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Community and Individual level socio-demographic determinants of routine Measles immunization uptake: Profile from measles endemic country Pakistan

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WHO World Health Organization

DHS Demographic and Health Survey

PDHS Pakistan Demographic and Health Survey

FATA Federally Administered Tribal Areas

NIPS National Institute of Pakistan Studies

JPMA Journal of Pakistan Medical Association

ABSTRACT:

Background:

Despite the availability of a safe, cheap and effective vaccine for measles and inspiring success stories of the elimination and eradication of this disease from major regions of the world, it is still endemic in Pakistan. Repeated national level campaigns have taken place but the coverage still remains below the optimal level. Therefore, this study aims to explore any socio-demographic factors which may be responsible for the reduced uptake of Measles vaccine in Pakistan.

Methods:

Secondary data analysis of the recent most available Pakistan Demographic Health Survey 2012-13 was carried out. The Pakistan Demographic Health Survey 2012-13 is a National level cross sectional survey which included a household sample of 14000 households. In the PDHS survey, mothers with the youngest child between the ages of 12-23 months were selected and vaccination status of the child was inquired through a questionnaire. The Measles vaccination status of a child was taken as an outcome variable in our study. Socio-demographic determinants of childhood vaccination uptake were identified through literature review and were taken as exposure variables. Associations between the exposure and outcome variables were calculated through multivariable binary logistic regression. The results were displayed using Unadjusted and adjusted Odds Ratios with 95% CI and p values. .

Results:

The study results revealed a prevalence of measles vaccination uptake to be 60.9%. The socio-demographic factors influencing the Measles vaccine uptake by children included their type of residence, region of residence, wealth quintile of the family and local access to health care facility. Individual level factors affecting the uptake included maternal age, education and empowerment. Individual factors of the child influencing this uptake were identified as the gender of the child and the birth order.

Increased likelihood of the child receiving the vaccination was found with urban residence, higher education status of mother, older age of mother, maternal empowerment, family wealth quintile, access to health care facility, possession of mobile phone, male gender and lower birth order of child.

Maternal age, education status and empowerment were found to have the greatest impact on the uptake of Measles vaccination among children in Pakistan.

Conclusion:

Despite repeated national level high costing campaigns, measles vaccination uptake is still much below the optimal level. Targeted interventions are needed to focus on the socio-demographic determinants of vaccine uptake identified in this study, to achieve the optimal uptake of Measles vaccination among Pakistani children below 2 years of age.

INTRODUCTION:

Pakistan is suffering from Measles endemic, despite repeated National and International efforts to eradicate this disease. A safe, cheap and effective vaccination is available[3] and the World Health Organization aims to eradicate this disease from Pakistan by 2020[6]. Despite repeated vaccination drives throughout the country, this goal is not being achieved. This study tried to explore any socio demographic factors which could be causing obstacle in the achievement of this target. It identified these factors through the sophisticated statistical analysis of the latest and the largest National level demographic data of Pakistan[22].

BACKGROUND:

Measles is a highly contagious, serious viral disease[1] .It is one of the leading causes of deaths among young children, especially those under the age of 5 years[1]. In 2016 alone, 89780 deaths were attributed to measles globally[1]. Before the introduction of measles vaccination in 1963, the world suffered huge measles epidemics every couple of years. There were nearly 30 million

measles cases every year and mortalities exceeding 2 million annually2. By the age of fifteen, more than 95% of individuals were infected with this virus[2].

With the introduction of Measles vaccine in 1963, these epidemics were largely contained and marked reductions in the incidence rates were observed. During 2000-2015, a global decline of 75% in the measles incident cases was reported[3].

The Americas was declared to have achieved measles elimination in 2016 and the Western Pacific region is at the verge of its elimination[4]. Moreover, it is no longer endemic in 79% of the WHO European Region[4].

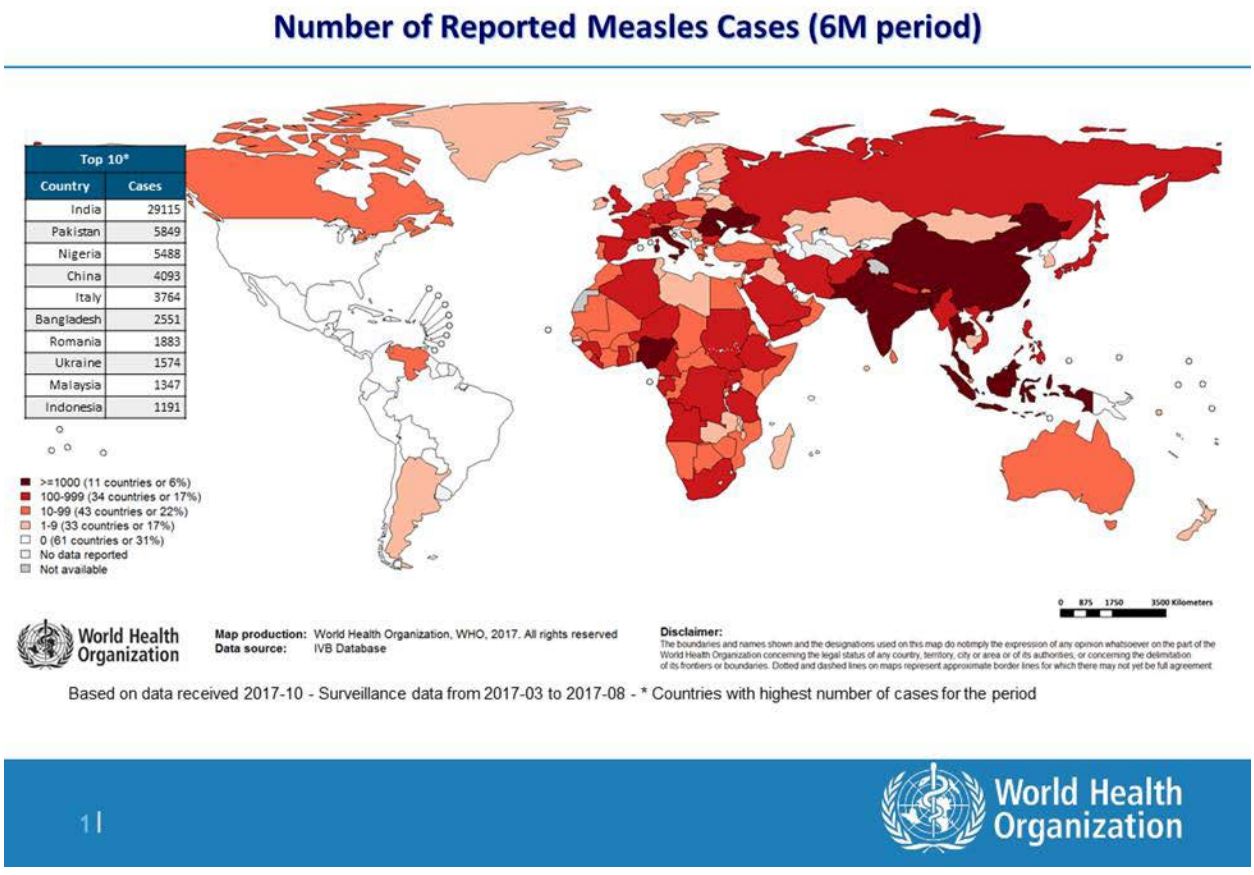

Figure 1: World map released by World Health Organization, based on data received in 2017, revealing the number of reported cases of Measles. Available from:

http://www.who.int/immunization/monitoring_surveillance/burden/vpd/surveillance_type/active/measles/en/

Unfortunately, Pakistan is still suffering from major mortalities and morbidities due to this disease. The number of cases of measles in 2012 was reported to be 14,000 with 210 patients dying of it[5]. The World Health Organization (WHO) is targeting Pakistan under the Measles elimination goal by 2020[6]. In order to effectively control measles, routine measles vaccine coverage of >90% is required[7]. Majority (62%) of lab confirmed measles cases of Pakistan in 2016 did not receive a single dose of measles vaccine[8]. Despite extensive immunization campaigns and inclusion of Measles vaccination in the compulsory and free EPI program (Expanded Program of Immunization) by the government, vaccine uptake is still not optimal. The government of Pakistan does repeated endeavors at National level in the form of vaccination campaigns, increasing its availability as a free vaccine in all government health care facilities and even door to door vaccination drives. Despite these large scale efforts, the question then arises, that what are the factors which are responsible for the decreased uptake of this vaccination? Many studies have been done globally to explore the answer to this question. For instance, a study[9] done in Istanbul, Turkey explored the reasons for the non-vaccination of children under 5 years of age against measles. It concluded that decreased access to vaccination centers, parents' lack of knowledge about vaccination, parents' lack of formal education and non-resident immigration status of the family were the reasons for non-vaccination of their children. Another study[10] done on the South African country of Mozambique pointed towards inaccessibility to vaccination sites, no schooling of mothers and children born in home instead of maternity centers to be the reasons for incomplete

vaccination against the vaccine preventable diseases. A case control study[11] was conducted in Ethiopia with similar objectives and indicated the importance of maternal awareness and household monthly income in the immunization status of the children. A systemic review[35] of the published literature was done by Rainey et al. in 2011 to explore the reasons of low vaccination uptake in Low and Middle Income Countries like Pakistan. Their findings showed that parental attitudes and knowledge required local interventions to optimize the vaccination uptake in children.

