Volume Matters: Physician Practice Characteristics and Immunization Coverage Among Young Children Insured Through a Universal Health Plan

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ABSTRACT

OBJECTIVES. We studied the association between immunization coverage for a cohort of 2-year-old children covered by a universal health insurance plan and pediatric provider and other health services characteristics.

METHODS. We assembled a cohort of 101,570 infants born in urban areas in Ontario, Canada, between July 1, 1997, and June 31, 1998. Children were considered to have up-to-date (UTD) immunization coverage if they had ≥5 immunizations by 2 years of age, ie, the recommended 3 doses and 1 booster of diphtheria-polio-tetanus-pertussis/Haemophilus influenzae type b vaccine and 1 dose of measles-mumps-rubella vaccine. Provider practice characteristics were derived from outpatient billing records, and 1996 census data were used to derive neighborhood income quintiles. The association between UTD immunization status and provider characteristics was assessed with multilevel regression models, controlling for patient characteristics.

RESULTS. Overall, the rate of complete UTD immunization coverage was low (66.3%) despite a large number of primary care visits (median: 19 visits). Children whose usual provider had a low volume of pediatric primary care were less than one half as likely to be UTD. Other factors associated with not being UTD included very low continuity of care, low continuity of care, and usual provider in practice for <5 years. With adjustment for patient and provider characteristics, there was no difference in immunization coverage for general practitioners versus pediatricians. Children from low-income neighborhoods were less likely to be UTD.

CONCLUSIONS. Despite universal access to primary care services, rates of complete immunization coverage among 2-year-old children in Ontario are low. Because visit rates are high, primary care reform should include interventions directed at provider immunization practices to reduce missed opportunities.
UP-TO-DATE (UTD) IMMUNIZATION status of children is an important measure of the effectiveness of the primary health care system. As Rodewald et al noted, immunization status is a robust measure of quality of care, given its association with the prevention and reduction of vaccine-preventable diseases, its high rate of acceptance among physicians, its correlation with other preventive services, and the legislated requirements of documentation in many countries. Many studies document a myriad of reasons for low coverage levels; these range from obvious barriers such as insurance status to a range of somewhat more invisible access barriers associated with low levels of parental education and socioeconomic status, lack of a usual provider of care (UPC), and low continuity of care. Other important factors include parental concern regarding side effects and lack of knowledge about the immunization schedule. Important physician practice factors include long waiting times and difficulties getting appointments, lack of reminder systems, and physician adherence to recommendations regarding contraindications and screening for immunization status at all visits.

In Canada, where children are covered universally by a public health insurance system that covers primary care visits and the basic series of immunizations without cost to the parent, there are fewer structural barriers to immunization. The use of combination vaccines for diphtheria-polio-tetanus-pertussis (DPTP)/Haemophilus influenzae type b (Hib) and measles-mumps-rubella (MMR) also facilitates coverage. However, the few data available suggest that immunization rates for this primary series fall well below the 95% target set by Health Canada. The most recent National Immunization Coverage Survey of households by Health Canada, performed in 2002, found that only 56.7% of 2-year-old children had received all of the recommended DPTP/Hib and MMR immunizations. These low coverage levels have important repercussions, such as a recent rubella outbreak in Ontario involving almost 300 people, including nonimmune pregnant women, as well as measles outbreaks sustained in the middle 1990s in many Canadian jurisdictions. Low coverage rates may also indicate that other basic goals of primary care are largely unmet. There has been little research investigating the reasons for such low rates of coverage in a health system such as Canada’s and whether there are health system factors amenable to interventions to increase coverage.

