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Association between social capital and second dose of measles vaccination in Japan: Results from the A-CHILD study

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ABSTRACT

Background and Objectives: Measles vaccination is important to prevent outbreak, and social capital can be an important preventive factor. However, there have been very few studies that investigated the association between social capital and measles vaccination, especially the second dose, which is more likely to be suboptimal. This study aimed to investigate the association between social capital and second dose of measles vaccine.

Methods: Data were derived from a population-based study of first-grade elementary school children (6–7 years old) in Adachi City, Tokyo. Caregivers were asked to complete a questionnaire, and 4291 of them provided a valid response (response rate: 80.1%). Among these 4291 valid responses, 69 responses were excluded since variables for social capital measures were missing, which resulted in analytic sample size of 4222. We analyzed the association between measles vaccination and social capital including social ties, social trust and mutual aid by multilevel logistic regression analysis with a random intercept model.

Results: About 8.9% of the children did not receive a second dose of measles-containing vaccines. After covariates adjustments, increase of one-standard-deviation of poor individual-level social ties showed 11% lower odds of receiving measles-containing vaccines (OR: 0.89, 95% CI: 0.80–0.99). By contrast, no significant association between community-level social ties and measles vaccination was found. Regarding social trust, no significant association between individual-level social trust and measles vaccination was found. However, increase of one-standard-deviation of poor community-level social trust showed 11% lower odds of receiving measles-containing vaccines (OR: 0.89, 95% CI: 0.79–0.998). There was no association between mutual aid and measles vaccination.

Conclusion: Social ties and social trust were associated with second dose of measles vaccination. Fostering social capital may be effective in raising the low rate of second dose of measles vaccine.

1. Introduction

Although the elimination of measles, defined as the absence of endemic transmission of measles, has been achieved in Japan in 2015 [1,2], imported measles cases have caused multiple local outbreaks. In 2017, 187 people were affected [3], and in mid-2018, 161 patients originating from imported cases were reported [4].

Measles-containing vaccines are included in the national routine immunization program [1,2] and children can receive the two doses of the vaccine at no cost. The first dose is administered at the age of one, while the second is administered within one year prior to commencing elementary schools [1]. Since the efficacy of a single dose of measles-containing vaccines is 90–95% [5,6], and the population level of immunity needed to prevent outbreak is estimated to be about 95% from herd immunity perspective [5], a vaccination rate of more than 95% for both the first and the second doses is recommended [1,5,6].

According to recent national statistics [1,7], the vaccination rate for the first dose was over 95% in 2016; however, the rate for the second dose was 93.1%. Notably, this rate has been below 95% for more than 10 years. Thus, it is crucial to clarify the reasons for suboptimal vaccination rate for measles, especially for the second dose.

Based on the social ecological model by McLeroy et al. [8], individual behaviors are affected by factors in multiple levels such as interpersonal (e.g., social support and network involving friends and the family), organizational (e.g., rules, regulation, social norms and values in the organization), community (e.g., informal social network in the community), and public policy (e.g., local and national policies) [8,9]. Thus, clarifying the contextual factors that

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could affect individual behaviors is essential to devise effective strategies to improve immunization rate.

Among the possible factors that could affect people's vaccinating behavior, social capital has been investigated in relation to several vaccines. Coleman defined social capital as the resources that people belonging to a community can utilize [10]. Social capital has been linked to intention to receive [11,12] or actual uptake of the pandemic influenza vaccines [13–15]. In addition, Story reported the inverse association between community-level bonding social capital and completion of all recommended vaccines in India [16]. Regarding measles vaccinations, Nagaoka et al. found the associations between measles vaccination and several social capital indicators such as volunteer rates and move-in ratios at the municipal level [17], although the authors used ecological study design.

To our knowledge, no study has used individual-level data to analyze the effect of individual-level and community-level social capital on measles-containing vaccine uptake to tease out the individual-level effect and the community-level effect by using multi-level modeling.

