Parental Country of Birth and Childhood Vaccination Uptake in Washington State

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abstract

BACKGROUND: Underimmunization of certain immigrant populations can place them at high risk of experiencing vaccine-preventable disease outbreaks.

METHODS: We conducted a retrospective cohort study between January 1, 2008, and May 1, 2013, among children included in the Washington State Immunization Information System. We assessed receipt of 1 or more doses of measles-containing, hepatitis A, pneumococcal, and diphtheria-tetanus-acellular pertussis-containing vaccines between 12 and 23 months of age. We compared children with 1 or more parents born in Somalia, Ukraine, Russia, Mexico, or India to children with 2 parents born in the United States. Poisson regression models with robust SEs were used to provide prevalence ratios adjusted for maternal education and number of prenatal visits.

RESULTS: We identified 277 098 children, including 65 466 with foreign-born parents. Children of Somali-born parents were less likely to be immunized against measles than children of US-born parents (prevalence ratio: 0.82; 95% confidence interval: 0.80–0.84); this decrease became more pronounced over time ($P < .01$). No such disparity between these groups was observed with other vaccines. Compared with children of US-born parents, children of Ukrainian-born and Russian-born parents were less likely to be immunized, whereas children of Mexican-born and Indian-born parents were more likely to be immunized with any of the specified vaccines.

CONCLUSIONS: We found country-specific patterns of immunization that may reflect underlying cultural or other beliefs. Certain immigrant communities with higher rates of immunization refusal may be at risk for vaccine-preventable diseases and require new forms of public health outreach.

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WHAT'S KNOWN ON THIS SUBJECT: Low measles-mumps-rubella immunization coverage among Somalis has been linked to a large outbreak of measles in Minnesota. Little is known about immunization of other immigrant groups.

WHAT THIS STUDY ADDS: Compared with children of US-born parents, children of Somali-born parents were less immunized against measles; children of Mexican and Indian parents were more immunized, whereas children of Russian and Ukrainian parents were less immunized with any of the specified vaccines.

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Investigations conducted among children residing in the United States have indicated that foreign-born children or those born to foreign-born parents generally have lower vaccination coverage than US-born children.[1–3] However, little is known about whether such disparity is limited to or especially pronounced among certain countries of origin or types of vaccines. One study in Minnesota revealed that measles-mumps-rubella (MMR) vaccination coverage in Somali children was initially greater than in non-Somali children but subsequently declined (from 91% in 2004 to 54% in 2010) and was much lower than in non-Somali children by the end of the study period.[4] This decline was attributed to the perceptions in the Somali community that Somali-American children have high rates of autism and that the MMR vaccine causes autism.[4–6] This decline in MMR vaccination uptake among Somali children was associated with a large measles outbreak in Minnesota.[4]

Immigrant communities may be at risk for future outbreaks of vaccine-preventable diseases (VPDs) for several reasons. First, immigrant families tend to concentrate in certain neighborhoods.[7,8] If large proportions of these neighborhoods are unvaccinated, herd immunity can be compromised at a local level. Outbreaks of VPDs have been attributed to "clusters" of unvaccinated individuals.[9–11] Second, immigrant families frequently travel back to their home countries where they may be exposed to endemic VPDs. They may also be exposed to imported cases of VPDs through traveling friends and family members. In addition, anthropologic studies have revealed that some immigrants have strong beliefs in traditional medicine, mistrust of medical authorities, lack of experience with preventative care and low-levels of health literacy, all of which may contribute to vaccine refusal.[12–14]

Washington State represents a unique setting to study the effects of country-specific cultural beliefs on vaccination uptake. The number of documented foreign-born immigrants to Washington State has dramatically increased over the past 2 decades: in 2011, foreign-born immigrants made up 13%[15] of the state's population, up from 7% in 1990.[16] Washington State is 1 of the top 10 states in the nation for refugee resettlement.[17] There are also many undocumented immigrants who work in the state's seasonal agricultural sector.[18] The most common regions of origin for immigrants in Washington State include Asia (41%), Latin America (31%), Eastern Europe (9%), and Africa (6%).[19] The number of immigrants from Africa has increased more than 10-fold since 1990[19] and Washington State has the third largest population of Somali immigrants in the nation.[20] Furthermore, Washington State has a comprehensive vaccine registry, the Washington State Immunization Information System (WAIIS), populated by state birth records, which has been validated for research purposes.[21]