Currently in Ontario, the largest province in Canada with a population of >12 million, primary care to children is delivered predominantly by >12 000 family/general practitioners. Physicians designated as family physicians have completed 2 years of residency and been accredited. General practitioners are those who have completed a general internship only, a route no longer possible for licensure. We use the term family physician to cover both groups. The ~460 community pediatrists in Ontario provide primary care to children predominantly in large urban centers. Although >40% of family physicians are in some form of group practice, there are no data available on whether this includes sharing patients and health records or merely space. No data are available on how many pediatricians practice in a group. More than 95% of these primary care physicians are remunerated through a fee-for-service system, with few incentives to provide comprehensive or 24-hour/7-day care. There are currently initiatives to reform the delivery of primary care with incentives to form group practices that provide 24-hour/7-day coverage, share patients, and include nonphysician providers such as nurse practitioners.

The goals of this study were to assess whether provider characteristics such as volume of primary care delivered to children, years of practice, and specialty and health services characteristics such as continuity of care were related to UTD immunization status in a population-based cohort of 2-year-old children in Ontario, controlling for socioeconomic status. We hoped to ascertain whether these health services characteristics were related to immunization coverage among young children and might inform current policy initiatives aimed at improving the quality of primary health care delivery.

METHODS

Databases
All data are housed at the Institute for Clinical Evaluative Sciences, and ethics approval for this work was obtained from the Sunnybrook and Women’s College Health Sciences Centre Research Ethics Board. We use a scrambled, anonymous, health card number to link data across various databases. The databases included hospital discharge abstracts (Discharge Abstract Database), which are mandatory submissions from hospitals to the Canadian Institute for Health Information; the physician fee-for-service claims file (Ontario Health Insurance Plan), the mechanism through which all fee-for-service physicians are paid by the Ontario Ministry of Health; the Ontario health care registry (Registered Person’s Database), which includes demographic information for all residents eligible for health care; the Corporate Physicians’ Database, which contains information on physician demographic characteristics, specialty training, and practice location; and the 1996 Canadian Census.

Study Cohort
We identified all infants born alive in an Ontario hospital between July 1, 1997, and June 31, 1998 (131 026 infants) from the Discharge Abstract Database. We deliberately chose this study period because it would allow a 2-year follow-up period before the approval of newer vaccines (pneumococcus and meningococcus) that initially were not funded by the Ontario government and
are not being evaluated in this study. We excluded infants whose initial newborn hospital stay was >1 month (1462 infants), because this population’s immunization needs might be different from those of the healthy infant population (they might receive additional immunizations such as that for respiratory syncytial virus) and some receive immunizations in the hospital, which might not be captured in our databases. We also excluded infants living in rural areas (15 331 infants), because some receive immunizations from health professionals who are not reimbursed on a fee-for-service basis and thus are not in our database.14 Rural areas are defined as those with a population concentration of <1000 persons or a population density of <400 persons per km². We excluded infants who had an invalid health card number (1512 infants), moved out of province (661 infants), or died before their second birthday (37 infants). We excluded infants who had no well-infant visits (670 infants) or <4 primary care visits (4398 infants) in 2 years. These children are likely to have resided in Ontario intermittently (which was not recorded in our health registry) or sought care from a salaried provider (in certain settings such as community health centers) for whom we do not have data. Our data cover 95% of primary care providers. The proportion of children excluded is comparable to the proportion of providers on alternate payment plans. There were 5044 children (4.7%) with no immunizations at 2 years of age. We excluded these children from the final cohort of 101 570 children because their immunization status most likely reflects parental preference rather than health care services characteristics. These children had large numbers of well-infant and primary care visits and similar distributions of primary care provider types and characteristics and continuity of care, compared with the children with immunizations. We did include these children with no immunizations in a total coverage estimate for the province.

Health Services Characteristics
We obtained all outpatient records from the physician claims database for the study cohort’s first 2 years of life. We classified a well-infant care visit as any visit with a diagnosis of well-infant care or a fee code for an annual visit (used primarily for children at ≥2 years of age). To define primary care visits, we included other nonconsultative visits to family physicians or pediatricians that are representative of sick and well-care visits. These codes include the majority of services provided by these physicians other than requested specialist consultations (list of fee codes is available on request from the authors). We then assigned a UPC to each child, on the basis of the physician who provided the majority (>50%) of well-infant care and immunization care (98 386 children) or, if there was a tie, the majority of primary care (2849 children). For the remaining 335 children for whom there was still a tie, we assigned the physician who provided the most recent primary care.

