Taking a Closer Look: An Examination of Measles, Mumps, and Rubella Immunization Uptake in Saskatoon

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ABSTRACT

Background: Immunization is one of the most successful public health initiatives in Canada, yet continuous monitoring of coverage rates is essential to ensure high uptake for sustained success. The purpose of this study was to utilize newly available data from the Saskatchewan Immunization Management System (SIMS) to examine city and neighbourhood uptake of the Measles, Mumps and Rubella vaccine and identify potential factors that contribute to low immunization uptake in Saskatoon.

Methods: The study examined records for 10,287 two year olds between 1999 and 2002 using an ecological study design. The first step consisted of simple rate calculations to determine the total, complete, up-to-date and not up-to-date immunization rates for the city of Saskatoon and in each residential neighbourhood. Quantitative neighbourhood-level data were then used to determine if neighbourhood variables could significantly contribute to the variation in immunization coverage.

Results: The findings revealed MMR/MR immunization rates were relatively stable between 1999 and 2002. However, significant disparities were found at the neighbourhood level, with areas of social and economic disadvantage having lower rates of total, complete, and up-to-date immunization uptake compared to areas of greater social and economic wealth. Multivariate linear regression revealed 80.6% of variation in up-to-date immunization uptake in Saskatoon could be explained by the proportion of single mothers and vehicles per capita in the neighbourhood.

Conclusion: Significant inequities in immunization uptake exist on the neighbourhood level in Saskatoon. These findings are supported by the literature and may indicate the presence of real or perceived barriers to immunization in some Saskatoon neighbourhoods.

MeSH terms: Immunization; measles; mumps; rubella; neighbourhood

La traduction du résumé se trouve à la fin de l'article.

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Immunization has proven to be one of the most significant and successful advances in disease prevention. Over the last 100 years, the incidence of vaccine-preventable diseases in Canada has decreased 95% and vaccination has become the cornerstone of preventive health care.¹ Measles, mumps, and rubella (MMR) are three of the many diseases that have drastically declined following the implementation of large-scale immunization programs in Canada. However, the threat of re-emergence remains in areas where immunization coverage is substandard.

The Canadian Public Health Association states targeting high-risk groups and identifying ways to minimize immunization inequities is an important component of any immunization program.¹ Saskatoon Public Health Services recognized the need for strong researched-based evidence to support and inform immunization programming decisions and provided newly available data from the Saskatchewan Immunization Management System (SIMS) to examine the strengths and gaps in their MMR immunization program.

MMR vaccine uptake was chosen for examination due to the MMR-Autism controversy sparked by the 1998 Wakefield et al. article.² The study led to serious concern among parents throughout North America and Europe and resulted in major measles outbreaks in the United Kingdom.³ Although the controversial study was retracted in 2004⁴ and the theory of linking vaccines to autism was disproved by a number of other studies,⁵⁻⁸ parental concerns continue to linger and can be influenced by the media and the Internet.⁹⁻¹¹ Other factors such as mobility,¹² poverty,¹³⁻¹⁵ low parental education,^{12,16,17} lack of transportation,¹⁸⁻²¹ single-parent families,^{13,17} delayed immunizations by health care professionals,²¹⁻²⁴ and concern over multiple injections²⁵ also pose a threat to maintaining high coverage rates.

Given this context, a study was conducted to address the following objectives: a) to describe the "up-to-date" MMR/MR immunization coverage rate in Saskatoon residential neighbourhoods between 1999-2002, b) to determine if MMR/MR coverage rates had remained stable, increased, or decreased between 1999-2002, and c) to

identify which neighbourhood characteristics significantly contribute to the prediction of MMR/MR coverage rates in Saskatoon highlighting real or perceived barriers to immunization.

METHODS

Sample

The population under investigation consisted of all two year olds living within the City of Saskatoon between the years of 1999 and 2002 and covered by the Saskatchewan Health Plan. According to the data in the Saskatchewan Health Covered Population Report, there were 10,827 two year olds living in the Saskatoon Health Region during this time. Five hundred and forty records (4.9% of total records) could not be linked to a residential neighbourhood in Saskatoon due to an incorrect postal code, retired postal code, post office box, or were outside of study neighbourhoods (i.e., industrial/non-residential). These cases were not retained for further analysis, resulting in a total sample of 10,287 children.