There is an information gap of such studies specific for Pakistan, exploring the factors responsible for decreased uptake of Measles vaccination here. To the best of our knowledge, some studies *did* explore the determinants of vaccine preventable diseases in Pakistan but each one of them had limitations. The limitations included small sample sizes, restriction of geographical coverage, and non-specificity to the disease of our interest, that is, Measles. These studies included small scale independent studies done for the urban cities of Pakistan like Karachi[16], Lahore[17], Peshawar[18] and Malakand[19]. These studies had small sample sizes ranging from 150 to 828 mothers being enrolled for data collection. Therefore, the results of these studies could not be credited to the status of National representation. To achieve optimal uptake of Measles vaccination throughout Pakistan, National level policies are needed to ensure universal coverage. For this purpose, a study which can give us results at National level was very necessary. Further exploration led us to a larger study[20] by Imran et al. but was limited to just 2 out of the 4 provinces of Pakistan. A national level study[38] exploring the determinants for all vaccine preventable diseases was found but it had the limitations of being conducted on an old survey of 2006-2007 and was not specific to Measles. This study explored the

determinants of non-utilization of all EPI vaccinations in Pakistan. Specificity for Measles was necessary as the results can be confounded by selective uptake of vaccinations depending on the disease. A publication[21] by Kazi et al. in 2013 also emphasized on the need for a study to explore any determinants having association with Measles vaccination uptake to help formulate and amend National level policies.

There is thus a need for a comprehensive National level study to explore all possible determinants affecting the immunization uptake of children under the age of 2 years specific for Measles. This would enable the policy makers to formulate policies at National level that will lead to the achievement of optimal uptake of Measles vaccination by children in Pakistan aged below 5 years. Moreover, without paying due attention to the factors hindering the vaccination uptake, the WHO and Pakistani governmental efforts for measles elimination or eradication will be wasted. Therefore a study attempting to explore any factors, their association and their significance in measles vaccination uptake is critical to achieve the WHO goals for Pakistan and eliminating this fatal burden from our country.

AIMS:

To assess the effect of community and individual level socio-demographic factors on the vaccination uptake of Pakistani children aged 12-23 months of age at a National level to help formulate and amend future National policies accordingly.

OBJECTIVES:

The specific objectives of the study are as follows:

- To estimate current prevalence of Measles routine immunization among Pakistani children between 12-23 months of age.

- To identify socio-demographic factors that are associated with Measles routine immunization uptake among Pakistani children.

- To compare all factors and determine which factors have the greatest impact on the vaccination uptake of a child and their importance in Pakistani context.

METHODS:

DATA SOURCE:

The data for this study was sourced from the Pakistan Demographic Health Survey (PDHS) 2012-2013. This is the recent most available National level demographic survey of Pakistan[22]. Data was accessed from the DHS website after few registration steps. These steps included the filling of a simple and quick available on the DHS website[23]. The required fields in the form were name, email address, password, institution name, phone number and country of residence. The second step was to specify a project title with at least a 300-word description of the project. The third step was to choose the region and country of interest. After selecting these, the request was submitted to access the dataset. Within a week, access was granted after using the same email address and password provided before.

PDHS METHODOLGY:

The Pakistan Demographic Health Survey is the largest household survey conducted in Pakistan to date[22]. According to its website, DHS data was investigated to be free from systemic bias[24].

Participants:
Ever married Pakistani men and women aged between 15-49 years were eligible to participate.

Study design:
PDHS 2012-13 followed a cross sectional study design.

Sampling:
The sample for the 2012-13 Pakistan Demographic Health Survey aimed to represent the total population of Pakistan22. Some areas like Azad Jammu and Kashmir, Federally Administered Tribal Areas (FATA) and restricted military areas were excluded from the survey due to security reasons. The four provinces of Pakistan and the Gilgit Baltistan region were included in the survey.

The estimated sample size of the survey was 14,000 households using stratified 2 stage cluster sampling. The first stage involved the trained staff of National Institute of Population Studies (NIPS) obtaining household listings from 500 (248 urban and 252 rural) survey sample areas around the country. The second stage involved the household selection through systemic sampling of each survey area. This resulted in the 14,000 households selected (6,944 from urban areas and 7056 from the rural areas).

Data collection tool:
Questionnaires were used to collect data from each participant.

METHODOLGY FOR PRESENT STUDY:

Study design
Secondary data analysis of the PDHS 2012-2013 was carried out.

Sampling:

Our data was limited to mothers with a last-born child (youngest child) between the ages of 12 to 23 months. The reason for this selection criterion was that one dose given for Measles vaccine is given after the age of 9 months and 12-23 months is the youngest age group by which age, the child should be fully immunized with all the compulsory vaccinations of the Expanded Program of Immunization (EPI). The PDHS survey has also utilized the same age group for collecting information regarding vaccination uptake.

Data Entry:

The data downloaded from the DHS website was entered in the STATA software. It was cleaned and edited for inconsistencies. After excluding all incomplete information, final analysis was carried out on the final dataset with complete information on all study variables. The final dataset was double entered, checked and validated.

Variables used for analysis:

Outcome Variable (Dependent Variable):

Measles vaccination uptake status of children aged 12 to 23 months as reported by the participating mothers or vaccination card was used. The measles vaccination was defined as a measles injection or an MMR injection; that is, a shot in the arm at the age of 9 months or older, to prevent him/her from getting measles. Responses were Yes, No and Don’t know. By using the all collected information (vaccination card or mother's self-report), measles vaccination uptake was categorized as "Yes" and "No" (Don't know response was recoded as No). After defining the outcome variable, the response options were specified and coded.

Exposure Variables (Independent Variables):

Method to identify exposure variables:

A brief literature review was done to help identify the exposure variables for this study. The search was confined to the last decade (2008-2018) to keep the focus on recent most studies. Key words like "vaccination, uptake, determinants, factors and immunization" were used. This yielded a large number of studies over a thousand in number. Few studies of interest included a study[9] done in Istanbul, Turkey to explore the reasons for non-vaccination among children. The reasons in the results included inaccessibility to health care facility, lack of knowledge about vaccination, parents' low education level and recent immigration. Another study[13] done in the same country revealed maternal empowerment, economical constraints, accessibility to health care services and lack of communication between mothers and health workers to be important factors associated with vaccination uptake of children.

Few other studies done in African countries like Mozambique and Ethiopia were discovered which had similar objectives. The study[10]in Mozambique revealed inaccessibility of the vaccination sites, lack of maternal education and child being born in home instead of a health care facility to be important reasons associated with the incomplete vaccination of children. The research[11] in Ethiopia identified mother's knowledge about vaccination and household income to be important predictors of incomplete vaccination in children.

A systemic review[35] of the published literature was done by Rainey et al. in 2011 to explore the reasons of low vaccination uptake in Low and Middle Income Countries like Pakistan. Their findings showed that parental attitudes and knowledge required local interventions to optimize the vaccination uptake in children. A theory to use communication via Mobile phones (mHealth) was reviewed systematically to improve vaccination uptake in Low and Middle

income countries[45]. Although only three out of the 21 peer reviewed studies included in this systemic review[45] were done in Pakistan, nevertheless the review presented an important theory that may play a positive role in increasing the vaccination uptake.