We calculated each child’s continuity of care with their UPC as the proportion of all primary care visits with that provider. Because overall continuity was high, we did not use tertiles but grouped data according to clinically meaningful categories of very low (<50% of all visits to the UPC), low (50–67.0% of visits), medium (67.1–86.0% visits), and high (>86.0% of visits) continuity. We used the physician claims data to characterize the 6867 UPCs according to specialty (pediatrician: 395 UPCs; family physician: 6472 UPCs) and the Corporate Physicians’ Database for the length of time in practice. We analyzed 2 years of claims data (July 1, 1997, to June 30, 1999) to determine each physician’s volume of primary care billings for children 0 to 6 years of age. Volume was divided into 3 groups of low, medium, and high. These volume categories were designed to ensure adequate representation of family physicians in the highest group and pediatricians in the lowest. Low-volume practices were characterized by <3000 billings, medium-volume by 3000 to 6000 billings, and high-volume by >6000 billings over 2 years for primary care for children 0 to 6 years of age. Almost 5% of children who saw pediatricians were in the lowest-volume category and 10% of children whose UPC was a family physician were in the highest. Using assumptions of physicians working a 5-day week and 48-week year, with an average of 30 billings per day, those in the high-volume category would have ≥42% billings for children 0 to 6 years of age, those in the medium-volume category between 21% and 42%, and those in the lowest-volume category <21%.

Demographic Information
There are no individual-level sociodemographic data available from our administrative data apart from postal code. We linked each child’s postal code of residence to the 1996 Canadian Census to attribute the mean household income quintile of the child’s enumeration area, as a proxy for socioeconomic status. Typically, census enumeration areas are populated by <2000 people (average: 650). The income quintiles are calculated separately for cities and towns on the basis of size, to account for differences in the cost of living as well as household size. Therefore, it is impossible to report the mean income of a quintile because it varies across areas. Canada does not define a “poverty level” as used in the United States; however, these income quintiles are operationalized by Statistics Canada to represent low-income cutoff values, with an emphasis on relative cost of living and household size.15 A small number of postal codes cannot be assigned an income quintile because the areas have unstable populations; we assigned children in these areas to a category of missing income.
Outcome Measure

We computed immunization status by using the physician claims data fee codes for immunizations; with the exception of influenza, these codes are not vaccine-specific. Two different fee codes are used, depending on whether the immunization is given in the context of a visit in which other care is provided (code G538) or is the sole reason for the visit (code G539). In both cases, physicians are paid for the immunization. For immunizations at <12 months of age, we enumerated only 1 immunization per visit. Some children had 2 immunization billings because the routine immunizations given at 2, 4, and 6 months were still sometimes given as 2 separate injections during this time period. We defined UTD status at age 2 as having had 5 immunizations, representing the recommended 3 doses and 1 booster of DPTP/Hib vaccine to be given at 2, 4, 6, and 18 months and 1 combined dose of MMR vaccine to be given after the first birthday. During the study period, the current routine vaccinations (pneumococcus and meningococcus) were not licensed in Canada. Although the varicella vaccine was licensed during the time of the study, it was not recommended by the National Advisory Committee on Immunization until 1999, was not funded by the Ontario Health Insurance Plan, and did not initially have high uptake.16,17 Physicians are reimbursed for providing immunizations, in addition to the fee for well-infant visits. All physicians have billing systems in place that use one fee code for a well-infant visit and another for an immunization. The fee schedule in Ontario at the time of this study was Canadian $26.50 for a well-infant visit and $3.65 for each immunization (injection, not antigen) provided. Universally funded vaccines are delivered to physician offices free of charge by the public health departments, which also monitor refrigeration and storage requirements. There were no vaccines shortages during the period studied.