Data collection

The SIMS data, received by the Saskatoon Health Region (SHR) in early 2003, contained all MMR/MR immunization records for each child who received the vaccine from January 1, 1996 to December 31, 2002 in the SHR and was used as the numerator for coverage rate calculations. The Saskatchewan Health Covered Population Report, which provided the total number of two year olds with health care coverage as of June 30th of each year, was used for the denominator. All data used for rate calculations were provided with postal code information, enabling neighbourhood assignment for each child.

The Saskatoon Health Information and Strategic Planning System (SHIPS), a health region-based analysis unit that provides data for planning, evaluation, and policy development, provided neighbourhood data on socio-economic indicators, proportions of single mothers/fathers, proportions of visible minorities obtained originally from the Statistics Canada 2001 Census and from Saskatchewan Health Vital Statistics. The City of Saskatoon provided the number of vehicles registered in each residential neighbourhood as well as

TABLE I
Coverage Rate Definitions

Coverage Term	Definition
Total	% of children who have received at least one dose of the MMR/MR vaccine at any age up to date of data extraction.
Complete	% of children who have received two doses at any age up to date of data extraction.
Up-to-date	% of children who received two doses before 730 days (2 years of age).
Not up-to-date	% of children who were incomplete or delayed in the receipt of the MMR/MR vaccine.

Figure 1. MMR/MR coverage rates and trends, Saskatoon 2-year-olds (1999-2002)

total population counts for 2002 to determine vehicles per capita for each neighbourhood.

Data analysis

Coverage rates for several scenarios of MMR/MR immunization completion as per recommended guidelines²⁶ were determined (definitions given in Table I). The number of days elapsed between a child's birthday and the day they received their MMR/MR vaccination was calculated. The percent coverage rate was calculated by dividing the number of children fitting each definition (numerator) by the total population of two year olds and multiplying by 100. Children who had not received MMR/MR immunization are not included in the numerator but would have been included in the denominator. Coverage rates were calculated for Saskatoon overall and for each residential neighbourhood under investigation.

To address the third objective, we utilized an averaged up-to-date coverage rate over the period 1999 to 2002 in Saskatoon. Residential neighbourhoods with fewer than 10 children were combined with other neighbourhoods in the city to protect the confidentiality of the subjects, thus reducing the number of neighbourhoods analyzed from 56 to 49. Neighbourhood variables selected for inclusion in the models were chosen based on the literature review.¹²⁻²¹ Socio-economic and demographic characteristics of each of the 49 residential neighbourhoods were identified as the independent variables and averaged up-to-date immunization coverage rate was defined as the dependent variable. Bivariate linear regression analysis and multivariate linear regression analysis were used to determine the relationship between neighbourhood characteristics and up-to-date immunization uptake.

Figure 2. Neighbourhood distribution of average up-to-date MMR/MR coverage rates (1999-2002), Saskatoon, Canada

Figure 3. Proportion of female-headed lone-parent families versus up-to-date immunization uptake (Adj. $R^2 = 0.782$)

RESULTS

Figure 1 presents the MMR/MR immunization coverage rates and trends for Saskatoon children for the period of 1999 to 2002. Overall, rates appear to be stable

over the four-year period with total uptake around 90%, up-to-date uptake around 70% and not up-to-date rates around 20%. A slight decrease in not up-to-date immunization over time is a positive trend. Further analysis revealed this trend to be

more prominent in low-uptake neighbourhoods, possibly indicating increased immunization efforts in these areas in recent years.

Figure 2 represents the average up-to-date coverage rates between 1999 and 2002. Coverage rates over the four years were combined to reduce the impact of year-to-year variability in the coverage rates. Lower average coverage rates are seen in the low-income neighbourhoods whereas higher up-to-date immunization rates are seen in neighbourhoods that are more socio-economically advantaged. Only 3 of the 49 neighbourhoods reached an average up-to-date immunization rate above 90%.