The search was then confined to only those studies which were specific for Pakistan, done in the last decade and addressed the disease of our interest, Measles. The results included a 2009 study[36] done in Pakistan which emphasized the importance of knowledge and evidence based discussion to improve the childhood vaccination uptake. Another study[39] was done in the same year by Anderson et al. which aimed to explore the local determinants of measles vaccination uptake in four districts of Pakistan. With a large sample of 14,542 children, this analysis identified household economic stability, mother's formal education, mother's knowledge about vaccine preventable diseases, evidence based discussions and proximity to Health care center to have positive association with vaccination uptake by children. Access to health care labeled as 'Health care Equity' was confirmed to be influencing childhood measles vaccination uptake in Lasbella district of Pakistan by Steven et al.[44], despite governmental efforts for universal coverage. However a hopeful finding was revealed in this study that in both urban and rural areas, discussion and knowledge about vaccines had a positive effect on vaccination uptake, which was independent of the negative effect of inequity. Another interesting research[43] done in 2012 on measles vaccination uptake in Pakistan revealed that the paternal education status also played an important role in the vaccination uptake of children in Pakistan. This positive association was found to be independent of the maternal education status. Another article[42] was published in the same year in the Journal of Pakistan Medical Association (JPMA), exploring the influencing factors on vaccination uptake in Pakistan. It identified parental socio-economic

status, awareness and attitude towards vaccine controversies as vital factors influencing the vaccination uptake. Parental awareness was again explored in another study[41] published in 2015, for its association with measles vaccination. Although limited to just one metropolitan city of Pakistan, this study emphasized the importance of parental awareness about measles as a potentially fatal disease and the effectiveness of the vaccine, to be a contributing factor in the increased uptake of Measles vaccination in Karachi, Pakistan. A more recent publication[40] was made in 2017 with the objective of exploring the association of household economic status, maternal education and empowerment on the uptake of Polio vaccination in Pakistan. Although specified for polio, this study gave us important exposure variables which could have influence on the Measles vaccination uptake of children too. This study was done on the same 2012-13 DHS data which is used in our study. The results of this study, therefore, were included to be explored in our study too. Lastly, a recent most study[37] was done in 2018 which explored the reasons for the non-vaccination and incomplete vaccination among children in Pakistan. Although it discussed the vaccination uptake of all the diseases in the EPI schedule, but interesting results were presented. Lack of knowledge and community awareness, decreased demands among parents, distance from vaccination center and non-availability of supplies were concluded to be responsible for the decreased uptake of vaccination among children. It was a cross sectional study with a large sample of 8400 households. This study, however, did not focus on measles vaccination which is the disease of our interest. The results could therefore be different for vaccination uptake if specified for measles. Therefore, these determinants were also included in our study to explore their association with Measles Vaccination Uptake.

To conclude, although the literature review was brief, some direction was achieved to explore the socio-demographically plausible variables that might have some association with Measles vaccination uptake. With the availability of the recent most National level data, it was now possible to explore if the associations identified in these studies were true or not for Measles vaccination uptake in Pakistan at a National level, through sophisticated Statistical methods described in the Statistical Analysis section. The above mentioned studies gave us these exposure variables;

- Access to health care
- Parent's knowledge about vaccination
- Parent's level of education
- Mother's knowledge about vaccination
- Mother's education
- Father's Education
- Maternal Empowerment
- Recent immigration
- Family economic status
- Communication between mothers and health care workers
- Child's place of birth

- Knowledge, awareness about vaccination and evidence based discussion
- Attitude towards the vaccination controversies
- Demand for vaccination
- Use of mobile phones

Data availability was then checked in the DHS database for the above mentioned exposure variables. Data was lacking on Immigration status and knowledge and awareness about Measles vaccination. Therefore these variables were excluded from our study. The rest were included with their closest match in DHS data. The variables were then separated into two groups: Individual level and Community level. Each variable was then defined, data in the DHS survey related to them was extracted and response options were coded. Their type, data extraction, coding, response options, method of analysis and selection is given below. Uniform procedures were applied to all variables regardless of type.

INDIVIDUAL LEVEL EXPOSURE VARIABLEs:

Wealth Quintile: Household economic status was identified to have association with vaccination uptake in children by a study[9] done in Turkey, another one[11] in Ethiopia and also in a few studies done in Pakistan[39, 41, 42]. This variable was therefore included in our study to verify whether the association found in these studies match with ours or not.

This is an ordinal (categorical) variable. The wealth index constructed in the PDHS serves as an indicator of the household economic status. The calculation of this index is done by using data on ownership of selected household assets, such as television and bicycles; housing construction materials, water access types and sanitation facilities. PDHS used a statistical

procedure called principal components analysis to generate this index. This procedure gives a continuous scale of relative wealth which is then separated into five wealth quintiles. The five wealth quintiles in the PDHS report were lowest, second, middle, fourth and highest. We assigned the titles of poorest, poorer, middle, richer and richest to these quintiles respectively. Code 1-5 was given from lowest to highest quintile.

Mother's age in years: Maternal age and empowerment are closely related as shown in a recent study[26] conducted in Pakistan. Therefore, we tried to explore the association of maternal age and empowerment status with the uptake of Measles vaccination in their children.

This is a categorical variable. The question asked in the questionnaire was "How old are you" and respondent's answers were categorized in three categories. Those aged 15-24 years were given code 1, 25-34 years of age was given code 2 and greater than 34 years of age was coded as 3.

Mother's education level: Maternal education level was identified to have an important association with children's vaccination uptake. This was revealed in various studies[9, 10, 39, 41, 43.] This variable was therefore included in the study to explore whether the association found in other countries of the world and smaller cities of Pakistan are true at a National level or not.

This is a categorical variable. 4 categories were made. Code 1 was given to 'No education'. Code 2 was given to 'Primary level', code 3 to 'Secondary' and Code 4 to 'Higher Education level'. Primary referred to completing classes 1-5, Secondary referred to completing classes 6-10 while having an education of grade 11 and above was referred to as Higher.

2. Mother's Empowerment status: Mother's empowerment status was found to be highly associated with children vaccination status. For instance, a study done in Turkey[9]and another one done in Pakistan[41] showed this association in their results. Therefore, this variable was included in the study to verify the results on a National level data and explore the association in Measles context.

This is a dichotomous variable. Mothers who were directly involved in decision making to any of the following indicator questions were labeled as "Empowered", while other responses were labeled as "Not empowered". The questions were:

a. Who usually makes decisions about health care for yourself: you, your husband, you and your husband jointly, or someone else?

b. Who usually makes decisions about making major household purchases: you, your husband, you and your husband jointly, or someone else?

c. Who usually makes decisions about visits to your family or relatives: you, your husband, you and your husband jointly, or someone else?

Access to health care: Inaccessibility to health care was found to be one of the reasons for low vaccination uptake in studies like one done in Istanbul, Turkey[9]. This association was reconfirmed by another study[13] done in the same country, a South African country of Mozambique[10], along with studies done in Pakistan[37, 39, 44]. As discussed before, these studies had limitations of being done on a smaller scale and were geographically limited; this variable was included in our analysis to further explore the association.

This is a dichotomous variable. The response options were 'Yes' and 'No'. Those who visited a health care facility in the last twelve months were considered 'Yes' and given code 1, while those who didn't visit any health care facility in the last 12 months were considered 'No' and given code 0.

Access to antenatal care: Health care proximity and access have been identified in many studies discussed above to have a strong association with Measles vaccination uptake in Low and Middle Income Countries like Pakistan. The DHS data provided more details on this subject like data on ante natal and post natal visits, so these two variables were also selected for further review in our study. This is a dichotomous variable. The number of ante natal visits during the last pregnancy was inquired. Three response options were considered. Those who had no ante natal visit were given code 1. Those who had one to three ante natal visits were given code 2 and those who visited three or more times were given code 3.

Access to postnatal care: For the justification mentioned above for accessibility and number of ante natal visits, the number of post natal visits was also included as an independent variable. This is a dichotomous variable. Two response options of 'Yes' and 'No' were considered to the question whether the last born child had post natal checkups within the two months of delivery. Code 0 was given to the 'No' response while code 1 was given to the 'Yes' response.

Access to modern communication services: This is a dichotomous variable. If the household had any telecommunication service like mobile phones or telephone (land-line), it was considered a positive response and was given code 1, while no access to any telecommunication service was considered a 'No' and given Code 0.

