

The impact of pandemic A(H1N1)pdm09 influenza and vaccine-associated adverse events on parental attitudes and influenza vaccine uptake in young children



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ARTICLE INFO

Article history:

Received 14 March 2014

Received in revised form 9 May 2014

Accepted 15 May 2014

Available online 28 May 2014

Keywords:

Influenza
Vaccination
Parental attitudes
Children

ABSTRACT

Introduction: Parental attitudes towards vaccination significantly influence vaccine uptake. The A(H1N1)pdm09 influenza pandemic was followed in 2010 by an unprecedented increase in febrile reactions in children receiving trivalent inactivated influenza vaccine manufactured by bioCSL. Uptake of TIV in children <5 years in Western Australia (WA) decreased in 2010 and has remained low. The impact of pandemic A(H1N1)pdm09 and adverse-events on parental attitudes towards vaccination is uncertain.

Materials and Methods: A parental attitudes survey towards influenza illness and vaccination was conducted as part of the West Australian Influenza Vaccine Effectiveness study. Vaccination status was assessed by parental interview and confirmed by the national register and/or vaccine providers. Parental attitudes from vaccinated and unvaccinated children and attitudes in 2008–2009 and 2010–2012 were compared. Principal Component Analysis was conducted to determine core attitudes that influenced vaccine uptake.

Results: Vaccination history and parental attitude surveys were available from 2576 children. Parents of fully vaccinated children less frequently stated that influenza was a mild disease, more frequently stated that influenza vaccine was safe and were less frequently worried about vaccine side effects.

Uptake of influenza vaccine decreased significantly from 2010 onwards. From 2010, parents were less concerned about severe influenza, but more concerned about vaccine side effects and safety. Despite this significant shift in attitudes towards influenza vaccine, parental acceptance of vaccines on the national immunisation program did not change. Principal Component Analysis revealed that attitudes around vaccine safety and efficacy were the most important attitudes impacting on vaccine uptake.

Conclusions: Parental attitudes to influenza vaccine changed from 2010. Confidence in the WA preschool influenza vaccination program remains low yet appeared unchanged for other vaccines. Restoring public confidence in childhood influenza vaccination is needed before uptake can be improved.

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Abbreviations: WAIVE, Western Australian Influenza Vaccine Effectiveness Study.

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1. Introduction

Young children have the highest rates of influenza-associated hospitalisation [1,2]. Annual influenza vaccination is the most effective method for preventing influenza virus infection and its complications and is routinely recommended for young children in the United States, Canada, Finland and the United Kingdom [1,3].

In addition to preventing infection in the individual vaccine recipient, recent studies suggest that childhood influenza vaccination may reduce the impact of influenza in the community [4].

Despite a recommendation for routine influenza vaccination in many jurisdictions, uptake of vaccination varies significantly. Factors associated with improved uptake included a parental belief that influenza infection is severe in children and a recommendation for vaccination by their family physician or general practitioner [5–9]. Concern about vaccine safety and a belief that children are not at risk of severe influenza are associated with reduced vaccine uptake.

Following several influenza-related deaths in previously healthy preschool children in 2007 [10] the state of Western Australia (WA) implemented a paediatric influenza vaccination program. Trivalent inactivated vaccine (TIV) was recommended and provided free for all children aged 6 months to <5 years. This was in addition to the national program which recommended vaccination in children 6 months and older with underlying medical conditions associated with severe influenza.

As part of the WA preschool paediatric influenza vaccination program, the West Australian Influenza Vaccine Effectiveness (WAIVE) study was commenced in 2008. Children presenting to Princess Margaret Hospital, the only tertiary referral paediatric hospital in WA, with an influenza-like-illness were eligible for enrolment. A parental survey on attitudes towards influenza vaccine was conducted on parents of enrolled children as part of the WAIVE study.