Bivariate regression analyses revealed that nine out of twelve neighbourhood variables tested were highly significant in explaining the neighbourhood-level variation in the up-to-date MMR/MR uptake ($p < 0.001$), specifically: percentage of population who had moved within the last year, median family income, percentage of families living below the Low-Income Cut-off, percentage of families with household annual income $< \$10,000$, percentage of teenage mothers, percentage of population with less than grade 9 education, number of registered vehicles per capita, percentage of female-headed lone-parent families, and percentage of male-headed lone-parent families. The strongest correlation was found between immunization uptake and the percentage of female-headed lone-parent families within the neighbourhood with an Adjusted R^2 of 0.782 (Figure 3).

The nine significant neighbourhood variables were then selected for inclusion in multiple linear regression analysis. As shown in Table II, 80.6% of the overall variation in up-to-date MMR/MR coverage uptake in Saskatoon neighbourhoods can be explained by the proportion of single-parent families headed by females and number of vehicles registered per neighbourhood.

DISCUSSION

MMR/MR immunization uptake

Overall, the MMR/MR coverage rate among Saskatoon children two years of age was 90% and the rate remained relatively stable between 1999 and 2002. A slight decrease in the total MMR/MR coverage rates in Saskatoon in recent years may indi-

cate more families are choosing not to immunize their children at all. However, more monitoring and evaluation at the individual level is required to test this hypothesis. The complete MMR/MR coverage rate was at 85% in 1999 with a slight downward trend over the following three years. The downward trend for complete coverage rates is most likely related to the shorter amount of time later birth cohorts had to enter the database or receive a second immunization to achieve complete status prior to data extraction in 2003.

Up-to-date and not up-to-date immunization rates also remained relatively constant over the time period analyzed. Of the approximately 90% of children who received the MMR/MR vaccination in Saskatoon between 1999 and 2002, about 70% of those received two doses before the age of two years, effectively meeting the immunization schedule in Saskatchewan.²⁶ On the other hand, around 20% of children in Saskatoon were either incomplete or delayed in the receipt of at least one MMR/MR immunization. It is important to note that a decline in not up-to-date immunization rates suggests that, over time, fewer children were incomplete or delayed in their receipt of the MMR/MR vaccine in Saskatoon – this is a positive finding. However, it is difficult to examine delayed and incomplete rates separately due to the data limitations with the cohorts used (i.e., the trade-off, whereby as complete rates increase over time, not up-to-date rates decrease). More research focusing at the individual level on understanding why some children may never complete the immunization regime as recommended and the impact that residing in certain neighbourhoods may have on this outcome is needed.

Despite the relative stability of immunization trends and moderately good up-to-date immunization rates in Saskatoon overall, there is clear evidence that disparities in immunization uptake exist at the neighbourhood level. The map highlights the inequalities of immunization uptake across neighbourhoods, showing that of the 49 neighbourhoods, only 3 had an average up-to-date immunization rate above 90% (Figure 2).

Perhaps the most important findings relate to the coverage of MMR/MR immunization in inner-city neighbourhoods of

TABLE II

Significant Adjusted Neighbourhood Correlates of Up-to-date MMR/MR Coverage Uptake Among Saskatoon Children (2 year olds), 1999-2002

Final Model Variables	β (Beta)	S.E. (β)	95% CI (Lower)	95% CI (Upper)	p-value
Female-headed lone-parent families	-1.420	0.179	-1.780	-1.059	<0.001
Vehicle registration	0.227	0.086	0.054	0.401	0.011

Adjusted R² = 0.806

Saskatoon. These neighbourhoods had an average total immunization rate of 75%, average complete rate around 60%, and an average up-to-date coverage rate of approximately 45%. One inner-city neighbourhood had average total, complete, and up-to-date immunization rates of 64%, 50% and 30%, respectively. These findings are important as the same inner-city neighbourhoods also face greater social and economic disadvantage. On the other hand, neighbourhoods with higher levels of social and economic advantage, situated primarily on the far east side of Saskatoon, had higher coverage rates. It is clear that the social and economic disadvantages within the inner-city neighbourhoods play a role in immunization uptake. This finding is supported in the literature.¹³⁻¹⁵

Neighbourhood correlates of MMR/MR immunization uptake

Of the neighbourhood variables analyzed, two were significant independent correlates of up-to-date immunization uptake in Saskatoon. These two variables were the percentage of female-headed lone parents within a neighbourhood and the number of vehicles registered in a neighbourhood. The final multivariate linear regression analysis included both variables and together they explained 80.6% of variation in up-to-date immunization uptake at the neighbourhood level. These results indicate that at the neighbourhood level, the mechanisms for socio-economic inequalities seen in MMR/MR uptake might be due to lower accessibility of health centres due to lack of transportation and possibly lack of support available for single mothers.