The aims of the study were to examine (1) whether there was a decline in measles-containing vaccine coverage among children of Somali-born parents in Washington State similar to that observed in Minnesota; (2) whether any observed decline in measles-containing vaccine coverage among Somalis was specific to measles-containing vaccines or whether there were declines in other vaccines as well; and (3) whether other immigrant groups had similar patterns of vaccination coverage to those of children with Somali-born parents. We compared vaccination coverage between children of US-born parents and children of parents born in 5 other countries: Somalia, Ukraine, Russia, Mexico, and India. Ukraine and Russia were chosen on the basis of qualitative and anecdotal reports of vaccine hesitancy noted in those communities by local physicians and Washington State Department of Health staff.[22] Mexico and India were chosen because those were the largest sources of immigrant parents in Washington State during the study period. The overarching goals of this study were to determine patterns of vaccine refusal among various immigrant groups, allowing for identification of populations at risk for VPDs and informing targeted and culturally relevant public heath interventions.

METHODS

Study Population and Setting

We conducted a retrospective cohort study to compare vaccination coverage between children of US-born parents and children of parents born in Somalia, Ukraine, Russia, Mexico, or India. Children with 2 US-born parents or 1 or more parents from Somalia, Ukraine, Russia, Mexico, or India were included. Because our primary hypothesis concerned measles-containing vaccine refusal by Somali parents, we chose to study the age range during which the first measles-containing vaccine is typically given, 12 to 15 months.[23] We also included children 16 to 23 months of age, to increase the sensitivity of the study in capturing vaccination refusal rather than vaccination delay.

We included children with dates of birth January 1, 2008, to May 1, 2013, who were listed in WAIIS and had an available Washington State birth certificate (thus, children born in foreign countries were excluded from this study). We did not include children with dates of birth before January 1, 2008, based on our previous research revealing WAIIS to be less complete during that period. We abstracted the following

variables from the Washington State birth certificate: name, birth certificate number, date of birth, sex, mother's country of birth, father's country of birth, number of prenatal visits during pregnancy, and maternal education. From WAIIS, we abstracted name, birth certificate number, vaccine type, and date at which the vaccine was given. Linkages between birth certificates and WAIIS were made with the birth certificate number and confirmed by using name and date of birth.

Measures

Exposures

The primary exposure in this study was birth of 1 or more parents in Somalia. Secondary exposures were birth of 1 or more parents in 4 other foreign countries: Ukraine, Russia, Mexico, or India. To avoid counting children more than once, country categories were classified hierarchically (Somalia > Ukraine > Russia > Mexico > India) on the basis of a priori hypotheses of vaccine refusal. That is to say, a child with 1 parent from Somalia and 1 parent from the Ukraine would be considered part of the Somalia group for the purposes of our study. Because there were a substantial number of children with 1 parent from Ukraine and 1 parent from Russia (n = 464; 15% of 3192 infants initially classified in the Ukrainian group), we performed a sensitivity analysis with an alternative hierarchy (Somalia > Russia > Ukraine > Mexico > India). Changing the order of the hierarchy did not meaningfully change the results for any of the included vaccines.

Outcome

The primary outcome was receipt of 1 or more doses of measles-containing vaccine (MMR, MMR-varicella [MMRV] or measles vaccine) between 12 to 23 months of age. Secondary outcomes were receipt of 1 or more doses of a priori selected vaccines typically administered during the same age range (hepatitis A, pneumococcal, and diphtheria-tetanus-acellular pertussis [DTaP]-containing vaccines). Varicella was not examined because varicella vaccine is frequently given in combination with MMR (MMRV), and MMRV was already included in the primary outcome assessment.

Covariates

Covariates in the multivariable models were selected a priori and included maternal education (as a marker of socioeconomic status) and number of prenatal visits (as a marker of health care utilization). We classified maternal education into 3 categories on the basis of terciles of maternal education seen in children of US-born children: high school or less, some college or associates degree, or bachelor's degree or higher. Number of prenatal visits was categorized as 0 to 9 or 10 and above on the basis of the American College of Obstetrics and Gynecology's recommendations for prenatal visits.[24]

Statistical Analysis

Poisson regressions with robust SEs were used to quantify the relationship between parental country of birth and receipt of vaccination by means of prevalence ratios (PRs) and corresponding confidence intervals (CIs). We assessed whether there was effect modification by time by including an interaction term comprising parental country of birth and birth year in our model. All analyses were conducted with Stata (version 12.1; Stata Corp, College Station, TX). Ethical approval was granted by the Washington State Department of Social and Health Services Institutional Research Board and Seattle Children's Hospital Institutional Research Board.