Analyses

We used logistic regression to assess the effects of patient and provider characteristics on UTD immunization status by 2 years of age. The unit of analysis was the individual child. Models included both patient- and provider-level variables. These multilevel models enable (1) interpretation of patient- and provider-level factors, (2) optimal control for confounding at all levels, and (3) inference to individual patients.18,19 Provider characteristics included volume of primary care billings, provider specialty, and years in practice. All models controlled for patient characteristics of gender and socioeconomic status, as well as continuity of care with the provider. Because patients seeing the same physician might have correlated outcomes, we used quasi-likelihood or generalized estimating equation logistic regression models to account for this clustering of patients within physicians.20 These models adjust for this correlation by inflating the standard error of the regression estimates. The net effect of the clustering was to increase the width of the confidence intervals by ~5% to 12%. We also assessed the interaction between physician specialty and primary care volume. All analyses used the SAS procedure GENMOD (SAS 8.0; SAS Institute, Cary, NC).

RESULTS

Figure 1 illustrates the proportion of children who were UTD at the end of each recommended time period. There

![Figure 1](https://example.com/figure1.png)
was a gradual decline in the proportion of children who were UTD at each interval. At 3 months, only 12.5% of children had no immunizations; by 7 months, 32.4% of children were behind schedule. At 13 and 19 months, less than one half of children were UTD, which suggests that even those who were UTD at 2 years had periods of suboptimal coverage. At 2 years, 66.3% of children were UTD but 20% were missing only 1 immunization. With the inclusion of children with no immunizations, the rate of UTD coverage decreased to 63.2%.

Table 1 describes the sociodemographic and health services characteristics of the children on the basis of immunization status. Children who were UTD at 2 years of age were more likely to live in a higher-income neighborhood and to have had more well-infant and primary care visits in the first 2 years of life. The UTD children were also more likely to have a UPC who was a pediatrician and to have high continuity of care. They were also more likely to have a UPC with a high volume of billings for primary care for children 0 to 6 years of age and one who had been in practice 16 to 25 years. Both groups had large numbers of primary care visits over 2 years, although only 69.5% of the non-UTD group compared with 88.5% of the UTD group, had the minimal number of well-infant visits (5 visits) to be fully immunized at those visits by 2 years of age.

Table 2 displays unadjusted and adjusted odds ratios of UTD immunization status at 2 years of age. Mean household incomes of the children’s neighborhoods demonstrated a gradient, with children from the highest-income neighborhoods being most likely to be UTD. There was no difference in the median number of primary care visits according to income quintile except for those in the lowest quintile (6 visits, compared with 7 visits for all other quintiles; data not shown).

Children with lower continuity of care were much less likely to have UTD immunizations than were those with higher continuity. Physician volume of primary care billings for children 0 to 6 years of age was a strong predictor of UTD immunization status, with children in low-volume practices being less than one half as likely to be UTD, compared with children in high-volume practices. The effect of volume reached a threshold between 7500 and 10 000 billings, after which there was no additional benefit. This volume range would approximate a full-time practice with ~50% of all billings for children 0 to 6 years of age. Physician specialty was unrelated to UTD immunization status, after adjustment for patient and provider characteristics. Physician specialty was confounded by volume, because pediatricians had higher pediatric primary care volumes than did family physicians; however, with adjustment for volume, specialty was no longer a significant predictor of UTD status. There was no statistically significant interaction between provider specialty and volume of primary care practice. Finally, children with UPCs who had been in practice for 16 to 25 years were most likely to be UTD, especially compared with those with UPCs who had been in practice for <5 years.

To explore missed opportunities, we studied whether the volume of pediatric billings in a practice was related to a propensity to immunize children at visits other than those for well-infant care. There was just over 10% correlation between the volume of pediatric billings and the proportion of immunizations given to children 1 to 6 years of age not in conjunction with well-infant and annual examination visits.