Limitations

Limitations associated with this study include a general concern of ecologic fallacy; that is, inappropriately drawing conclusions on individual-level relationships (e.g., children of single parents are less likely to be immunized) from aggregate, neighbourhood-level data that we have presented in this study.

The quality of the SIMS data has not been subject to rigorous test, and there is some potential for misclassification error. For example, the effect of family mobility on accurate immunization coverage calculations in highly mobile neighbourhoods – particularly in the inner city – is a significant challenge. This increases the potential for children to be inadvertently excluded from the database, potentially affecting uptake rates.

The issues of mobility in this study were complex, but all attempts were made to mitigate the effects of misclassification throughout the study, with the most obvious being the use of average coverage rates. Averaged up-to-date coverage rates were also used as the dependent variable in the bivariate and multivariate analyses in an attempt to reduce the variability within each neighbourhood as the population count shifted from year to year; however, the relationship between neighbourhood variables and immunization uptake were still found to be present and highly significant.

The results of this study provide strong evidence of significant neighbourhood disparities in MMR/MR uptake within Saskatoon. Targeted projects initiatives aimed at minimizing systematic and parental barriers to immunization are recommended, together with further research at the individual and neighbourhood level to accurately assess real and/or perceived barriers to immunization.

REFERENCES

1. Canadian Public Health Association. The value of immunization in the future of Canada's health system: Submission to the Commission on the Future of Health Care in Canada. Ottawa, ON: CPHA, 2001.
2. Wakefield A, Murch S, Anthony A, Linnell J, Casson D, Malik M, et al. Ileal-lymphoid-nodular hyperplasia, non-specific colitis, and pervasive developmental disorder in children. *Lancet* 1998;351:637-41.
3. Jansen V, Stollenwerk N, Jensen H, Ramsay M, Edmunds W, Rhodes C. Measles outbreaks in a population with declining vaccine uptake. *Science* 2003;301:804.

