccines for Children (VFC) provider and was able to provide free vaccination for children eligible for that program.[24]

Costs of school-located immunization clinics were reported for four programs. In the SLIV program which vaccinated students in three Minnesota counties, the administrative cost of the program was $183,770. The cost to deliver a dose of vaccine was $9.78 and the cost per fully immunized child was $11.52. This program used vaccine donated by the manufacturer and VFC vaccine, so the cost of vaccine was not included in the estimate.[29] In Hawaii, the total cost of the SLIV program was $2,480,493, approximately 50% of which was used to purchase vaccine. However, 46% of vaccine doses were acquired from the VFC program at no cost to the state. The all-inclusive cost of vaccinating a child in the Hawaii SLIV program was $27.37 per dose. A total of 16,920 person-hours were expended to conduct the 345 first dose and 277 second dose clinics.[5] The Tennessee SLIV program used vaccine donated by the manufacturer. Knox County Health Department staff members devoted approximately 5000 hours to organizing and conducting the clinics. School nurses worked 2700 hours during the SLIV program. Diverting staff to organize and conduct the clinics resulted in the cancellation of 84 half-day clinics for various programs at the county health department. Cash expenditures by the Knox County Health Department totaled $43,000, of which $28,000 was for the purchase of vaccine for school staff.[11] New York City spent more than $4.6 million to conduct their H1N1 SLIV programs, not including the cost of vaccine and supplies. As a result, administrative costs were more than $22 per dose delivered.[6] In San Diego, the cost of the SLIV program to the schools averaged $2345 for paid staff. However, schools also incurred additional, unspecified costs for materials, supplies, duplication and lunch for volunteers. Two-thirds of schools used volunteers to help organize the clinics.[27]

Discussion

The available medical literature clearly indicates that school-located influenza vaccination programs can successfully immunize large numbers of children. SLIV programs have been conducted at all levels, from the individual school through all schools, both public and private, in an entire state. Many well-organized programs have been able immunize 40–50% of children, and a few programs have been able to immunize more than 50% of children. SLIV programs have also been able to achieve high rates of second dose administration for young children who require two doses of influenza vaccine. The 2008 recommendation that all children six months through 18 years of age should be vaccinated against influenza has likely contributed to the increased the number of school programs conducted in the United States over time; however, the outcomes of specific programs conducted before and after the 2008 recommendation appear similar.

Immunization coverage was universally highest in the elementary grades.[35] This may reflect the increased severity of illness for younger children, a greater desire of parents to protect the health of younger children, and/or the increased need for parents to stay home when a younger child is ill. Younger children also may be more compliant in conveying the required consent forms to and from home. Lower immunization rates among older students may reflect the increasing independence of these students as well as the complexity of accessing students who are changing classes frequently. The level of participation at both private and public schools appears to be similar. While one advantage of SLIV programs is that they may provide better access to socioeconomically disadvantaged students, the Tennessee SLIV program found that these students participated in the program at lower rates relative to other students.[11]

SLIV programs also appear to be able to vaccinate large numbers of children with minimal disruption to the school day.[35,36] Actual time in the clinic and away from the classroom is usually less than 10 minutes. While it has been reported that a small number of students may experience syncope, serious adverse events are rare and occur at a rate consistent with the known characteristics of both types of influenza vaccine.

Health departments have generally carried the primary burden of organizing and conducting the clinics and answering parents' questions.[37] Methods for organizing SLIV clinics have been reviewed in references 19, 33, 38 and 39, and there is ongoing research to further define the best practices.[20,40-42] The most important contributions of the school are to distribute and collect the consent forms through their normal channels and to provide the physical space for the clinics. Additional volunteer and/or paid staff may be needed for schools to accomplish these tasks.[27]

The full support of the school administration and school nurses is needed for the program to be successful.[25] Critical factors for success are adequate planning/coordination, a dedicated program coordinator, detailed training of staff and consistent funding.[21,36] Incident command strategies may facilitate management of the clinics.[33] Experience has shown that SLIV programs are most difficult to organize and conduct in the first year of the program and become easier in following years.[36]