**DISCUSSION**

To our knowledge, this is the first study to document the relationship between the volume of primary care of young children and a primary health care outcome, such as immunization status. There is a large body of volume-outcome literature that has focused primarily on volumes of surgical procedures. Although giving immunizations is not equivalent to performing a Whipple procedure, often the volume effect represents a complex set of patient care processes. We found a strong relationship between volume of pediatric primary care and level of immunization coverage of the children seen by that physician, which seems to explain the difference in immunization coverage between children seen by family physicians and pediatricians. This difference was noted in one US study, although a measure of volume of children seen by the practice in the past month was not associated with coverage rates; however, the sample of providers was small (251 providers). In our data, there was no interaction between the volume and the provider type, so that, for the same volume, the 2 physician groups had similar immunization coverage rates. We showed that volume of pediatric primary care was correlated only weakly with a propensity to use visits other than well-infant care to immunize. Clearly understanding what is responsible for the volume-outcome relationship is crucial. Surveys of pediatricians and family physicians have found the former to be more likely to have tracking systems and to use illness visits to vaccinate patients but overall found that most immunization practices and attitudes were similar between the 2 provider groups. It may be that physicians who perform a large volume of pediatric primary care use reminders or tracking systems, keep more abreast of true contraindications, and screen for immunization status at more visits. Having so many children in their practice, these physicians may have effective systems in place, such as delegating immunizations to nursing staff members.

The finding that children whose physicians were new to practice were less likely to be UTD may also reflect an inexperience in establishing office-based practices that encourage better coverage rates. Initiatives to bring some of these issues and other quality improvement issues into residency curricula are nascent in Canada.
National bodies such as the Canadian Pediatric Society are beginning to offer educational programs to stimulate pediatric and family practice residents to be "immunization champions."25 As larger primary care practices are encouraged by current primary care reform in Ontario, establishing such immunization champions, be they newly trained or more experienced physicians, will be important. US research suggests that these role models are one of the most important predictors of improving immunization coverage among 2-year-old children in Ontario; the low level of complete DPTP/Hib and MMR immunization for this important intervention.

Although we cannot explain definitively the basis for the volume or time in practice relationships, we can document that there are a large number of missed opportunities for immunization. Children whose immunizations are not UTD see physicians slightly less frequently but the median number of primary care visits for this group in the first 2 years of life is still 17. With 60% of these children seeing their own physician >69% of the time, there are multiple missed opportunities for bringing these children UTD. However it is noteworthy that <70% had the minimum of 5 well-infant visits necessary to achieve full coverage. Evidence from a US, randomized, controlled trial suggested that tracking with outreach is more effective than physician prompting in increasing immunization coverage.27 In the context we describe, with high rates of primary care visits but well-infant visit rates that are less than optimal, interventions directed at bringing children to the provider for such visits more frequently, by using reminders and recalls, should be combined with those directed at physicians to reduce missed opportunities. This may be especially effective for physicians early in their careers. Evidence from the United States also suggests that levels of remuneration for vaccinations may be an important factor in coverage rates.27 Primary care reform will need to address the relatively low (currently Canadian $3.75) renumeration for this important intervention.

The importance of these findings is underscored by the low level of complete DPTP/Hib and MMR immunization coverage among 2-year-old children in Ontario; however, the fact that 20% of children could be brought UTD with 1 immunization is cause for some optimism. Although we cannot comment on whether these children needed a booster for DPTP/Hib or their first MMR vaccination, data from Health Canada suggested that
immunization events (99.8%) are accounted for in bill-