Access to media: Waterson et al.[45] explored an interesting theory of using mobile phones (mHealth) as a mode of communication to increase awareness and knowledge about vaccination in general public. Lack of knowledge, awareness, discussion and/or communication were identified in many studies[9, 11, 13, 35, 36, 37, 39, 41, 42, 44]. Therefore, this was considered as an important variable to be explored further. This is a dichotomous variable. Mothers who had access to any media like reading newspaper, magazine, listening to radio and/or watching television were labeled as 'Yes' and given Code 1 while no access to any of the above was considered negative and given the Code 0.For the reasons mentioned above in the details of the 'Access to modern communication studies', access to media was also included in the study.

Child's gender: Male-female dichotomy has been identified as an important factor driving the dynamics of children's vaccination uptake both globally[30] and in countries including India[31, 32, 33,] and Nigeria[34]. To the best of our knowledge, there was no such study found for Pakistan which explored this association with Measles vaccination uptake in children below 2 years of age. This gender disparity was therefore included as an exposure variable in the study to be explored for Pakistan.

This is a dichotomous variable. The sex of the last child was inquired and males were given code 1 while females were given Code 2.

Child's birth order: Child's birth order was considered important to be included in the study because this determinant has been shown to have association with the voluntary immunization of a child by his parents in a large sample study[27] recruiting 110,902 children in Israel. Few

other studies[28, 29] also identified this as an important variable associated with children's vaccination uptake.

This is a dichotomous variable. The birth order of the last child was given Code 1 if the last child was among the first four children of the family and was given Code 2 if the birth order was greater than 4.

COMMUNITY LEVEL EXPOSURE VARIABLES:

Type of Residence (Urban/rural): This is a dichotomous variable. The target population included all urban and rural areas of all the four provinces of Pakistan (Punjab, Sindh, Khyber Pakhtunkhwa and Baluchistan and Gilgit Baltistan. The PDHS[22] used the urban and rural administrative definition as used in the 1998 Population census[46]. Urban areas were given the code of 1 while rural areas were given a code of 2.

Region of Residence: This is a nominal variable. Administratively, Pakistan is divided into four provinces (Punjab, Sindh, Khyber Pakhtunkhwa and Baluchistan), two autonomous territories two autonomous territories (Azad Jammu and Kashmir, Gilgit-Baltistan) and one federal territory (Islamabad Capital Territory). Therefore, the 6 regions used in our study included all the 4 provinces, one autonomous territory and one federal territory and were given codes from 1-6 as shown in the Table. Due to security reasons[22]Azad Jammu and Kashmir, FATA and some military protected areas were not included in the PDHS survey, therefore they were not included in our study also due to non-availability of data. This exclusion should not affect the National representation of our study as it only comprises of 3% of the total population of Pakistan.

There are a few differences in the population characteristics of the four provinces of Pakistan. For instance, the province of Baluchistan is very scarcely populated (about 5% of the total population of Pakistan) but covers nearly 43% of the land area of Pakistan[22]. On the other hand the province of Punjab is the largest province in terms of population with nearly 56% of the total population residing here. Not just in terms of land area and population, the provinces also differ in climates, agricultural area, languages and culture. Therefore this variable was included in our study to explore whether residing in different regions of the country had any association with the Measles vaccination uptake of the children as indicated in one of the studies explored[43.]

Coding Plan:

A coding plan was created. Independent variables were defined and possible response options were specified. The variables and their response options were given codes. The resulting descriptions and coding can be found in Annex 1.

STATISTICAL ANALYSIS:

STATA/IC version 14.0 was used for data analysis. Associations were identified using Pearson chi square analysis between dependent and independent values and Probability value (p-value) was calculated using chi square test. The associations were then further calculated through multivariable binary logistic regression. The results were displayed using Unadjusted and adjusted Odds Ratios with 95% CI and p values.

Ethical considerations:

The DHS surveys use procedures and questionnaires approved and reviewed by the Institutional Review Board (IRB). The survey was ensured to be compliant with the U.S Department of Health and Human Services regulations for the protection of human participants by the IRB[23].

Informed consent is collected by the participants who have the right to accept or reject participation. For children involved, consent is obtained by the parent or guardian. Explicit details are given about the purpose, potential risks and benefits and expected duration of the survey. Personal identities are kept confidential by coding[23].

For the current study, there was no ethical concern as no Human or Animal testing, experiments or tissues were involved. It is a desk based study on a publicly available data. Data is easily available online. Ethical approval from the LSHTM committee was also received.

RESULTS:

Of the 13,558 women included in the Pakistan Demographic and Health Survey 2012-13, only 7076 mothers were able to provide information regarding measles uptake for their last child. A total of 6810 mothers comprised the study sample aged between 15 and 49 years after excluding the missing information. Results found that only 60.9% (n=4144) of the children received measles vaccination, and 39.1% (n=2666) children did not receive any measles vaccination.

The majority mothers (n=3616) were in the range of 25-34 years of age (mean age= 29.63±6.43 years), belonged to rural areas (n=3801), had no education (55.2%, n=3761).

Regarding health characteristics, results found that mothers who had access to: healthcare facility were 76.6% (n=5219), antenatal care facility were 74.5% (n=5072), postnatal care facility were 43.2% (n=2943). Detailed socio-demographic and health characteristics of mothers are described in Table 1 given below

Table 1: Descriptive characteristics of study variables (n=6810)

Characteristics	N	(%)
Mother's Age in years (categorical)		
15 – 24	1544	22.7%
25 – 34	3616	53.1%
> 34	1650	24.2%
Place of residence		
Rural	3801	55.8%
Urban	3009	44.2%
Region of residence		
Islamabad (ICT)	440	6.5%
KPK	1442	21.2%
Sindh	1454	21.4%
Punjab	1752	25.7%
Gilgit Baltistan	672	9.9%
Baluchistan	1050	15.4%
Mother's Education level		
Higher	825	12.1%
Secondary	1250	18.4%
Primary	974	14.3%
No education	3761	55.2%
Wealth quintiles		
Richest	1375	20.2%
Richer	1319	19.4%
Middle	1295	19.0%
Poorer	1339	19.7%
Poorest	1482	21.8%
Mother's empowerment status		
Empowered	3540	52.0%
Unempowered	3270	48.0%
Access to healthcare		
No	1591	23.4%

Yes	5219	76.6%
Access to antenatal care		
None (0 visit)	1738	25.5%
1-3	2479	36.4%
3+	2593	38.1%
Access to postnatal care		
No	3867	56.8%
Yes	2943	43.2%
Access to media		
No	2057	30.2%
Yes	4753	69.8%
Access to modern communication services (mobile phones)		
No	6019	88.4%
Yes	791	11.6%
Child's Gender		
Male	3524	51.7%
Female	3286	48.3%
Child's birth order		
1-4	4624	67.9%
> 4	2186	32.1%

Results of chi square analysis

Table 2 represents the associations between the dependent and independent variables of our interest. Regarding maternal characteristics, mothers who fell in the youngest age group of 15-24 years reported the highest percentage of non-uptake of Measles vaccination for their child. While 55% of those who were older than 34 years of age reported positive uptake of Measles uptake of their children. 62.3% of mothers who lacked formal education reported no measles vaccination uptake of their children while those having higher education showed a positive response of 68.6%. Regarding empowerment status, 59.5% of mothers who had no power over household decisions reported No vaccination uptake of their child while those labeled as 'Empowered' showed a 54.3% response of uptake. 57.6% of those mothers who did not have access to health care facilities had not gotten their children vaccinated. But interestingly, only a

slight difference of results was seen for those mothers who had access to health care facilty. Mothers who never visited ante natal facility in their pregnancy showed a 66.3% report of negative uptake of children's vaccination. While those who were fortunate enough to have more than 3 visits showed 59.7% positive response. 58.9% of mothers who had no access to post natal facility did not get their child vaccinated. All maternal characteristics had a p value of less than 0.001

53.5% of households who had access to media and 63.6% who had access to modern communication services had gotten their children vaccinated.

Male-female dichotomy didn't dictate the results as was expected. Only a little difference was observed between the male and female gender of the child in the measles vaccine uptake. The Probabilty value (p-value) was however 0.022 in this case. Table 2 is on the next page.