In 2010, administration of influenza vaccine to Australian children <5 years was temporarily suspended following a significant increase in febrile adverse events following immunisation [11,12]. These adverse events were attributed to one manufacturer's brand of influenza vaccine (Fluvax[®] and Fluvax Junior[®]; bioCSL). Investigations demonstrated that administration of Fluvax[®] and Fluvax Junior[®] was associated with a 44 fold increase in febrile convulsion compared with previous seasons [11,12]. The rate of febrile convulsions was calculated to be 4.4 per 1000 (95%CI: 3.4 to 5.6) doses of Fluvax[®] and Fluvax Junior[®] administered [11]. Once the safety of alternative products was demonstrated, the recommendation for TIV in young children (all children 6–59 months in WA; children with risk factors for severe disease in other states) was reinstated on the 30th July 2010 [13].

According to data available from the Australia Childhood Immunisation Register, five brands of influenza vaccine were administered to children <5 years of age in WA during the study period: Fluvax[®] and Fluvax Junior[®] (bioCSL); Fluarix[®] (Glaxo-SmithKline); Fluvirin[®] (Novartis); Influvac[®] and Influvac Junior[®] (Abbott) and Vaxigrip[®] and Vaxigrip Junior[®] (Sanofi-Pasteur). bioCSL Fluvax accounted for 50–85% of all doses administered between 2008 and 2010, with Vaxigrip[®] accounting for most of the remaining doses during those years. When bioCSL Fluvax[®] became contraindicated for children <5 years of age, Vaxigrip[®] accounted for 86% and 75% of all doses administered in 2011 and 2012, respectively, with the remaining doses largely consisting of Influvac[®] and Fluarix[®] brands of TIV.

The WAIVE study presented a unique opportunity to assess parental attitudes towards vaccination between 2008 and 2012, during a period which included the emergence of A(H1N1)pdm09 influenza pandemic and serious adverse events due to the bioCSL influenza vaccine. At establishment, the WAIVE study was designed to explore the impact of parental attitudes on vaccine uptake.

2. Material and methods

All children presenting with an influenza-like illness (ILI) to the Emergency Department of Princess Margaret Hospital during the

influenza seasons of 2008–2012 inclusive were eligible for enrolment. ILI was defined by at least one acute respiratory symptom or sign plus either a documented fever $\geq 37.5^{\circ}\text{C}$ or history of fever in the past 96 h. Following written consent from parents or guardians, clinical data, parental attitudes and nasopharyngeal samples were collected. Parental attitudes towards influenza illness, influenza vaccination and immunisation in general were assessed on all enrolled children. The questionnaire was administered to the parent or guardian when the child was recruited into the study. All questions could be answered as yes, no or unsure.

Vaccination status was assessed during the parental interview and confirmed by the Australia Childhood Immunisation Register (ACIR). If vaccination status could not be determined or discrepancies were noted, immunisation providers were contacted. "Fully vaccinated" was defined as (i) two doses of TIV at least 21 days apart and at least 14 days prior to presentation or (ii) one dose of TIV at least 14 days prior to presentation and two or more doses in a previous year [14]. "Unvaccinated" children were those not receiving a dose of TIV in the year of enrolment. The remaining children were defined as "partially vaccinated". Vaccine uptake estimates were calculated from influenza-test negative controls subjects enrolled in the WAIVE study. Fully vaccinated and partially vaccinated children were expressed as a proportion of the total influenza-test negative controls and 95% confidence intervals calculated.

Statistical analysis was performed using SPSS 20.0.0 (IBM Corp. New York, NY). Differences in categorical variables were tested by two-sided χ^2 test or Fisher exact test. A *p* value of 0.05 was considered significant. Attitudes of parents whose children were vaccinated were compared with those whose children were not vaccinated. Parental attitudes in 2008–2009, prior to the adverse events of 2010, and in 2010–2012 were also compared.

Principal components analysis (PCA) was performed to reduce the set of interrelated questionnaire items into a smaller number of independent factors representing different core attitudes to the disease and the vaccine. Factors with eigenvalues >1 were extracted and, after varimax rotation, Z-scores for the extracted factors were calculated for each respondent. These factor scores were then used as independent variables and included in a binary logistic regression model with vaccine uptake (fully vaccinated) as the outcome and age, sex, indigenous status, preterm birth, presence of co-morbidities and out-of-home care attendance as potential confounders. Adjusted odds ratios and 95% confidence intervals were calculated.