<7% of 2-year-old children are missing the latter. From a public health perspective, a missed DPTP/Hib vaccination may be somewhat less alarming, although the low coverage rates are cause for concern and data suggest that the problem persists beyond 2 years of age. A Toronto Public Health report documented that in 2000 only 60% of 230 000 school-aged children were UTD. With incomplete coverage, Canadian children are at risk for outbreaks of preventable diseases. A May 2005 rubella outbreak in an underimmunized community in Ontario that affected almost 300 children and a number of pregnant women serves as a stark reminder. Although Canada has not seen a level of measles outbreaks such as that in the United States in 1989 to 1990, possibly because the overall level of partially immunized children may be higher, >5% of our eligible cohort had no immunizations and another 6% had only 1 or 2 by 2 years of age. It is not known what the ultimate fates of these children are and whether they are immunized eventually before school entry. Clearly this is a group that warrants special consideration in attempts to improve coverage. The socioeconomic gradient in immunization coverage, although not steep, merits mention. It reiterates the lesson that barriers to care are not only financial and that strategies to increase coverage need to focus on practices serving low-income children.

Finally, the low rates of immunization coverage, coupled with the proportion of children with <5 well-infant visits in 2 years, raise concerns about the overall quality of primary health care for young children in Ontario. Underimmunization is a marker for a lack of other preventive and early intervention services, such as well-infant visits and screening for tuberculosis, anemia, and lead. Outreach interventions aimed at increasing immunization coverage also increase rates of other preventive services. It is unclear in the Canadian context whether immunization is an anomaly that is related to a lack of physician reminder systems or to specific factors related to immunization or is reflective of other aspects of quality of primary care. It is likely, however, that these low rates signal a problem in the delivery of preventive care to young children, given that immunization is one of the few preventive care measures for which physicians are remunerated above the visit fee.

The main limitation of this study is that the outcome is based on physician billing data collected for administrative purposes and the billing data are not specific to the type of vaccine provided. Therefore, we cannot comment on which vaccines children are missing, and we cannot analyze whether the timing of all of the vaccines is appropriate (for example, whether children are receiving the MMR vaccine before their first birthday). Although we could not validate the use of the data for immunization surveillance in Ontario, a Manitoba chart abstraction study suggested that the vast majority of immunization events (99.8%) are accounted for in billing data. Although the remuneration is not large, there is a financial incentive to submit billings. The overall rate we report is comparable to findings from other sources of immunization data, such as a combination of billing and public health data and a national sample based on parental report. Even if we added the children with no immunizations to our denominator, the coverage estimate would be within the range reported with these other data sources.

Our databases have limited ability to determine how a group practice might have an impact on immunization coverage. Although our data allowed us to group physicians according to practice postal code, this is not a valid way to measure clinically meaningful group practices. Many physicians practice in the same building, and even those who share an office and support staff may not share patients. A meaningful examination of the effects of group practices on immunization rates would require assessment of group practices at this level of detail.

CONCLUSIONS

The policy implications of these findings are that primary care reform aimed at improving access to a designated established “medical home” for primary care of children might improve immunization rates, given the relationship between continuity of care and coverage. However, current health policy reformers in Ontario and other Canadian jurisdictions could benefit from many other lessons derived from extensive research and practice aimed at improving coverage rates in the United States. Using venues such as emergency departments and conducting 1-day “blitzes” are less effective in the long term than improving office-based processes. Given the universal access to care in Canada, such emphasis is even more appropriate. Current requests by the Ministry of Health for the creation of family health networks in Ontario include funding for information systems. Ideally, these should function as recall and reminder systems but also as data repositories that are easily accessible, to track coverage for the purposes of quality improvement initiatives within a practice. One physician or nurse should be identified as an immunization champion for each practice. Although the role of financial incentives is controversial, keeping immunizations on the agenda as a quality indicator will be important as Ontario defines how primary care performance is tied to remuneration. Finally, there have been calls for decades for a national immunization surveillance system in Canada. As a nation that provides universal access to health care, we may be complacent about how well we perform on a very basic measure of primary health care for children. We do not often measure or report our performance or focus our improvement efforts where they count, in the individual practice.
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