In this study, we aimed to investigate the effect of individual-level and community-level social capital on measles-containing vaccine uptake at the time of the second dose using a population-based data of caregivers with first-grade elementary school children (aged 6–7 years old) in Adachi City, Tokyo, Japan.

2. Materials and methods

2.1. Sample

The data used in this study originated from the Adachi Child Health Impact of Living Difficulty (A-CHILD) study conducted in 2015. Details of this study were previously described [18–22]. The survey involved all the 69 public elementary schools in Adachi City and questionnaires were sent to 5355 first-grade children (aged 6 to 7 years) in the elementary schools. The survey asked children to take the questionnaire home and return it after their caregivers had completed it. In total, 4467 responses were returned and 4291 of them contained a valid response with informed consent to enroll their child/children in the study (response rate: 80.1%). Among these 4291 valid responses, 69 responses were excluded as variables for social capital measures were missing, which resulted in analytic sample size of 4222. This study was approved by the Ethics Committee at Tokyo Medical and Dental University (M2016-284).

3. Measure

3.1. Measles vaccinations

In Japan, the national routine immunizaiton program recommends that children receive the first dose of measles-containing vaccines when they are one year old, and the second dose within one year before they commence elementary schools [1]. In this study, measles vaccination was measured by asking caregivers of first-grade elementary school children (aged 6–7) whether they vaccinated their children within one year before they were admitted to elementary schools. The intraclass correlation coefficient (ICC) for measles vaccinations that assesses the degree at which the observed variance stem from between-community variance was 0.003 (95% CI: 0.0004 to 0.02).

3.2. Social capital

Individual-level social capital was measured using the following questions [15,23]: "Do you agree or disagree with the following statements? (1) People in your community can be trusted (social trust); (2) This community is close-knit (social ties); (3) People in your community are willing to help their neighbors (mutual aid) [15,23]." The responses were provided on a five-point Likert scale as follows: 1 = strongly agree, 2 = somewhat agree, 3 = neither agree nor disagree, 4 = somewhat disagree, and 5 = strongly disagree. Each response was centered by the community-level group mean to reduce potential collinearity with the community-level variable, and was scaled so that the effect of a one-unit increase can be interpreted as the effect of a one-standard-deviation increase.

To assess community-level social capital, each response was aggregated to the school level [14], and was scaled so that the effect of a one-unit increase can be interpreted as the effect of a one-standard-deviation increase. The school district ("*kouku*" in Japanese) was used as the unit for community level for the following reasons [24]. First, the school district is the proxy for a geographical area where people can walk around easily from home, interact with each other on a daily basis, and is an area where community activities take place [22,24,25]. Second, previous studies in Japan assessing the effect of community-level social capital on health outcomes utilized the school district or a similar level of geographic area as the unit for community level [24,26,27]. Because we have 69 schools, the total number of school districts was also 69.

The sample variance for each community-level and individual-level social capital measure was shown in supplementary Table 1. The intraclass correlation coefficient (ICC) for each individual-level score for social capital that assesses the degree at which the observed variance stem from between-community variance was 0.01 (95% CI: 0.01 to 0.03), 0.04 (95% CI: 0.03 to 0.06), and 0.02 (95% CI: 0.01 to 0.04) for social trust, social ties, and mutual aid, respectively.

3.3. Covariates

Covariates included parents' age, marital status, education, poverty status, number of siblings and gender of the child, as shown in Table 1. Based on Townsend's deprivation theory relating to relative poverty [28], poverty was defined using the combination of monetary and non-monetary criteria as a household with either a lack of basic necessities (e.g., not having a telephone or air-conditioner), a lack of capacity to pay for lifeline utility costs (e.g., electricity or gas), or a low household income below JPY3 million (about USD27,000) per year based on 50% of the median national household income [29].