Ethics approval for the study was obtained from the ethics committees of Princess Margaret Hospital for Children (1673/EP), the South Metropolitan Area Health Service and the Western Australian Aboriginal Health Information and Ethics Committee.

3. Results

Vaccination history and parental attitude surveys were available from 2576 children enrolled in the WAIVE study including 483 fully vaccinated, 225 partially vaccinated and 1868 unvaccinated children (2008: 326 children; 2009: 591 children; 2010: 264 children; 2011: 610 children; 2012: 785 children). The median age of children for whom data on parental attitudes was collected was 1.87 years (interquartile range: 1.19 to 3.04 years). There was no significant difference in age, sex, indigenous status, preterm birth and household size between vaccinated and unvaccinated children (Table 1). Fully vaccinated children more frequently had comorbidities and were less likely to be attending out-of-home care compared with unvaccinated children.

Parental attitudes towards influenza illness and vaccination were compared between fully vaccinated, partially vaccinated and unvaccinated children. A number of significant differences were

Table 1
Demographics: unvaccinated vs. partially vaccinated vs. vaccinated children (2008–2012).

	Unvaccinated (n = 1868)	Partially vaccinated (n = 225)	Fully vaccinated (n = 483)	Total (n = 2576)
Age <2 years	970/1840 (52.7%)	119/217 (54.8%)	269/477 (56.4%)	1358/2534 (53.6%)
Male sex	1029/1847 (55.7%)	110/222 (49.5%)	272/482 (56.4%)	1411/2551 (55.3%)
Indigenous	108/1815 (6.0%)	17/216 (7.9%)	19/479 (4.0%)	144/2510 (5.7%)
Any comorbidity [†]	245/1799 (13.6%)	32/218 (14.7%)	92/481 (23.7%)	369/2498 (14.8%)
Preterm birth	275/1811 (15.2%)	36/219 (16.4%)	77/481 (16.0%)	388/2511 (15.5%)
Attending out of home care [*]	1258/1799 (69.9%)	141/218 (64.7%)	281/480 (58.5%)	1680/2497 (67.3%)
Household size >5 people	106/1692 (6.3%)	9/208 (4.3%)	23/470 (4.9%)	138/2370 (5.8%)

[†] Unvaccinated vs. fully vaccinated: $p < 0.005$.^{*} $p < 0.0001$.**Table 2**
The impact of parental attitudes on vaccination uptake (2008–2012).