RESULTS

A total of 277 098 children met the inclusion criteria. Seventy-six percent of the cohort had 2 US-born parents. Mothers of children with Somali-born, Ukrainian-born, and Mexican-born parents tended to have lower levels of education than mothers of children with US-born parents, whereas mothers of children with Russian-born and Indian-born parents tended to have higher levels of education (Table 1). Mothers of children with foreign-born parents from all countries except India had lower number of prenatal visits compared with US-born parents (Table 1).

When compared with children of US-born parents (92%; Table 2), a lower proportion of children of Somali-born parents (76%; Table 2) received measles-containing vaccines (PR: 0.83; 95% CI: 0.81–0.85). This relationship was not substantially changed in the multivariable analysis (PR: 0.82; 95% CI: 0.80–0.84; Table 3). We observed a steady decline in measles-containing vaccination coverage for children of Somali-born parents during the study period, which was not observed with other vaccines or in children with other parental countries of origin (Figs 1 and 2). We found that birth year significantly modified the association between receipt of measles-containing vaccine and parental country of birth (P < .01). The decrease in measles-containing vaccine coverage among children with Somali-born parents relative to those with US-born parents became consistently more pronounced over time (Table 4).

Children of Somali-born parents did not have lower coverage than children of US-born parents with other vaccines. In fact, children of Somali-born parents were slightly more likely to receive hepatitis A (PR: 1.02; 95% CI: 1.00–1.05; Table 3) and pneumococcal vaccination (PR: 1.02; 95% CI: 1.01–1.04; Table 3) compared with children of US-born parents.

Children of parents born in Ukraine or Russia tended to have lower vaccination coverage than that of US-born parents for each of the

TABLE 1 Characteristics of Study Population: Children of US-Born and Foreign-Born Parents From Select Countries of Parental Birth

Characteristic	US-Born[a]	Somalia[b,c]	Ukraine[b,c]	Russia[b,c]	Mexico[b,c]	India[b,c]
N (%) unless otherwise specified	*N* = 211 632	*N* = 2306	*N* = 3192	*N* = 1533	*N* = 51 831	*N* = 6604
Girl	103 468 (49)	1136 (49)	1552 (49)	740 (48)	25 604 (49)	3211 (49)
Maternal education						
High school or less	65 859 (31)	1720 (79)	1278 (40)	348 (23)	42 154 (83)	524 (8)
Some college or associates degree	75 144 (36)	370 (17)	1317 (42)	488 (32)	6565 (13)	461 (7)
Bachelor's degree or higher	69 865 (33)	85 (4)	566 (18)	689 (45)	1905 (4)	5602 (85)
Number of mother's prenatal visits						
0–9	54 658 (28)	982 (46)	1370 (45)	485 (35)	18 871 (40)	1529 (27)
10+	142 058 (72)	1146 (54)	1652 (55)	904 (65)	28 885 (60)	4076 (72)

[a] Reference group contains children with 2 US-born parents.
[b] Characteristics of children with 1 or more parents from specified birth country.
[c] Categories are hierarchical with Somalia > Ukraine > Russia > Mexico > India.

TABLE 2 Receipt of ≥1 Measles-Containing, Hepatitis A, and DTaP-Containing Vaccines by Children 12 to 23 Months of Age With US-Born and Foreign-Born Parents From Selected Countries

Parental Country of Origin (*N*)	≥1 Measles-Containing Vaccine[a]		≥1 Hepatitis A Vaccine		≥1 Pneumococcal Vaccine[b]		≥1 DTaP-Containing Vaccine[c]	
	N	%	*N*	%	*N*	%	*N*	%
US[d] (211 632)	195 110	92	170 847	81	188 980	89	183 769	87
Somalia (2306)	1763	76	1893	82	2095	91	1926	84
Ukraine (3192)	2569	80	1762	55	2328	73	2622	82
Russia (1533)	1300	85	1058	69	1260	82	1309	85
Mexico (51 831)	50 149	97	46 763	90	47 809	92	46 197	89
India (6604)	6264	95	6146	93	6202	94	6180	94