Table 2: Factors associated with measles vaccination uptake (n=6810)

	Measles vaccination uptake			
	No	**Yes**	**p-value***	**Chi-square value**
	n (%)	**n (%)**		
Mother's Age in years (categorical)			<0.001	116.0
15 – 24	981 (63.5)	563 (36.5)		
25 – 34	1840 (50.9)	1776 (49.1)		
> 34	743 (45.0)	907 (55.0)		
Place of residence			<0.001	109.1
Rural	2203 (58.0)	1598 (42.0)		
Urban	1361 (45.2)	1648 (54.8)		
Region of residence			<0.001	215.3
Islamabad (ICT)	139 (31.6)	301 (68.4)		
KPK	770 (53.4)	672 (46.6)		
Sindh	853 (58.7)	601 (41.3)		
Punjab	761 (43.4)	991 (56.6)		
Gilgit Baltistan	368 (54.8)	304 (45.2)		
Balochistan	673 (64.1)	377 (35.9)		

Mother's Education level			<0.001	381.6
Higher	259 (31.4)	566 (68.6)		
Secondary	496 (39.7)	754 (60.3)		
Primary	467 (47.9)	507 (52.1)		
No education	2342 (62.3)	1419 (37.7)		
Wealth quintiles			<0.001	393.4
Richest	482 (35.1)	893 (64.9)		
Richer	602 (45.6)	717 (54.4)		
Middle	665 (51.4)	630 (48.6)		
Poorer	776 (58.0)	563 (42.0)		
Poorest	1039 (70.1)	443 (29.9)		
Mother's empowerment status			<0.001	131.0
Empowered	1617 (45.7)	1923 (54.3)		
Unempowered	1947 (59.5)	1323 (40.5)		
Access to healthcare			<0.001	23.39
No	917 (57.6)	674 (42.4)		
Yes	2647 (50.7)	2572 (49.3)		
Access to antenatal care			<0.001	293.9
None (0 visit)	1152 (66.3)	586 (33.7)		
1-3	1367 (55.1)	1112 (44.9)		
3+	1045 (40.3)	1548 (59.7)		
Access to postnatal care			>0.001	156.6
No	2272 (58.9)	1586 (41.1)		
Yes	1283 (43.6)	1660 (56.4)		
Access to media			<0.001	211.9
No	1352 (65.7)	705 (34.3)		
Yes	2212 (46.5)	2541 (53.5)		
Access to modern communication services (mobile phones)			<0.001	90.98
No	3276 (54.4)	2743 (45.6)		
Yes	288 (36.4)	503 (63.6)		
Child's Gender			0.022	5.27
Male	1797 (51.0)	1727 (49.0)		
Female	1767 (53.8)	1519 (46.2)		
Child's birth order			0.017	5.705
1-4	2374 (51.3)	2250 (48.7)		
> 4	1190 (54.4)	996 (45.6)		

*p-value calculated using Chi-square test

Results of univariate logistic regression:

Univariate logistic regression models indicate that those children whose mothers were older than 34 years were 2.12 times more likely to have measles vaccination uptake (OR = 2.12, 95% CI 1.84-2.45, p-value <0.001) as compared to those mothers who were younger. Higher education (OR = 3.61, 95% CI 3.07-4.23, p-value <0.001), richest wealth quintile (OR = 4.34, 95% CI 3.71-5.08, p-value <0.001), more than 3 antenatal visits (OR = 2.91, 95% CI 2.56-3.30, p-value <0.001), access to media (OR = 2.20, 95% CI 1.97-2.45, p-value <0.001) and access to mobile phones (OR = 2.08, 95% CI 1.78-2.43, p-value <0.001) were significant positive factors against child's measles vaccination uptake. Furthermore children those mothers, lived in rural areas (OR = 0.59, 95% CI 0.54-0.65, p-value <0.001), were unempowered (OR = 0.57, 95% CI 0.51-0.62, p-value <0.001), had no access to healthcare facility (OR = 0.75, 95% CI 0.67-0.84, p-value <0.001), and had no access to postnatal care (OR = 0.53, 95% CI 0.48-0.59, p-value <0.001) were significantly less likely to have measles vaccination uptake. (See detail in Table 3)

Table 3: Factors associated with measles vaccination uptake-Univariate Logistic regression(n=6810)

	Measles vaccination uptake		
	cOR	**95% Confidence intervals**	**p-value**
Mother's Age in years (categorical)			
15 – 24	1		
25 – 34	1.68	1.48 - 1.90	<0.001
> 34	2.12	1.84 - 2.45	<0.001
Place of residence			
Urban	1		
Rural	0.59	0.54 - 0.65	<0.001
Region of residence			
Punjab	1		
Sindh	0.54	0.46 - 0.62	<0.001
KPK	0.67	0.58 - 0.77	<0.001
Balochistan	0.43	0.36 - 0.50	<0.001
Gilgit Baltistan	0.63	0.53 - 0.75	<0.001

Islamabad (ICT)	1.66	1.33 - 2.07	<0.001
Mother's Education level			
No education	1		
Primary	1.79	1.55 - 2.06	<0.001
Secondary	2.51	2.20 - 2.86	<0.001
Higher	3.61	3.07 - 4.23	<0.001
Wealth quintiles			
Poorest	1		
Poorer	1.70	1.45 - 1.98	<0.001
Middle	2.22	1.90 - 2.59	<0.001
Richer	2.79	2.39 - 3.26	<0.001
Richest	4.34	3.71 - 5.08	<0.001
Mother's empowerment status			
Empowered	1		
Unempowered	0.57	0.51 - 0.62	<0.001
Access to healthcare			
Yes	1		
No	0.75	0.67 - 0.84	<0.001
Access to antenatal care			
None (0 visit)	1		
1-3	1.59	1.40 - 1.81	<0.001
3+	2.91	2.56 - 3.30	<0.001
Access to postnatal care			
Yes	1		
No	0.53	0.48 - 0.59	<0.001
Access to media			
No	1		
Yes	2.20	1.97 - 2.45	<0.001
Access to modern communication services (mobile phones)			
No	1		
Yes	2.08	1.78 - 2.43	<0.001
Child's Gender			
Male	1		
Female	0.89	0.81 - 0.98	0.022
Child's birth order			
1-4	1		
> 4	0.88	0.79 -0.97	0.017

cOR: unadjusted odds ratio

Results of Multivariate logistic regression

After adjusting all study variables, multivariate logistic regression showed that children whose mother were, older than 34 years (OR = 2.74, 95% CI 2.29-3.29, p-value <0.001), had higher education (OR = 1.74, 95% CI 1.41-2.15, p-value <0.001), were richest (OR = 1.49, 95% CI 1.17-1.90, p-value 0.001), had more than 3 antenatal visits during pregnancy (OR = 1.54, 95% CI 1.31-1.81, p-value <0.001) and had access to media (OR = 1.28, 95% CI 1.12-1.47, p-value <0.001) were significantly more likely to have measles vaccination uptake. Some graphs have been illustrated below to show the association of Maternal Education and Wealth quintile with measles vaccination.

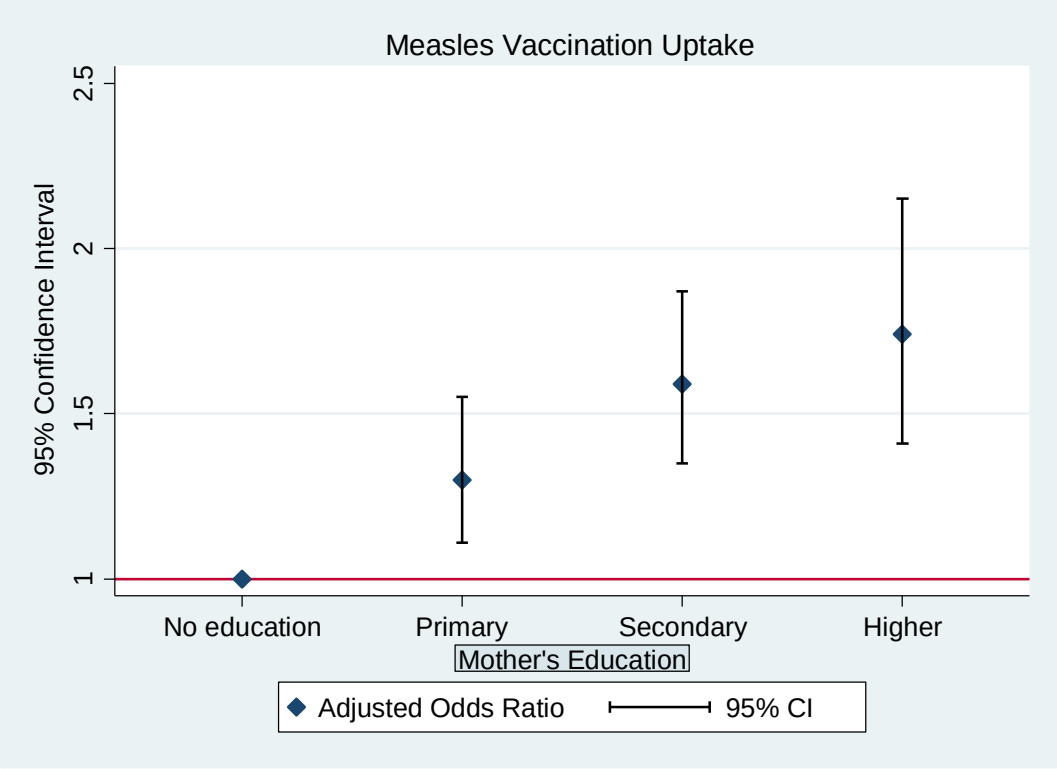

Figure 2: Adjusted Odds Ratios alongwith their Confidence Intervals for the Measles vaccination uptake in children, depending on Maternal Education.