3.4. Statistical analyses

A multilevel logistic regression model with a random intercept was used to estimate the effect of each community-level and individual-level social capital measure on measles vaccinations. The following covariates were included in the adjusted models: parents' age, marital status, education, poverty status, number of siblings and gender of the child. For these covariates, dummy variables were created for missing value. All analyses were performed with STATA SE statistical package, version 14 (StataCorp LP, College Station, TX, USA).

4. Results

Table 1 shows the characteristics of the sample population. The mean age of caregivers was 38.4 years (SD: 5.3) and 8.7% of mothers were single. Based on our poverty criteria that was defined by monetary and non-monetary criteria, 24.4% of participants were classified as living in poverty. The gender distribution of children

Table 1
Characteristics of the sample populations.

Variable		Total (n = 4222)	
		N or Mean	% or SD
Parental characteristics			
Age	≤29	203	4.8
	30–34	711	16.8
	35–39	1399	33.1
	40–44	1301	30.8
	≥45	471	11.2
	Missing	137	3.2
Marital status	Married	3746	88.7
	Never married/ Divorced/Widowed/ Others	365	8.7
	Missing	111	2.6
Education of caregivers	Junior high school	304	7.2
	High school or higher	3797	89.9
	Missing	121	2.9
Poverty status (defined by monetary and non-monetary criteria)	Poverty criteria met	1032	24.4
	Not met	3165	75
	Missing	25	0.6
Annual household income (million yen)	<3.00	483	11.4
	3.00–5.99	1713	40.6
	6.00–9.99	1278	30.3
	≥10.00	360	8.5
	Missing	388	9.2
Lack of basic necessities	Yes	660	15.6
	No	3369	79.8
	Missing	193	4.6
Lack of payment capacity	Yes	386	9.1
	No	3648	86.4
	Missing	188	4.5
Number of siblings	1	2166	51.3
	2	943	22.3
	3	179	4.2
	4	37	0.9
	5	8	0.2
	6	6	0.1
	Missing	883	20.9
Child gender	Male	2164	51.3
	Female	2053	48.6
	Missing	5	0.1

is equivalent. About 8.9% of children did not receive a second dose of measles-containing vaccine.

Table 2 shows the result of analyses for associations between social ties and measles vaccinations using a multilevel logistic regression model with a random intercept. After adjustment for other covariates, the results showed that increase of poor individual-level social ties score by a one-standard-deviation was associated with 11% lower odds of receiving measles containing vaccines (odds ratio (OR): 0.89, 95% confidence interval (CI): 0.80 to 0.99). By contrast, we did not observe a significant association between community-level social ties and measles vaccinations after adjusting for other covariates (OR: 0.93, 95% CI: 0.82 to 1.04).

Table 3 shows the result of analyses for associations between social trust and measles vaccinations. The results showed that increase of poor community-level social trust score by a one-standard-deviation was associated with 11% lower odds of receiving measles containing vaccines (odds ratio (OR): 0.89, 95% confidence interval (CI): 0.79 to 0.998). However, there was no significant association of individual-level social trust with measles vaccinations after adjustment for other covariates (OR: 0.96, 95% CI: 0.86 to 1.06).

Table 4 shows the result of the analyses for associations between mutual aid and measles vaccinations. No significant associations of both community-level mutual aid and individual-level mutual aid with measles vaccinations were observed after adjusting for other covariates.

For sensitivity analyses, we conducted an analysis by including all three measures of social capital in the same model and found that the similar result was obtained (supplementary Table 2).

5. Discussion

In this study, we found that social capital was associated with measles vaccination at the time of the second dose after covariates adjustment. Previous studies have shown the link between social capital and several vaccines including pandemic influenza vaccine, measles vaccine, and the link between social capital and the completion of all recommended vaccinations by 12 months of age [11–17], although most of these studies have focused on pandemic influenza vaccine [11–15]. Using individual population data, some studies have found that individual-level social capital was associated with intention to receive pandemic influenza vaccines [11,12]. In addition, using state-level data [13] or combination of individual and state-level data with multi-level modeling [14], other studies have found an association between state-level social capital and actual uptake of pandemic influenza vaccines in the United States [13,14]. Of note, although an ecological study design, Nagaoka et al. have reported the effect of community-level social capital on measles vaccination in Japan [17].