[a] Includes MMR, MMRV, and measles vaccine.
[b] Includes 7-valent and 13-valent pneumococcal conjugate vaccines (PCV7 and PCV13).
[c] Includes DTaP as well as DTaP combination vaccines (DTaP/hepatitis B/inactivated poliovirus vaccine [IPV], DTaP/*Haemophilus influenzae* type B /IPV, and DTaP/IPV).
[d] Includes children with 2 US-born parents.

included vaccines. The effect was most pronounced for the hepatitis A vaccine. Only 55% of children of Ukrainian-born parents were vaccinated against hepatitis A compared with 81% of children of US-born parents (PR: 0.69; 95% CI: 0.67–0.71; Table 3). Similarly, only 69% of children of Russian-born parents received hepatitis A vaccine (PR: 0.84; 95% CI: 0.81–0.88; Table 3).

In contrast to the Ukrainian and Russian groups, greater proportions of children with parents born in Mexico or India received vaccinations compared with children of US-born parents. This relationship existed for all included vaccines but was most pronounced for hepatitis A (Mexico PR: 1.12; 95% CI: 1.12–1.13; India PR: 1.14; 95% CI: 1.13–1.15; Table 3).

DISCUSSION

We found that children of Somali-born parents were less likely to be vaccinated with measles-containing vaccines compared with children of US-born parents. Children of Somali-born parents did not show decreases relative to children of US-born parents in the other vaccines. The decreased measles vaccination coverage of children with Somali-born parents that we observed is consistent with the findings of the aforementioned Minnesota study.[4] It is also consistent with MMR vaccine hesitancy identified by qualitative research in the Seattle Somali community.[13] Qualitative research in both Washington State and Minnesota has revealed that MMR vaccine hesitancy among Somalis is primarily linked to the belief that MMR causes autism.[5,13] The fact that refusal of measles-containing vaccines by Somali parents in our study was specific and did not extend to the other included vaccines lends further credence to this explanation.

Similar to the Minnesota study, the decrease in measles vaccination coverage among Somali children became more pronounced over time. It should be noted, however, that the decline in the Minnesota study began in 2008, whereas the decline in our study began in 2011 (corresponding to the 2010 birth year). The Minnesota Somali community receives frequent visits by Dr Wakefield,[6,25,26] the author of the retracted article that first purported an erroneous link between MMR and autism.[27] Somali families in Washington are in frequent contact with friends and family in Minnesota (F. Mohamed, personal communication, 2015). It is possible that the trend we observed represents the adoption of Minnesota-based vaccine hesitant beliefs.

In contrast to the specific effect on measles vaccination seen in children of Somali-born parents, children of Ukrainian and Russian-born parents had lower vaccination coverage with all included vaccines. One

TABLE 3 PRs and 95% CIs for Receipt of ≥1 Measles-Containing, Hepatitis A, Pneumococcal (PCV) and DTaP-Containing Vaccines for Children 12 to 23 Months of Foreign-Born Parents Compared With Children 12 to 23 Months of 2 US-Born Parents, Adjusted for Maternal Education and Number of Prenatal Visits

Parental Country of Origin	≥1 Measles-Containing Vaccine[a]			≥1 Hepatitis A Vaccine			≥1 Pneumococcal Vaccine[b]			≥1 DTaP-Containing Vaccine[c]		
	PR[d,e]	95% CI	P	PR[d,e]	95% CI	P	PR[d,e]	95% CI	P	PR[d,e]	95% CI	P
US-born	1.00	Ref.	Ref.	1.00	Ref.	Ref.	1.00	Ref.	Ref.	1.00	Ref.	Ref.
Somalia	0.82	0.80–0.84	<.01	1.02	1.00–1.05	.02	1.02	1.01–1.04	<.01	0.99	0.97–1.01	.42
Ukraine	0.87	0.86–0.89	<.01	0.69	0.67–0.71	<.01	0.82	0.80–0.84	<.01	0.96	0.94–0.98	<.01
Russia	0.92	0.90–0.94	<.01	0.84	0.81–0.88	<.01	0.92	0.89–0.94	<.01	0.98	0.96–1.00	.04
Mexico	1.04	1.04–1.04	<.01	1.12	1.12–1.13	<.01	1.04	1.04–1.05	<.01	1.05	1.05–1.06	<.01
India	1.04	1.03–1.04	<.01	1.14	1.13–1.15	<.01	1.03	1.03–1.04	<.01	1.04	1.03–1.05	<.01