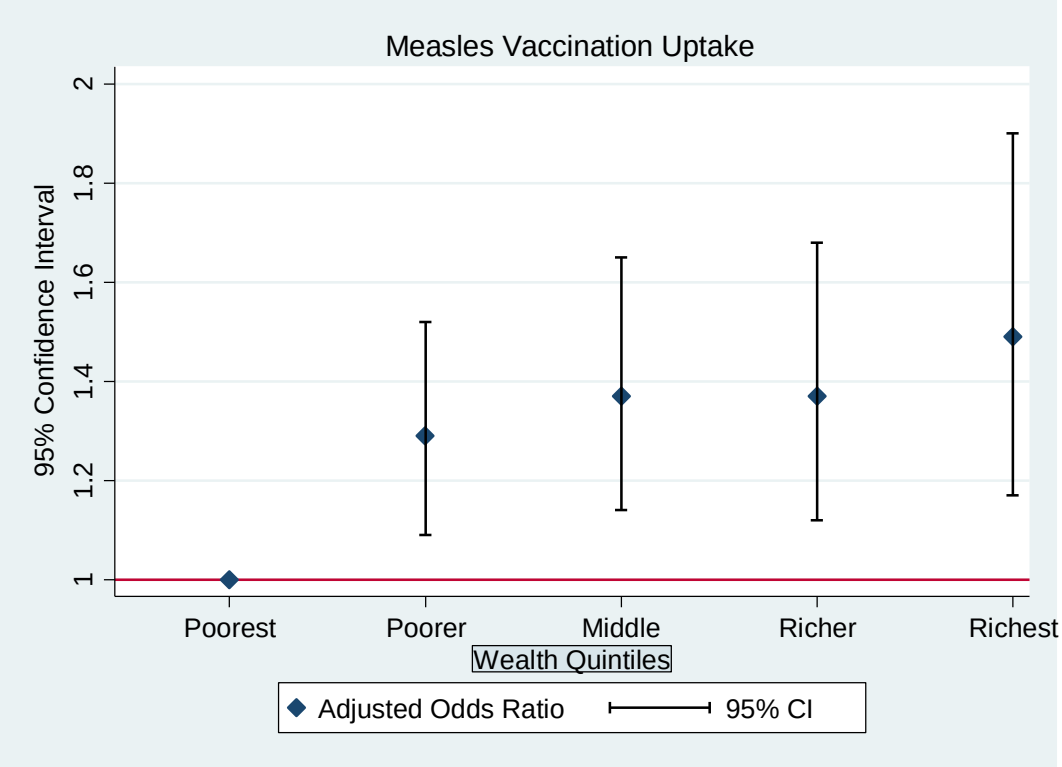

Figure 3: Graph illustrating the Adjusted Odds ratios alongwith their Confidence Intervals to show the association between Measles vaccination uptake and Wealth quintile of the household.

However, children of mothers who, lived in Baluchistan region (OR = 0.69, 95% CI 0.57-0.83, p-value <0.001), were unempowered (OR = 0.78, 95% CI 0.70-0.87, p-value <0.001), had no access to postnatal care (OR = 0.74, 95% CI 0.66-0.83, p-value <0.001) were significantly less likely to have measles vaccination uptake. Child female gender and high birth order were also significantly associated with their measles vaccination uptake. (Table 4)

Table 4: Factors associated with measles vaccination uptake-MLR(n=6810)

	Measles vaccination uptake		
	aOR	**95% Confidence intervals**	**p-value**
Mother's Age in years (categorical)			
15 – 24	1		
25 – 34	1.73	1.51 - 1.98	<0.001
> 34	2.74	2.29 - 3.29	<0.001
Place of residence			
Urban	1		
Rural	0.94	0.83 - 1.07	0.426
Region of residence			
Punjab	1		
Sindh	0.56	0.48 - 0.66	<0.001
KPK	0.92	0.79 - 1.08	0.336
Balochistan	0.69	0.57 - 0.83	<0.001
Gilgit Baltistan	0.85	0.69 -1.05	0.150
Islamabad (ICT)	1.04	0.82 -1.33	0.710
Mother's Education level			
No education	1		
Primary	1.30	1.11 - 1.55	0.001
Secondary	1.59	1.35 - 1.87	<0.001
Higher	1.74	1.41 - 2.15	<0.001
Wealth quintiles			
Poorest	1		
Poorer	1.29	1.09 - 1.52	0.003
Middle	1.37	1.14 - 1.65	0.001
Richer	1.37	1.12 - 1.68	0.002
Richest	1.49	1.17 - 1.90	0.001
Mother's empowerment status			
Empowered	1		
Unempowered	0.78	0.70 - 0.87	<0.001
Access to healthcare			
Yes	1		
No	1.03	0.89 - 1.18	0.656
Access to antenatal care			
None (0 visit)	1		
1-3	1.23	1.07 - 1.42	0.003
3+	1.54	1.31 - 1.81	<0.001
Access to postnatal care			
Yes	1		
No	0.74	0.66 - 0.83	<0.001
Access to media			

No	1		
Yes	1.28	1.12 - 1.47	<0.001
Access to modern communication services (mobile phones)			
No	1		
Yes	1.13	0.94 - 1.35	0.190
Child's Gender			
Male	1		
Female	0.90	0.81 - 0.99	0.048
Child's birth order			
1-4	1		
> 4	0.89	0.78 - 1.02	0.103

aOR: adjusted odds ratio for all study variables
MLR: multivariate logistic regression

Limitations

Limitations of the PDHS 2012-13:

1. The PDHS 2012-13 did not include some of the areas of Pakistan like Azad Jammu and Kashmir and military protected areas due to security reasons. Although the population of these areas account for just 3% of the total population of Pakistan, the results could be different is these areas were included.

2. Information on child's immunization status is collected by mother's reporting and vaccination cards. Mother's reporting could therefore have limitations of recall or social desirability bias leading to over estimation of results as mother's reporting was weighted same as vaccination records.

3. Refusal to participate in the survey could affect the outcome and give under/over estimations of the results.

Limitations of Our study:

1. Causal relationships of the associations cannot be established between the variables because of the cross-sectional nature of the survey.

2. The literature review could have been done more systematically with meta-analysis.

3. The results of the PDHS 2017-2018 are now released in September 2018. When this study was started, 2012-13 was the recent most survey. The newer survey data could give different results

4. Generalizability of the result or transferability could be limited for other countries as the survey and analysis was limited to Pakistan only.

DISCUSSION/CONCLUSION:

As was indicated some other studies and the World Health Organization, the measles vaccination uptake in Pakistani kids aged 12 to 23 months was found out to be very low. The optimal level required for the effective control of this disease is >90% while our nationwide study revealed a prevalence of just 60.9% which is very low.

To further explore the factors which could have influenced this low uptake, a literature review was done. This gave us some possible socio demographic determinants which could be affecting the low uptake despite repeated high-profile vaccination campaigns. These determinants were indicated in different studies but these studies were either conducted in different countries or were conducted at some local level with smaller sample sizes and potential geographical biases. Therefore, a National level scientific analysis, specific to Pakistan

and to measles, was needed to explore the associations and determine their significance and influence.