Parental attitude	Vaccination status	Parental responses			Significance
		Disagree (%)	Unsure (%)	Agree (%)	
Influenza is a mild disease	Unvaccinated	58.6	16.9	24.5	$p < 0.001$
	Partially vaccinated	69.0	10.8	20.2	
	Fully vaccinated	76.2	10.5	13.3	
Influenza can put young children in hospital	Unvaccinated	1.0	4.5	94.5	Not significant
	Partially vaccinated	0.6	4.0	95.5	
	Fully vaccinated	0.6	2.6	96.8	
Influenza can kill young children	Unvaccinated	3.3	17.4	79.4	$p = 0.001$
	Partially vaccinated	3.4	12.6	83.9	
	Fully vaccinated	2.0	9.0	89.0	
Influenza vaccine is safe	Unvaccinated	13.1	57.2	29.8	$p < 0.001$
	Partially vaccinated	10.6	49.6	39.9	
	Fully vaccinated	2.3	24.1	73.6	
Influenza vaccine protects children against the influenza	Unvaccinated	14.0	43.8	42.2	$p < 0.001$
	Partially vaccinated	11.9	32.4	55.7	
	Fully vaccinated	14.9	29.8	55.3	
You can catch the influenza from the vaccine	Unvaccinated	35.9	40.5	23.6	$p < 0.001$
	Partially vaccinated	54.3	33.1	12.6	
	Fully vaccinated	56.9	24.6	18.5	
I am worried about side effects of the influenza vaccine	Unvaccinated	15.8	17.1	67.0	$p < 0.001$
	Partially vaccinated	47.4	17.7	34.9	
	Fully vaccinated	49.7	19.5	30.7	
It is better to have natural immunity against influenza	Unvaccinated	18.5	43.2	38.3	$p < 0.001$
	Partially vaccinated	42.5	36.2	21.3	
	Fully vaccinated	47.1	32.7	20.2	
Influenza vaccine will overload my child's immune system	Unvaccinated	40.5	51.8	7.7	$p < 0.001$
	Partially vaccinated	63.6	34.1	2.3	
	Fully vaccinated	74.21	23.9	2.0	
Children who have asthma should get an influenza vaccine	Unvaccinated	5.3	64.4	30.3	$p < 0.001$
	Partially vaccinated	1.7	44.6	53.7	
	Fully vaccinated	2.6	40.8	56.6	
Children who have a chronic disease should get an influenza vaccine	Unvaccinated	3.5	59.1	37.4	$p < 0.001$
	Partially vaccinated	2.8	40.3	56.8	
	Fully vaccinated	1.7	37.4	60.9	
Health young children should get an influenza vaccine	Unvaccinated	15.2	53.3	31.5	$p < 0.001$
	Partially vaccinated	4.0	20.7	75.3	
	Fully vaccinated	3.2	17.3	79.5	
It is inconvenient to get an influenza vaccine	Unvaccinated	62.6	17.7	19.8	$p < 0.001$
	Partially vaccinated	73.1	5.7	21.1	
	Fully vaccinated	73.0	2.0	24.9	
Getting two needles in the first year is difficult to organize	Unvaccinated	67.6	20.1	12.3	$p < 0.001$
	Partially vaccinated	77.8	8.0	14.2	
	Fully vaccinated	82.7	3.7	13.5	
Vaccine being free is important	Unvaccinated	19.5	10.3	70.2	$p < 0.001$
	Partially vaccinated	25.7	3.4	70.9	
	Fully vaccinated	9.5	3.2	87.6	
I am too busy to get my child vaccinated against influenza	Unvaccinated	85.3	7.8	6.9	$p < 0.001$
	Partially vaccinated	92.0	3.4	4.5	
	Fully vaccinated	96.5	2.0	1.4	
My child has had all their routine vaccines	Unvaccinated	6.8	2.4	90.9	$p < 0.001$
	Partially vaccinated	2.3	1.1	96.6	
	Fully vaccinated	1.4	0.9	97.7	
I don't believe that children should have any vaccinations	Unvaccinated	90.1	7.1	2.7	$p = 0.001$
	Partially vaccinated	96.6	3.4	0.0	
	Fully vaccinated	94.8	2.3	2.9	