[a] Includes MMR, MMRV, and measles vaccine.
[b] Includes 7-valent and 13-valent pneumococcal conjugate vaccines (PCV7 and PCV13).
[c] Includes DTaP as well as DTaP combination vaccines (DTaP/hepatitis B/inactivated poliovirus vaccine [IPV], DTaP/*Haemophilus influenzae* type B /IPV and DTaP/IPV).
[d] PRs derived by Poisson regression with robust SEs. Reference group includes children with 2 US-born parents.
[e] Adjusted for categories of maternal education (high school or less; some college or associates degree; or bachelor's degree or higher) and number of prenatal visits (0–9 or 10+).

explanation is that vaccine refusal among these immigrant communities is associated with a more general fear of vaccines. Focus groups set up by the Washington State Department of Health involving Russian-speaking immigrants (including Ukrainians) revealed that the beliefs underlying their vaccine hesitancy were multifactorial and included fear of adverse events following immunization, fear of multiple vaccines given simultaneously, suspicion of corrupt medical authorities in their home countries as well as in the United States, and dissatisfaction with their doctor–patient relationship stemming from language and cultural barriers.[22] Given the widespread effect on all of the vaccines, the hesitancy among Ukrainian and Russian immigrants does not seem to be solely rooted in the MMR autism controversy.

Vaccine refusal by Ukrainian and Russian-born parents in the United States may also be linked to vaccine refusal in their home countries. In 2009, the Ukrainian media reported an erroneous link between the death of a 17-year-old boy and the measles-containing vaccine.[28] The cause of his death was subsequently found to be septic shock, unrelated to the vaccine, but misleading media reports fueled widespread vaccine refusal. Several million doses of vaccines subsequently went unused and had to be incinerated. It is unclear why coverage with the hepatitis A vaccine was so low among the Ukrainian and Russian groups in our study. The hepatitis A vaccine is 1 of the newest vaccines introduced in the toddler age group and may therefore be subject to greater suspicion. In addition, it is the only vaccine in this study that is not included in state child care and school entry requirements. Another explanation may be that these families perceived the risk associated with hepatitis A disease to be low. More research needs to be done to understand why

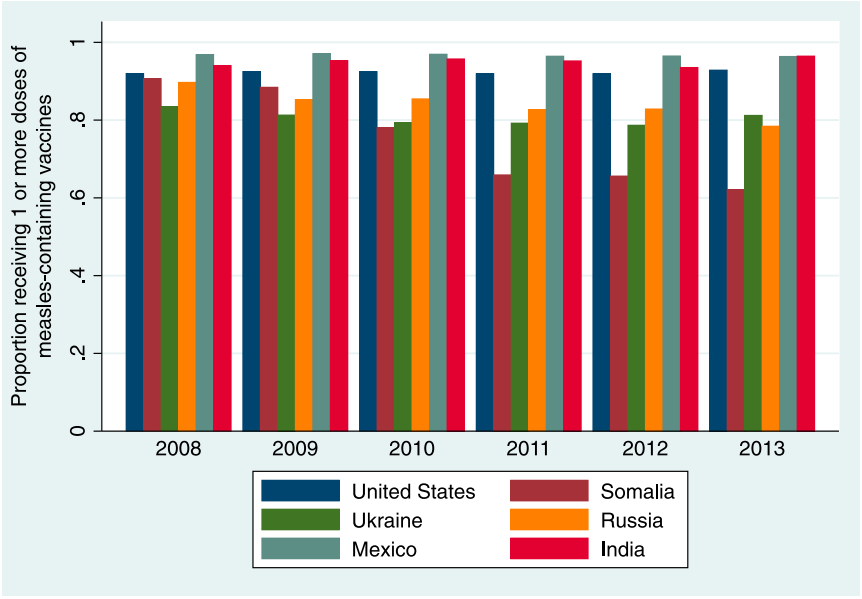

FIGURE 1
Receipt of measles-containing vaccines by parental country of birth and birth year.