In contrast, our study used individual-level population data to tease out the effects of individual-level and the community-level social capital on measles vaccination, and showed that lower individual-level social ties were associated with lower odds of receiving measles-containing vaccines when holding community-level social capital constant. In addition, we found that lower community-level social trust was associated with lower odds of receiving measles-containing vaccines.

This result suggests that, upon confirmation of our results in studies using longitudinal design, fostering social capital could increase the uptake of measles-containing vaccine at the time of the second dose in Japan.

Table 2
Association between social ties and measles vaccination (n = 4222).

	Crude		Adjusted[a]	
	OR	95%CI	OR	95%CI
Community-level social ties[b]	0.88	(0.78–1.00)	0.93	(0.82–1.04)
Individual-level social ties[c]	0.85[d]	(0.77–0.94)[d]	0.89[d]	(0.80–0.99)[d]

[a] Adjusted for parents' age, marital status, education, poverty level, child gender, number of siblings, and individual-level social tie using a logistic regression model with a random intercept.
[b] Variable for community-level social ties was scaled so that the effect of a one-unit increase can be interpreted as the effect of a one-standard-deviation increase.
[c] Variable for individual-level social ties was scaled so that the effect of a one-unit increase can be interpreted as the effect of a one-standard-deviation increase.
[d] $P < 0.05$.

Table 3
Association between social trust and measles vaccination (n = 4222).

	Crude		Adjusted[a]	
	OR	95%CI	OR	95%CI
Community-level social trust[b]	0.84[d]	(0.74–0.94)[d]	0.89[d]	(0.79–0.998)[d]
Individual-level social trust[c]	0.9[d]	(0.81–0.99)[d]	0.96	(0.86–1.06)

[a] Adjusted for parents' age, marital status, education, poverty level, child gender, number of siblings, and individual-level social tie using a logistic regression model with a random intercept.
[b] Variable for community-level social ties was scaled so that the effect of a one-unit increase can be interpreted as the effect of a one-standard-deviation increase.
[c] Variable for individual-level social ties was scaled so that the effect of a one-unit increase can be interpreted as the effect of a one-standard-deviation increase.
[d] $P < 0.05$.

Table 4
Association between mutual aid and measles vaccination (n = 4222).

	Crude		Adjusted[a]	
	OR	95%CI	OR	95%CI
Community-level mutual aid[b]	0.91	(0.80-1.04)	0.96	(0.85–1.08)
Individual-level mutual aid[c]	0.92	(0.83-1.02)	0.96	(0.87–1.07)

[a] Adjusted for parents' age, marital status, education, poverty level, child gender, number of siblings, and individual-level social tie using a logistic regression model with a random intercept.
[b] Variable for community-level social ties was scaled so that the effect of a one-unit increase can be interpreted as the effect of a one-standard-deviation increase.
[c] Variable for individual-level social ties was scaled so that the effect of a one-unit increase can be interpreted as the effect of a one-standard-deviation increase.

Among the several measures of social capital, we found associations of measles vaccinations with social ties and social trust, but not with mutual aid.