The first factor that came up in our study was the mother's age. This was found to have the greatest influence on the measles vaccination uptake of the children. The study revealed that children whose mothers were older than 34 years were twice more likely to vaccinate their children as compared to those who were at a younger age. The possible reason for this association could be the empowerment of women that comes socially with growing age of women in Pakistan[26]. With increased age of the mother and children of older ages, the mothers start gaining more decision powers along with knowledge and awareness which could be the reasons for this association.

Further exploring women empowerment and Measles vaccination uptake in young children, our results showed a clear increased likelihood of a child to receive Measles vaccination if his/her mother was empowered.

Women empowerment comes with age, education and wealth along with many other factors in Pakistan[26]. Further affirming this was the association found between maternal education status and our outcome variable. Higher education status of the mother showed a positive association with the child's Measles Vaccination uptake. All the maternal characteristics had a p value of less than 0.001, therefore future efforts could be directed towards women empowerment, attainment of education, discouraging marriages at younger ages and increased awareness campaigns. There will then be an increased likelihood of reaching the desired WHO goal of

measles eradication in a country like Pakistan. If these factors are continued to be ignored, we would never be able to achieve our goals despite repeated vaccination campaigns.

Another association highlighted in this study was the number of peri-natal visits. It is noted that the mothers who had nil access to antenatal and postnatal visits, contributed a major proportion of those whose children were not vaccinated. On the other hand, children of mothers having at least 3 pre-natal and post-natal visits were twice more likely to be vaccinated against Measles. These visits are very much linked to maternal empowerment, autonomous household decision making, wealth quintile and education status. All these factors point towards the significance of individual maternal determinants which influence the child's vaccination status.

Community level determinants which were found to be associated with a child's vaccination uptake were the type of residential area (urban/rural) and the province in which the family resided. The analysis revealed that the rural inhabitants and those residing in the province of Baluchistan were less likely to provide vaccination to their children. A reason for this could be the decreased availability of health care facilities in rural areas and Baluchistan province. The province of Baluchistan has lesser developed infrastructure and urbanization. These could complement our above findings of decreased access to health care facility. Therefore, the efforts of the next campaigns or any Measles vaccine related health policy should focus more on these areas and this province especially.

Birth order and female gender were also found to be significantly associated with the outcome variable of our interest. It was found that if the child's birth order was greater than fourth, then

that child was less likely to receive the vaccination. This was a comparatively new finding of our study and could be further verified through future researches. This could generate the potential role contraception awareness could play in the society. If number of children in a family could be reduced, then the children will be more likely to get vaccinated and can help achieve the herd immunity level required to eliminate this deadly disease. Moreover, the study also showed that if the child was a female, she was less likely to receive the vaccination and therefore this finding highlights the societal preference for male gender. This could be addressed by raising awareness about gender equality.

RECOMMENDATIONS

To achieve optimal uptake of Measles vaccine among children in Pakistan, the national policies should focus on the socio-demographic determinants which are responsible for the decreased uptake. Resources and efforts can be directed towards investments in campaigns like gender equality, vaccination awareness and emphasis on female education. A research trial could then be carried out to verify the effects. Further researches can be done on the theory of mHealth, using mobile phone communication to increase awareness and facilitate vaccine uptake.

CONCLUSION:

This study identifies some very important determinants to Measles which were not explored at this level for Pakistan before. Therefore, the results can be very helpful for future policy making processes. Maternal empowerment, education and awareness can play a huge role to achieve the optimal level of Measles vaccination uptake which is very much needed to control this deadly disease.

REFERANCES:

1. Weekly Epidemiological Record, 28 April 2017, vol. 92, 17 (pp. 205–228) [Internet]. World Health Organization. 2018 [cited 17 April 2018]. Available from: http://www.who.int/wer/2017/wer9217/en/

2. Plotkin's Vaccines - 7th Edition [Internet]. Elsevier.com. 2018 [cited 8 April 2018]. Available from: https://www.elsevier.com/books/plotkins-vaccines/plotkin/978-0-323-35761-6

3. Albrecht P, Ennis FA, Saltzman EJ, Krugman S. Persistence of maternal antibody in infants beyond 12 months: mechanism of measles vaccine failure. The Journal of pediatrics. 1977 Nov 1;91(5):715-8.

4. Mitchell C. Region of the Americas is declared free of measles | PAHO WHO [Internet]. Pan American Health Organization / World Health Organization. 2018 [cited 8 April 2018]. Available from: http://www.paho.org/hq/index.php?option=com_content&view=article&id=12528%3Aregion-americas-declared-free-measles&catid=740%3Apress-releases&Itemid=1926&lang=en

5. Kazi AN. Measles epidemic exposes inadequate vaccination coverage in Pakistan. BMJ. 2013;346:f245)

6. Global Vaccine Action Plan [Internet]. World Health Organization. 2018 [cited 8 April 2018]. Available from: http://www.who.int/immunization/global_vaccine_action_plan/en/

7. Helfand RF, Perry R, Strebel P. Vaccines must be given in order to protect. The Journal of infectious diseases. 2007;196:333–3350

8. VPD Surveillance Report, January – March, 2016 – Expanded Program on Immunization, Pakistan [Internet]. Epi.gov.pk. 2018 [cited 17 April 2018]. Available from: http://www.epi.gov.pk/vpd-surveillance-report-january-march-2016/

9. Orun SD, Bakirci N: Vaccination coverage and reasons for non-vaccination in a district of Istanbul. BMC Public Health. 2006, 6: 125-10.1186/1471-2458-6-125.

10. Jani JV, Schacht CD, Jani IV, Bjune G: Risk factors for incomplete vaccination and missed opportunity for immunization in rural Mozambique. BMC Public Health. 2008, 8: 161-10.1186/1471-2458-8-161.

11. Tadesse H, Deribew A, Woldie M: Predictors of defaulting from completion of child immunization in south Ethiopia, May 2008 – a case control study. BMC Public Health. 2009, 9: 150-10.1186/1471-2458-9-150

12. Owais A, Hanif B, Siddiqui AR, Agha A, Zaidi AKM: Does improving maternal knowledge of vaccines impact infant immunization rates? A community based randomized-controlled trial in Karachi. Pakistan. BMC Public Health. 2011, 11: 239-10.1186/1471-2458-11-239.

13. Opuzoglu A, Ay P, Hidiroglu S, Gurbuz Y: The barriers against childhood immunizations: a qualitative research among socio-economically disadvantaged mothers. European Journal of Public Health. 2007, 17 (4): 348-352. 10.1093/eurpub/ckl250.

14. Cockcroft A, Andersson N, Omer K, Ansari NM, Khan A, Chaudhry UU, Ansari U: One size does not fit all: local determinants of measles vaccination in four districts of Pakistan. BMC Int

Health Hum Rights. 2009, 9 (Suppl 1): S4-10.1186/1472-698X-9-S1-S4.

15. Hull H, Williams PJ, Oldfield F. Measles mortality and vaccine efficacy in rural West Africa. The Lancet. 1983 Apr 30;321(8331):972-5.

16. Sheikh S, Ali A, Zaidi AK, Agha A, Khowaja A, Allana S, Qureshi S, Azam I. Measles susceptibility in children in Karachi, Pakistan. Vaccine. 2011 Apr 18;29(18):3419-23.

17. Ghafoor F, Mohsin SN, Aasim M. Assessment of the Knowledge Attitude and Practices of Mothers Having Children in the Age Group of 9 to 36 Months regarding Measles and its Vaccination. Pakistan Journal of Medical Research. 2017 Apr 1;56(2):52.

18. Muhammad D, Ali S, Ahmad A, Fatima A. IMMUNIZATION STATUS; MOTHER'S AWARENESS AND FACTORS AFFECTING CHILDREN IMMUNIZATION STATUS IN PESHAWAR, PAKISTAN. Professional Medical Journal. 2017 Dec 1;24(12)

19. Ali A. Factors affecting uptake of Childhood Immunization through EPI in the Province of Khyber Pakhtunkhwa, Pakistan. OPHTHALMIC SECTION-ORIGINAL ARTICLES. 2018 Jan;16(1):537.)

20. Imran H, Raja D, Grassly NC, Wadood MZ, Safdar RM, O'Reilly KM. Routine immunization in Pakistan: comparison of multiple data sources and identification of factors associated with vaccination. International health. 2018 Feb 8;10(2):84-91.