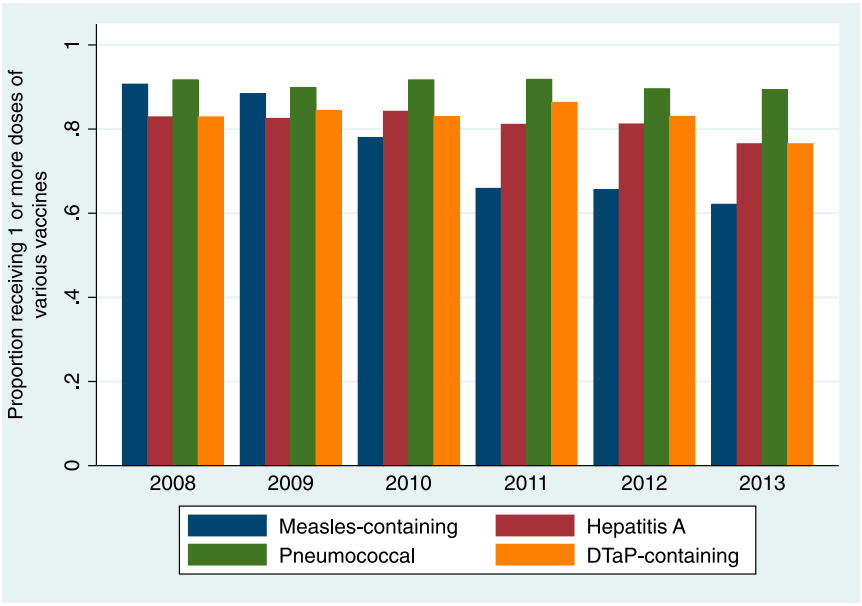

FIGURE 2
Receipt of vaccines by children with 1 or more Somali-born parents by birth year.

there may be particular refusal of this vaccine among Ukrainian and Russian immigrants.

We found that children of parents born in Mexico or India were more likely to be immunized with each of the included vaccines compared with children of US-born parents. The latest National Immunization Survey revealed that there were no differences in vaccination coverage between Hispanic Americans and white non-Hispanic Americans with almost all childhood vaccines.[29] That survey includes all those who identify as Hispanic, not just children of Mexican-born parents. One explanation for the findings in our study may be the lack of acculturation among first-generation immigrant parents. A study in California revealed that childhood vaccination coverage was lower in more acculturated Latino families compared with less acculturated Latino families.[30] Relatedly, another study revealed that Hispanic girls living in predominantly Hispanic neighborhoods were more likely to be vaccinated against human papillomavirus compared with Hispanic girls living in predominantly white neighborhoods.[31] It is unclear why acculturation seems to heighten vaccine refusal. As English fluency increases, families may be more exposed to antivaccine rhetoric through English-speaking media. It is also conceivable that the longer Mexican-American families live in the United States, the more likely they are to come into contact with vaccine-refusing parents.

One might hypothesize that parents from Mexico and India are more likely to vaccinate their children against VPDs compared with US-born parents because they have more direct experience with VPDs compared with native US-born parents. Although this may indeed be true, the same cannot be said for parents from Somalia, Ukraine, or Russia where outbreaks of VPDs, including measles, also regularly occur.[32–34]

One potential limitation in our study is the lack of completeness of the WAIIS. However, the WAIIS is populated by Washington State birth certificates and is considered to be almost complete by most measures. In 2011, there were 102.5% active cases in WAIIS compared with live births in Washington State (J. Warren, personal communication, 2013).[35] Only 2% of providers statewide do not participate in WAIIS.[36] One study revealed that only 1.0% of vaccinations recorded in a large local integrated health care organization could not be found in the WAIIS database.[21]

TABLE 4 PRs for Receipt of ≥1 Doses of Measles-Containing, Hepatitis A, Pneumococcal (PCV), and DTaP-Containing Vaccines for Children of Somali-Born Parents 12 to 23 Months of Age by Year of Birth, Adjusted for Maternal Education and Number of Prenatal Visits