Interestingly, although it was not focused on measles vaccination, a similar study in India used individual-level population data and multi-level modeling, and showed that community-level bonding ties were inversely associated with children completing all recommended childhood vaccinations, such as diphtheria-pertussis-tetanus vaccine, polio vaccine and BCG (Bacillus Calmette–Guerin vaccine and measles vaccine) by 12 months of age [16]. The authors concluded that the result may be due to the social norm of discouraging mothers from pursuing immunizations for their children in a community with high bonding ties [16]. Another study in India also pointed out the mixed effects of being a member of an organization (which could lead to gaining bonding ties with other members) on parental vaccinating behaviors depending on the type of organization (be it traditional or modern) [30]. Thus, community-level social capital could have different effects on vaccination in different communities depending on the social norm in the community [16,30]. Our result suggests that addressing social capital in similar communities in Japan might be important for increasing second-dose measles vaccination rate. However, it might also suggest the importance of favorable social norm in order for social capital to have positive effects on parental vaccinating behaviors.

Previous studies have linked generalized trust or institutional trust in health care to pandemic flu vaccinations [11,14]. The positive relationships between trust and pandemic flu vaccinations could be due to the pandemic flu vaccines being relatively novel to the public and it takes time for people to build up greater trust in the vaccine. However, in contrast to novel pandemic flu vaccines, measles vaccine has been introduced in Japan since 1966 [31]. Furthermore, information on the effectiveness and necessity of the vaccine is provided to the public on a regular basis [32], and access to a health center or pediatric clinic is easy. Thus, it is interesting that social trust can also boost the rate of measles vaccine uptake in Japan, because it may underscore the importance of social trust on vaccinations regardless of the novelty of the vaccines.

For mutual aid, in a systematic review by Quadri-Sheriff et al., the importance of "benefit to others" as a motivator to vaccinate their children remains to be determined [32]. Thus, our finding of null association between mutual aid and vaccinating behaviors is consistent with those of previous studies.

This study has several limitations. First, for the assessment of community-level social capital, each of the individual-level social capital measures was aggregated to the school level. Calculation of ICCs demonstrated that they were significantly different from zero, and a small ICC does not necessarily indicate no effect of community-level differences on other variables [33]. However, given the relatively small ICC, future studies incorporating different measures for community-level social capital may be warranted to replicate our findings. Second, as this is a cross-sectional study, reverse causation may be possible. Those who did not receive measles vaccination may induce lower level of social connection to avoid infection. Third, we did not assess the reason for not receiving measles vaccination. Thus, our social capital measure may be a proxy of other reasons for not receiving measles vaccination. Fourth, as individual social capital is based on an individual's response to the questionnaire, it would be an individual's assessment/perception of the availability of community-level social capital. However, we would also argue that the individual's perception of the social capital is important since if an individual does not know about the availability of or does not feel inclined to utilize community-level social capital, they cannot receive the possible beneficial effects of the community-level social capital. Finally, if people defined their "community" differently (that is, not as the school district), it could affect the association between community-level social capital and the vaccination, although a school district in Japan is a geographical area in which people can walk around easily from home, interact with each other on a daily basis, and represents an area where community activities usually take place [22,24,25].

In spite of these limitations, upon confirmation of our results in studies using longitudinal design, we could recommend policy implications that fostering social capital might be effective to promote second-dose measles vaccination uptake. Previous campaigns, such as "Strong Communities for Children" [34,35] in the United States and "Healthy Parents and Children 21" in Japan, have focused on fostering social capital [36]. However, there is also a caveat to this recommendation, because there is a possibility that community-level social capital has varied effects on people's vacci-

nating behaviors in different communities depending on the prevailing social norm [16,30]. Our results, along with the results of previous studies, may suggest that it is important for policy makers involved in campaigns that focus on social capital to be cognizant of community social norm for successful campaign implementation.

In conclusion, social capital, more specifically, social ties and social trust, were associated with the second dose of measles vaccination in Japan. Given the suboptimal coverage for this dose in the country, upon confirmation of our results in studies using longitudinal design, fostering social capital, possibly with the combination of provision of accurate medical information on measles vaccines, could be an important strategy to promote measles vaccination.

Conflict of interest

None of the authors has any conflict of interest to declare.

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Appendix A. Supplementary material

Supplementary data to this article can be found online at https://doi.org/10.1016/j.vaccine.2018.12.037.

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