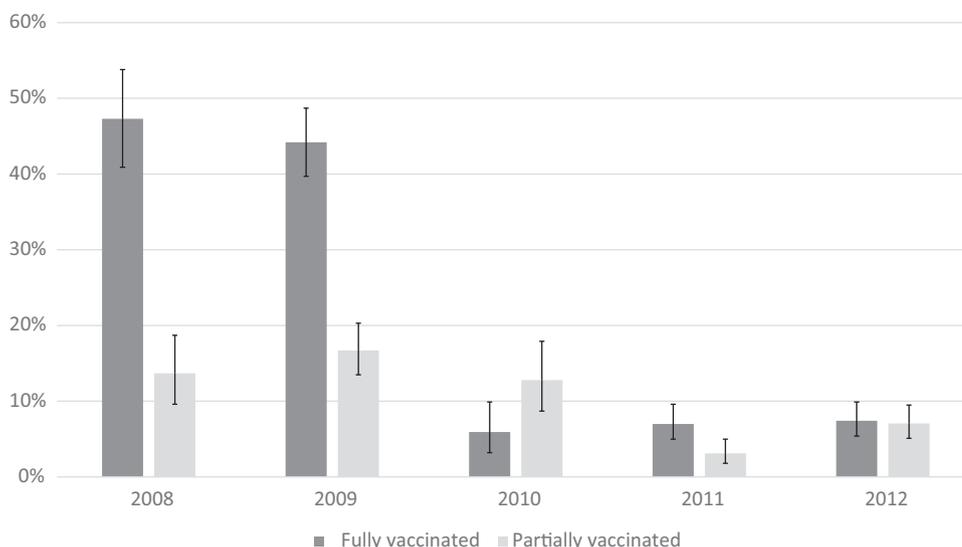


Fig. 1. Vaccine uptake in influenza test negative children presenting with influenza-like-illness.

identified (Table 2). Only 13.3% of parents of fully vaccinated children agreed that influenza was a mild disease compared with 20.2% and 24.5% of parents of partially or unvaccinated children ($p < 0.001$). Parents of fully vaccinated children more frequently agreed that influenza can kill young children compared with parents of partially or unvaccinated children (89.0% vs. 83.9% and 79.4%, respectively; $p = 0.001$). Parents of fully vaccinated children more frequently agreed that the vaccine was safe compared with parents of partially or unvaccinated children (73.6% vs. 39.9% and 29.8%, respectively; $p < 0.001$). Many parents of unvaccinated children were uncertain about vaccine safety. Parents of fully vaccinated children less frequently agreed with the statement “I am worried about side effects of the influenza vaccine” compared with parents of partially or unvaccinated children (30.7% vs. 34.9% and 67.0%, respectively; $p < 0.001$). Only 20.7% of all parents agreed with the statement “It is inconvenient to get an influenza vaccine” and 73.0% agreed with the statement “Vaccine being free is important”.

Parents used multiple sources of information to guide their choices about influenza vaccination. Of parents that were aware of the WA preschool influenza vaccine program ($n = 1498/2275$; 65.8%), 939 stated that the most frequent source of information about influenza vaccination was their general practitioner or health professional. This was followed in order by television ($n = 513$), friends and relatives ($n = 332$), newspaper ($n = 194$), radio ($n = 181$), posters ($n = 167$), childcare provider ($n = 126$) and the internet ($n = 94$). Parents of 768 (38.8%) enrolled children recalled actively discussing the influenza vaccination with their general practitioner. The parents of vaccinated children were more likely to have discussed vaccination with their general practitioner: fully vaccinated (75.5%), partially vaccinated (75.1%) and unvaccinated (23.4%, $p < 0.001$).

Uptake of influenza vaccine decreased significantly over time: 45.2% of children without influenza in the WAIVE study were fully vaccinated in 2008–9 compared with 7.0% in 2010–2012 ($p < 0.001$; Fig. 1). This dramatic decrease was observed in those with and without risk factors for severe disease: 45.1% vs. 12.6% in those with risk factors for severe disease and 42.1% vs. 5.2% in those without risk factors (both $p < 0.001$).

Parental attitudes were compared between years: no significant differences were observed when 2008 and 2009 were compared. Likewise, no significant changes in attitudes were observed in 2010, 2011 and 2012. However, when the two time periods were compared, a number of significant changes in parental

attitudes were observed (Table 3). Compared with 2008–2009, attitudes in 2010–2012 suggested fewer parents were concerned about the severity of influenza infection in young children. More agreed with the statement that “influenza is a mild disease” (2010–2012: 24.5% vs. 2008–2009: 17.5%; $p < 0.001$) and fewer parents agreed with the statement that “Influenza can kill young children” (2010–2012: 78.4% vs. 2008–2009: 89.2%; $p < 0.001$). Parents were more concerned about vaccine safety. Fewer parents agreed with the statement “Influenza vaccine is safe” (2010–2012: 30.2% vs. 2008–2009: 59.8%; $p < 0.001$) with many unsure about vaccine safety (2010–2012: 53.7% vs. 2008–2009: 36.9%). More parents agreed with the statement “I am worried about the side effects of flu vaccine” (2010–2012: 67.7% vs. 2008–2009: 39.2%; $p < 0.001$). Fewer parents stated that influenza vaccination should be recommended, independent of whether the child had risk factors increasing his or her likelihood of a more severe infection.