Birth year	≥1 Measles-Containing Vaccine[a]			≥1 Hepatitis A Vaccine			≥1 Pneumococcal Vaccine[b]			≥1 DTaP-Containing Vaccine[c]		
	PR[d,e]	95% CI	*P*	PR[d,e]	95% CI	*P*	PR[d,e]	95% CI	*P*	PR[d,e]	95% CI	*P*
2008	0.99	0.96–1.02	.59	1.09	1.04–1.15	<.01	1.01	0.98–1.05	.44	0.99	0.95–1.04	.82
2009	0.95	0.91–0.98	<.01	1.05	1.00–1.10	.06	1.03	1.00–1.07	.07	1.01	0.96–1.05	.81
2010	0.83	0.79–0.88	<.01	1.04	0.99–1.08	.09	1.05	1.02–1.08	<.01	0.96	0.92–1.01	.09
2011	0.70	0.65–0.75	<.01	1.00	0.96–1.05	.88	1.03	1.00–1.06	.08	1.02	0.98–1.06	.37
2012	0.71	0.66–0.76	<.01	0.97	0.92–1.02	.19	1.01	0.97–1.04	.74	1.01	0.96–1.05	.74
2013	0.65	0.57–0.75	<.01	0.91	0.83–1.01	.06	1.00	0.94–1.06	.95	0.91	0.83–1.01	.08

[a] Includes MMR, MMRV, and measles vaccine.
[b] Includes 7-valent and 13-valent pneumococcal conjugate vaccines (PCV7 and PCV13).
[c] Includes DTaP as well as DTaP combination vaccines (DTaP/hepatitis B/inactivated poliovirus vaccine [IPV], DTaP/*Haemophilus influenzae* type B/IPV and DTaP/IPV).
[d] PRs derived by Poisson regression with robust SEs. Reference group includes children with 2 US-born parents.
[e] Adjusted for categories of maternal education (high school or less; some college or associates degree; or bachelor's degree or higher) and number of prenatal visits (0–9 or 10+).

Another limitation is the possibility of secondary migration (movement from state to state after arrival in the United States). Within WAIIS it is impossible to distinguish between an undervaccinated child and 1 who has moved out of state. Secondary migration is known to occur among certain refugee and nonrefugee immigrant groups.[37] However, secondary migration is unlikely to explain the phenomenon of lower measles vaccination coverage in the Somali group, because we found no decrease in other vaccinations during the same study period. Secondary migration may have played a role in the Ukrainian and Russian groups, although Washington State tends to be the recipient of secondary migration by Russian-speaking refugees.[37]

There is also the question about whether our findings signify vaccine refusal or some other phenomenon such as poor health care access or decreased health care utilization. Washington State is a "universal purchase state" meaning that the state buys childhood vaccines in bulk and supplies them to providers at no cost.[38] Nevertheless, it is possible that children from certain immigrant groups are less likely to attend well child-care visits for other reasons. Differences in health care access and utilization are unlikely to explain the findings in the Somalia group because nonmeasles-containing vaccines were unaffected. It could explain the findings in the Ukraine and Russia groups, although when we adjusted for number of prenatal visits (as an albeit imperfect marker of access and health care utilization) there was no major change in our findings. Indeed, among various immigrant groups, Russian immigrants have been shown to have some of the highest proportions of health insurance.[39] The qualitative research of local Russian-speaking groups referenced above suggests that the decreased vaccination we observed is indeed

driven by vaccine hesitancy and refusal.[22]

CONCLUSIONS

This large cohort study of immigrant groups from 5 selected countries revealed that country-specific and vaccine-specific patterns of vaccination by parental country of birth exist, which may reflect underlying cultural or other beliefs. Further research needs to be done to understand the reasons behind country- and vaccine-level variability in vaccine refusal. Because immigrant groups tend to cluster socially and geographically, certain immigrant communities with higher rates of vaccine refusal may be at greater risk of VPDs. Innovative forms of public health outreach are needed to enhance immunization coverage among specific immigrant groups.

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ABBREVIATIONS

CI: confidence interval
DTaP: diphtheria-tetanus-acellular pertussis
MMR: measles-mumps-rubella
MMRV: measles-mumps-rubella-varicella
PR: prevalence ratio
VPD: vaccine-preventable disease
WAIIS: Washington State Immunization Information System

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