21. Kazi AN. Measles epidemic exposes inadequate vaccination coverage in Pakistan. BMJ. 2013;346:f245

22. PDHS final report 2012-2013 available from http://www.nips.org.pk/abstract_files/PDHS%20Final%20Report%20as%20of%20Jan%2022-2014.pdf

23. The DHS Program - login_main [Internet]. Dhsprogram.com. 2018 [cited 14 April 2018]. Available from: https://dhsprogram.com/data/dataset_admin/login_main.cfm;jsessionid=3CF0754BEA5FE19A2F0CA6F6C0F3861D.cfusion?CFID=12629846&CFTOKEN=913fe4071751f21-6E1CFD75-A673-8F1B-7BAF7A00820A3262

24. Murray CJL, Shengelia B, Gupta N, Moussavi S, Tandon A, Thieren M: Validity of reported vaccination coverage in 45 countries. Lancet. 2003, 362: 1022-1027. 10.1016/S0140-6736(03)14411-X)

25. The DHS Program - Protecting the Privacy of DHS Survey Respondents [Internet]. Dhsprogram.com. 2018 [cited 14 April 2018]. Available from: https://dhsprogram.com/What-We-Do/Protecting-the-Privacy-of-DHS-Survey-Respondents.cfm

26. Akram N. Women's Empowerment in Pakistan: Its Dimensions and Determinants. Social Indicators Research. 2017:1-21.

27. Gavrielov-Yusim N, Battat E, Neumann L, Friger M, Balicer RD. Birth order and private voluntary immunization—a study of 110,902 children. Vaccine. 2012 Jan 5;30(2):442-7.

28. Hawken S, Kwong JC, Deeks SL, Crowcroft NS, Ducharme R, Manuel DG, Wilson K. Association between birth order and emergency room visits and acute hospital admissions following pediatric vaccination: a self-controlled study. PloS one. 2013 Dec 4;8(12):e81070.

29. de CantuáriaTauil M, Sato AP, Waldman EA. Factors associated with incomplete or delayed vaccination across countries: a systematic review. Vaccine. 2016 May 23;34(24):2635-43.

30. Khera R, Jain S, Lodha R, Ramakrishnan S. Gender bias in child care and child health: global patterns. Archives of disease in childhood. 2013 Dec 14:archdischild-2013.

31. Prusty RK, Kumar A. Socioeconomic dynamics of gender disparity in childhood immunization in India, 1992–2006. PloS one. 2014 Aug 15;9(8):e104598.

32. Singh PK, Parasuraman S. 'Looking beyond the male–female dichotomy'–Sibling composition and child immunization in India, 1992–2006. Social Science & Medicine. 2014 Apr 1;107:145-53.

33. Singh PK. Trends in child immunization across geographical regions in India: focus on urban-rural and gender differentials. PloS one. 2013 Sep 4;8(9):e73102.

34. Singh K, Haney E, Olorunsaiye C. Maternal autonomy and attitudes towards gender norms: associations with childhood immunization in Nigeria. Maternal and child health journal. 2013 Jul 1;17(5):837-41.

35. Rainey JJ, Watkins M, Ryman TK, Sandhu P, Bo A, Banerjee K. Reasons related to non-vaccination and under-vaccination of children in low and middle income countries: findings

from a systematic review of the published literature, 1999–2009. Vaccine. 2011 Oct 26;29(46):8215-21.

36. Andersson N, Cockcroft A, Ansari NM, Omer K, Baloch M, Foster AH, Shea B, Wells GA, Soberanis JL. Evidence-based discussion increases childhood vaccination uptake: a randomised cluster controlled trial of knowledge translation in Pakistan. BMC International Health and Human Rights. 2009 Oct;9(1):S8.

37. Riaz A, Husain S, Yousafzai MT, Nisar I, Shaheen F, Mahesar W, Dal SM, Omer SB, Zaidi S, Ali A. Reasons for non-vaccination and incomplete vaccinations among children in Pakistan. Vaccine. 2018 Aug 23;36(35):5288-93.

38. Zaidi SM, Khowaja S, Kumar Dharma V, Khan AJ, Chandir S. Coverage, timeliness, and determinants of immunization completion in Pakistan: evidence from the Demographic and Health Survey (2006–07). Human vaccines &immunotherapeutics. 2014 Jun 4;10(6):1712-20.

39. Cockcroft A, Andersson N, Omer K, Ansari NM, Khan A, Chaudhry UU, Ansari U. One size does not fit all: local determinants of measles vaccination in four districts of Pakistan. BMC International Health and Human Rights. 2009 Oct;9(1):S4.

40. Khan MT, Zaheer S, Shafique K. Maternal education, empowerment, economic status and child polio vaccination uptake in Pakistan: a population based cross sectional study. BMJ open. 2017 Mar 1;7(3):e013853.

41. Khowaja AR, Sheikh S, Saleem AF, Zaidi AK. Parental awareness and coverage of mass measles vaccination drive 2011: cross-sectional survey in the metropolitan city of Karachi, Pakistan. Asia Pacific Journal of Public Health. 2015 Mar;27(2):NP2749-56.

42. Lorenz C, Khalid M. Influencing factors on vaccination uptake in Pakistan. J Pak Med Assoc. 2012 Jan 1;62(1):59-61.

43. Rammohan A, Awofeso N, Fernandez RC. Paternal education status significantly influences infants' measles vaccination uptake, independent of maternal education status. BMC public health. 2012 Dec;12(1):336.

44. Mitchell S, Andersson N, Ansari NM, Omer K, Soberanis JL, Cockcroft A. Equity and vaccine uptake: a cross-sectional study of measles vaccination in Lasbela District, Pakistan. BMC international health and human rights. 2009 Oct;9(1):S7.

45. Watterson JL, Walsh J, Madeka I. Using mHealth to improve usage of antenatal care, postnatal care, and immunization: a systematic review of the literature. BioMed research international. 2015;2015.

46. HOUSING INDICATORS - 1998 CENSUS | Pakistan Bureau of Statistics [Internet]. Pbs.gov.pk. 2018 [cited 28 September 2018]. Available from: http://www.pbs.gov.pk/content/housing-indicators-1998-census

ANNEX 1

Table 1: Coding plan of study variables

Variable	Description and Categorization	Response Options
Outcome Variable		
Measles vaccination uptake	A measles injection or an MMR injection--that is, a shot in the arm at the age of 9 months or older--to prevent him/her from getting measles? Responses were Yes, No and Don't Know	By using the all collected information (vaccination card or mother's self-report), measles vaccination uptake was categorized as "Yes" and "No" (Don't know response was recoded as No)
Independent Variables		
Mother's Age in years (categorical)	How old are you?	1= 15 - 24 2= 25 - 34 3= > 34
Place of residence	Type of place of residence	1= Urban 2= Rural
Region of residence	Region	1= Punjab 2= Sindh 3= Khyber Pakhtunkhwa 4= Balochistan 5= Gilgit Baltistan 6= Islamabad
Mother's Education level	Highest educational level	1= No education 2= Primary 3= Secondary 4= Higher
Wealth quintiles	PDHS provided information on household assets, and used to create a wealth quitile index as an indicator of household	1= Poorest 2= Poorer

		3= Middle 4= Richer 5= Richest
Mother's empowerment status	1. Who usually makes decisions about health care for yourself: you, your husband, you and your husband jointly, or someone else? 2. Who usually makes decisions about making major household purchases: you, your husband, you and your husband jointly, or someone else? 3. Who usually makes decisions about visits to your family or relatives: you, your husband, you and your husband jointly, or someone else?	Mothers who were directly involve in decision making to any of these indicators were labeled as “Empowered”, other responses were labeled ad “Un-empowered”.
Access to healthcare	Visited health facility last 12 months	0= No 1= Yes
Access to antenatal care	Number of antenatal visits during pregnancy	1= None (0 visit) 2= 1 - 3 3= 3+
Access to postnatal care	Baby postnatal check within 2 months	0= No 1= Yes
Access to media	1. Frequency of reading newspaper or magazine 2. Frequency of listening to radio 3. Frequency of watching television	Mothers who had access to any media were labeled as "Yes", other responses were labeled as "No".
Access to modern communication services (mobile phones)	Household has: telephone (land-line)	0= No 1= Yes
Child's Gender	Sex of the last child	1= Male

		2= Female
Child's birth order	Birth order of the last child	1= 1-4 2= > 4