Despite this significant shift in parental attitudes from 2010, parental acceptance of other (non-influenza) vaccines on the national immunisation program did not change: in 2010–2012, 92.2% of parents agreed with the statement “my child has had all their routine vaccinations” compared with 91.6% of parents in 2008–2009. Fewer parents discussed influenza vaccine with their general practitioner (33.5% in 2010–2012 compared with 54.9% in 2008–2009, $p < 0.001$) and fewer parents recalled their general practitioner recommending vaccination for their child. In 2008–2009, 76.4% of parents recalled their general practitioner recommending influenza vaccine; only 5.3% of GPs recommended against vaccination and 18.3% offering no specific advice. In 2010–2012, only 40.9% of parents recalled their general practitioners recommending influenza vaccination, with 13.4% not recommending vaccination and 45.7% not providing any specific advice ($p < 0.001$).

Principal components analysis of the questionnaire items resulted in the extraction of 3 factors accounting for 40% of the total data variance. These factors were termed safety and efficacy, availability and access, and severity of the illness. Items associated with these factors (rotated factor loading > 0.4) are shown in Table 4. Logistic regression modelling showed that positive attitudes towards safety and efficacy were the strongest predictor of vaccine uptake (adjusted OR (aOR): 3.38, 95%CI: 2.87 to 3.98) with perceptions of difficult access having a significantly negative impact on vaccine uptake (aOR: 0.74, 95%CI: 0.63 to 0.86). Attitudes towards the severity of influenza did not significantly predict vaccine uptake.

Table 3
Changes in parent attitudes: 2010–2012 compared with 2008–2009.

Parental attitude	Year	Parental responses			Significance
		Disagree (%)	Unsure (%)	Agree (%)	
Influenza is a mild disease	2008–2009	72.2	10.3	17.5	$p < 0.001$
	2010–2012	57.1	18.4	24.5	
Influenza can put young children in hospital	2008–2009	0.6	1.4	98.0	$p < 0.001$
	2010–2012	1.0	5.1	93.9	
Influenza can kill young children	2008–2009	1.8	9.0	89.2	$p < 0.001$
	2010–2012	3.4	18.2	78.4	
Influenza vaccine is safe	2008–2009	3.3	36.9	59.8	$p < 0.001$
	2010–2012	13.8	53.7	30.2	
Influenza vaccine protects children against influenza	2008–2009	15.5	37.9	46.6	Not significant
	2010–2012	13.7	42.5	43.8	
You can catch influenza from the vaccine	2008–2009	44.6	35.2	20.2	$p = 0.03$
	2010–2012	37.9	38.6	23.5	
I am worried about side effects of the influenza vaccine	2008–2009	42.0	18.8	39.2	$p < 0.001$
	2010–2012	15.1	17.1	67.7	
It is better to have natural immunity against influenza	2008–2009	35.7	36.5	27.8	$p < 0.001$
	2010–2012	19.5	42.9	37.5	
Influenza vaccine will overload my child's immune system	2008–2009	59.9	35.2	4.9	$p < 0.001$
	2010–2012	42.0	50.7	7.3	
Children who have asthma should get an influenza vaccine	2008–2009	4.3	50.0	45.7	$p < 0.001$
	2010–2012	5.0	63.7	31.4	
Children who have a chronic disease should get an influenza vaccine	2008–2009	3.7	46.0	50.3	$p < 0.001$
	2010–2012	3.1	58.3	38.6	
Health young children should get an influenza vaccine	2008–2009	9.7	30.7	59.7	$p < 0.001$
	2010–2012	14.2	52.3	33.5	
My child has had all their routine vaccines	2008–2009	5.3	3.1	91.6	Not significant
	2010–2012	6.0	1.8	92.2	
I don't believe that children should have any vaccinations	2008–2009	94.0	3.9	2.1	$p < 0.03$
	2010–2012	90.0	7.0	3.0	

4. Discussion

Following the introduction of routine influenza vaccination for children aged 6 months to 5 years in Western Australia in 2008, uptake of 47.3% was achieved in 2008 and 44.2% in 2009 (fully vaccinated), based on influenza negative children in the WAIVE study. The vaccine uptake observed in the early part of the program exceeded that achieved following similar recommendations in other comparable countries [15,16]. Between the 2009 seasonal influenza vaccination program and the start of the 2010 influenza season, two significant events occurred which appear to have influenced parental perception of influenza and influenza vaccination.