4. Murch S, Anthony A, Casson D, Malik M, Berelowitz M, Dhillon A, et al. Retraction of an interpretation. *Lancet* 2004;363(9411):750.
5. Taylor B, Miller E, Farrington P, Petropoulos M, Favour-Mayaud I, Li J, et al. Autism and measles, mumps, and rubella vaccine: No epidemiological evidence for a causal association. *Lancet* 1999;353(9169):2026-29.
6. Dales L, Hammer S, Smith N. Time trends in autism and in MMR immunization coverage in California. *JAMA* 2001;285(9):1183-85.
7. Meldgaard Madsen K, Hviid A, Vestergaard M, Schendel D, Wohlfahrt J, Thorsen P, et al. A population-based study of measles, mumps, and rubella vaccination and autism. *N Engl J Med* 2002;347(19):1477-82.
8. Kaye J, del Mar Melero-Montes M, Jick H. Mumps, measles, and rubella vaccine and the incidence of autism recorded by general practitioners: A time trend analysis. *BMJ* 2001;322:460-63.
9. Begg N. Media dents confidence in MMR vaccine. *BMJ* 1998;346:561.
10. Moreton J, Bedford H, Elliman D. MMR: Weighing up the risks – vaccine versus disease. *Community Practitioner* 1998;71(5):169-71.
11. Ramsay M, Yarwood J, Lewis D, Campbell H, White J. Parental confidence in measles, mumps and rubella vaccine: Evidence from vaccine coverage and attitudinal surveys. *Br J Gen Pract* 2002;52:912-16.
12. Miller L, Hoffman R, Baron A, Marine W, Melinkovich P. Risk factors for delayed immunization against measles, mumps, and rubella in Colorado two-year olds. *Pediatrics* 1994;94(2):213-19.
13. Bates A, Fitzgerald J, Dittus R, Wolinsky F. Risk factors for underimmunization in poor urban infants. *JAMA* 1994;272(14):1105-10.
14. Bates A, Wolinsky F. Personal, financial, and structural barriers to immunization in socioeconomically disadvantaged urban children. *Pediatrics* 1998;101(4):591-95.
15. Klevens R, Luman E. U.S. children living in and near poverty: Risk of vaccine-preventable diseases. *Am J Prev Med* 2001;20(4):41-46.
16. Marks J, Halpin T, Irvin J, Johnson D, Keller J. Risk factors associated with failure to receive vaccinations. *Pediatrics* 1979;64(3):304-9.
17. Salsberry P, Nickel J, Mitch R. Inadequate immunization among 2 year old children: A profile of children at risk. *J Pediatr Nurs* 1994;9(3):158-65.
18. Kimmel S, Maldon-Kay D, Burns I, Admire J. Breaking the barriers to childhood immunization. *Am Fam Physician* 1996;53(5):1648-60.
19. Salsberry P, Nickel J, Mitch R. Why aren't preschoolers immunized? A comparison of parents' and providers' perceptions of the barriers to immunization. *J Community Health Nurs* 1993;10(4):213-24.
20. Mack R, Darden P. Children's immunizations: The gap between parents and providers. *Health Mark Q* 1999;16(4):7-14.
21. Lannon C, Brack V, Stuart J, Caplow M, McNeil A, Bordley C, et al. What mothers say about why poor children fall behind on immunizations. *Arch Pediatr Adolesc Med* 1995;149:1070-75.
22. Farizo K, Stehr-Green P, Markowitz L, Patriarca P. Vaccination levels and missed opportunities for measles vaccination: A record audit in a public pediatric clinic. *Pediatrics* 1992;89:589-92.
23. Gamertsfelder D, Zimmerman R, DeSensi E. Immunization barriers in a family practice residency clinic. *J Am Board Fam Pract* 1994;7:100-4.
24. McConnochie K, Roghmann K. Immunization opportunities missed among urban poor children. *Pediatrics* 1992;89:1019-26.
25. Maldon-Kay D, Harper P. Too many shots? Parent, nurse, and physician attitudes toward multiple simultaneous childhood vaccinations. *Arch Fam Med* 1994;3:610-13.
26. Canadian Paediatric Society. Routine immunization schedule: Update 2004. *Pediatrics & Child Health* 2004;9(1):17-20.

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RÉSUMÉ

Contexte : Bien que l'immunisation soit l'une des initiatives les plus réussies dans le domaine de la santé publique au Canada, elle nécessite une surveillance continue de la couverture vaccinale afin de s'assurer que les taux de réception des vaccins demeurent élevés. L'objet de la présente étude était de recourir à des données récentes du Saskatchewan Immunization Management System (SIMS) afin de se pencher sur le taux de réception des vaccins contre la rougeole, les oreillons et la rubéole de la ville de Saskatoon et de ses quartiers, et de cerner les facteurs qui pourraient contribuer à un faible taux de réception des vaccins à Saskatoon.

Méthode : Les données relatives à 10 287 enfants âgés de deux ans, de 1999 à 2002, ont été analysées au moyen d'une étude écologique. La première étape consistait simplement à calculer les taux de couverture vaccinale totale, optimale, à jour et non à jour pour la ville de Saskatoon ainsi que pour chaque quartier résidentiel. Par la suite, les données quantitatives par quartier ont servi à vérifier si des variables relatives aux quartiers pouvaient avoir un effet important sur les variations de la couverture vaccinale.

Résultats : Les taux de vaccination ROR/RR sont demeurés relativement stables de 1999 à 2002. Cependant, des disparités importantes ont été décelées d'un quartier à l'autre : les quartiers désavantagés socialement et économiquement avaient des taux de vaccination plus faibles, relativement à la couverture vaccinale totale, optimale et à jour, que les quartiers plus favorisés socialement et économiquement. L'analyse de régression linéaire multivariée a révélé que 80,6 % des variations de la couverture vaccinale à jour à Saskatoon étaient attribuables à la proportion de mères seules et de véhicules par habitant se rapportant à un quartier donné.

Conclusion : Des inégalités importantes existent pour ce qui est de la couverture vaccinale au niveau des quartiers de Saskatoon. Ces observations sont appuyées par les études antérieures et pourraient signaler la présence de barrières à l'immunisation, réelles ou perçues, dans certains quartiers de Saskatoon.