SLIV programs may be less costly than vaccinating children elsewhere.[2,43,44] The two published cost estimates for seasonal vaccination were low and very similar, $10 for non-vaccine administrative costs in one program and $27 for both vaccine and administration in another program.[5,26] The administrative costs of the New York City H1N1 program were much higher, perhaps because of the rapid scale-up needed for the H1N1 campaign and the complexity of managing a limited supply of vaccine. Costs of conducting SLIV programs may decrease in the future as more young children are vaccinated and the need for second rounds of clinics decreases. The availability of vaccine without cost to schools or health departments through the VFC program helps to keep the cost of SLIV programs reasonable. Despite this, cost issues have been a major obstacle to the development of SLIV programs. Many health departments lack the capability to bill insurance companies for individual services. While negotiating billing agreements is complex and time-consuming, some SLIV programs have been successful in doing so.[21] A school vaccination program billing private insurers for Tdap vaccination in Colorado significantly increased coverage for that vaccine.[41] With the advent of health care reform and broader health insurance coverage for children, billing health insurance for SLIV programs could make such programs sustainable. Other approaches, including pooling funds from health insurance providers, should also be examined.

While most early SLIV programs described in published reports have used only LAIV, several programs have demonstrated that both vaccines can be used together in large programs successfully. Programs have demonstrated that 15–30% of students may have underlying high-risk medical conditions and as a result are not recommended to receive LAIV; this percentage was lower in programs targeting elementary school students and higher in programs that involved high school students. Consequently, TIV should be made available to students, either in the SLIV program itself or by directing students to public health clinics or private practices.

A significant limitation of the current analysis is that no data are available for SLIV programs that have not been described at medical conferences or in the medical literature. These omissions would include programs for which nothing has been described as well as additional years of identified programs, either before or after the year(s) described. For example, results have been reported for the Tennessee SLIV program for 2005 and 2006,[11,45,46] but the program continued from 2007 through 2009. The experience presented also may not be representative of all school immunization programs as unsuccessful programs may be less likely to have been reported. In addition, many of the reports reviewed were conference presentations and were not subject to formal peer review. While the data from these sources should be regarded as interim and potentially subject to revision, one would not expect peer review to result in significant changes to the reported descriptions of program outcomes.

SLIV programs can be successful, typically reaching 40–50% of students, and increasing overall vaccination levels among children in the community. Programs targeting elementary school students are likely to achieve the highest vaccine coverage. SLIV programs can be conducted with either LAIV or TIV or both vaccines. Disruption to classes is generally described as minimal. It is hoped that the successful implementation of SLIV programs as part of the H1N1 pandemic response will lead to broader implementation of such programs. However, if upcoming influenza seasons are perceived as more normal, there could be diminished support for conducting SLIV programs. The development of a financially sustainable model that can be replicated annually on a national scale is the greatest need for future development of SLIV programs in the US.

Methods

The National Library of Medicine PubMed system and Medical Intelligence Solutions' Knowledge Discovery Platform (New York, NY) were searched for studies published in medical journals and presented as abstracts or posters at scientific meetings, respectively, using the terms influenza, vaccination (or immunization) and school. All publications from January 2000–May 2010 were included in the search. Thirty-nine articles and 524 abstracts were initially identified; when available, conference posters and slide presentations posted online were reviewed. In a few instances, study authors were contacted to clarify published results. Three case studies published online by the National Association of City and County Health Officials (NACCHO) were also included in the analysis. Publications that provided quantitative data regarding US SLIV programs were selected for this review. One additional journal article[25] and one additional conference presentation[35] were identified that presented aggregated data on eight and 24 SLIV programs, respectively. These articles were reviewed but were excluded from the formal analysis as only pooled data were presented. When abstracts, posters and presentations were subsequently published in a medical journal, the journal manuscript was used as the source of final data.

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Conflicts of Interest

Harry Hull conducted the review on behalf of MedImmune and has received grant/research support and consulting fees from MedImmune. Chris Ambrose is an employee of MedImmune. Drs. Hull and Ambrose participated in the concept and design, analysis and interpretation of data, and drafting and revising the manuscript. Both authors approved the final manuscript.

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