In May 2009, the A(H1N1)pdm09 influenza pandemic resulted in a significant increase in hospitalisations and deaths [17]. In Australia and globally, the total number of severe cases and deaths was not as great as initially feared [18,19]. Lower uptake of season influenza vaccine following the influenza pandemic has been observed in other populations and has been attributed to the perceived mild impact of the influenza

pandemic [20,21]. We expect that the increased number of parents who perceived influenza to be a mild illness from 2010 onwards was influenced, in part, by the perceived lower than expected severity of the 2009 influenza pandemic. It remains uncertain how much this perception affected the uptake of seasonal influenza vaccine in Western Australia in 2010.

Seven weeks after the 2010 seasonal influenza vaccination was released in Australia, vaccination of children <5 years was suspended pending a national investigation. Public confidence in universal influenza vaccination for young children was damaged [22]. Based on findings from this study, parental understanding of the relative risks and benefits of the vaccine was the most important factor influencing influenza vaccine uptake. Given the changing attitudes identified over the study period, we conclude that the attitudinal changes were likely to have contributed to the lower vaccine uptake after 2010. These parental perceptions continue to be an issue despite published data demonstrating the safety of the seasonal influenza vaccine [23]. Of particular concern is the ongoing

Table 4
Principal component analysis identifying key factors influencing vaccine uptake.

Components	Parental attitudes included in principle component analysis	Adjusted odds ratio*	95% confidence interval
Factors associated with vaccine safety and efficacy	Influenza vaccine is safe	3.38	2.87 to 3.98
	Influenza vaccine protects children against the influenza		
	I am worried about side effects of the influenza vaccine		
	It is better to have natural immunity against influenza		
	Influenza vaccine will overload my child's immune system		
	Children who have asthma should get an influenza vaccine		
	Children who have a chronic disease should get an influenza vaccine		
Factors associated with availability and access	It is inconvenient to get an influenza vaccine	0.74	0.63 to 0.86
	Getting two needles in the first year is difficult to organise		
	I am too busy to get my child vaccinated against influenza		
Factors associated with the severity of influenza illness	Influenza is a mild disease	1.093	0.95 to 1.26
	Influenza can put young children in hospital		
	Influenza can kill young children		

* Adjusted odds ratio for full vaccination per unit increase in the factor Z-score.

poor uptake of influenza vaccine in those with significant medical comorbidities as these children are at greatest risk for influenza-related morbidity. As demonstrated in this parental survey and other vaccine uptake surveillance data [22,24], the impact appears to be restricted to influenza vaccine with no significant change in the uptake of childhood vaccines on the National Immunisation Program.

In addition to confirming the safety of influenza vaccine in children [23], demonstrating the significant benefits of childhood influenza vaccination to general practitioners, local physicians, paediatricians and the public is expected to further improve childhood influenza vaccine uptake. The WAIVE study has recently demonstrated vaccine effectiveness of TIV in children 6 to 59 months (2008, 2010–2012) of 64.7% (95%CI: 33.7 to 81.2) [25]. Previous research has demonstrated that discussion with a family doctor or general practitioner has a significant positive impact on vaccine uptake [6–9]. Of concern, is that despite published safety data [23] and ongoing surveillance for adverse events following TIV in children, 13.4% of general practitioners in 2010–2012 recommended against influenza vaccine and 45.7% provided no specific advice. Further targeted education of health professionals is essential to ensure that families enquiring about influenza vaccine are provided with contemporary safety and effectiveness data of the currently recommended TIVs in young children. Safety surveillance systems providing real-time safety data for that season's recommended influenza vaccines may help restore public and provider confidence in influenza vaccine safety and ultimately improve coverage [26].

This study has a number of strengths. The ability to track parental attitudes before and after the 2009 pandemic and after the adverse events in 2010 provided a unique opportunity to explore the possible effects of these events on vaccine uptake. Limitations included that attitudes were only available from parents of children who presented to hospital with influenza-like illness: It is possible that this cohort may have provided biased responses compared with community attitudes.

The pandemic may have decreased parents' concerns that influenza was a serious illness and the adverse events of 2010 undoubtedly decreased parental confidence in all influenza vaccines, even though significant adverse event were reported only with bioCSL vaccines. In order to increase the uptake of influenza vaccine in children it will be necessary to re-establish a contemporary understanding of the risks and benefits of influenza vaccination in childhood; this will be required for both parents and for health professionals.

5. Conclusions

Significant changes in parental attitudes and influenza vaccine uptake were observed following the 2009 A(H1N1)pdm09 influenza pandemic and adverse events observed in 2010. Despite published safety of alternative vaccine products distributed in 2010–2012, participation and confidence in the West Australian preschool influenza vaccination program by both the public and immunisation providers remains low.

Author contributions

Christopher Blyth: Dr Blyth supervised the project, analysed the data and wrote the initial draft of the manuscript.

Peter Richmond, Heath Kelly, David Smith and Paul Effler: Professors Richmond, Kelly, Smith and Effler designed the WAIVE study, supervised analysis and assisted in writing the manuscript.

Peter Jacoby: Mr Jacoby assisted designing the study, analysed the data and assisted with writing the manuscript.

Patrick Thornton and Christine Robins: Mr Thornton and Ms Robins enrolled patients, collated and cleaned the data and assisting with writing the manuscript.

All authors have reviewed and given final approval of the version to be published. All authors are accountable for all aspects of the work.

Conflicts of interest statement

Christopher Blyth, Christine Robins and Peter Richmond are members of the Vaccine Trials Group, Telethon Kids Institute. The Vaccine Trials Group has received funding from vaccine manufacturers for conducting clinical trials, although not in relation to this study.

Peter Richmond has served on a scientific advisory board regarding influenza vaccines for CSL Ltd., has received travel support from Baxter and GlaxoSmithKline to present at scientific meetings, and received Institutional funding for investigator-led epidemiological research from GlaxoSmithKline and CSL Ltd.

David Smith is a Director and board member for the Asia–Pacific Alliance for the Control of Influenza. It is a not-for profit Organisation controlled by an independent board that receives pharmaceutical company funding. He does not receive any payment only reimbursement of expenses. Prof Smith was a director and board member of a similar organisation, the Australian Influenza Specialist Group, until 12 months ago."

Vaccines for the Western Australian influenza vaccination program have been provided by CSL and Sanofi-Pasteur.

Acknowledgements

The Western Australian Influenza Vaccine Effectiveness (WAIVE) study team includes Christopher Blyth, Meredith Borland, Dale Carcione, Paul Effler, Gary Geelhoed, Peter Jacoby, Anthony Keil, Heath Kelly, Alan Leeb, Avram Levy, Katie Lindsay, Hannah Moore, Christine Robins, Peter Richmond, David Smith, Simone Tempone, Paul van Buynder, Simon Williams and Gabriela Willis.

The authors thank all the nurses and research assistants of the Vaccine Trials Group who recruited children for this study as well as all the study participants and their parents. The authors also thank staff of the Emergency, General Paediatrics, and Microbiology Departments of Princess Margaret Hospital for Children (1673/EP), Perth, WA. The authors thank all staff from PathWest Laboratory Medicine, WA, involved in processing and reporting study samples.

Funding for the WAIVE study is kindly provided by the Department of Health, Western Australia.

Trivalent influenza vaccination was kindly provided for the Western Australian Preschool Vaccination Program by Sanofi-Pasteur (2008–2012) and CSL Biotherapies (bioCSL;2008–2010).

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