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Date

Where there's a Will there's a Way: Attitudes and Perceptions of India's Primary Health Center Physicians Regarding Measles Eradication

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Abstract

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By Stephanie Lambert

In 2010, the WHO stated that measles "can and should be eradicated." Currently, measles continues to cause the death of approximately 158,000 people each year. Half of these deaths occur in India. The successful elimination of measles transmission in India is critical for the success of global measles eradication. In order to build the political will necessary to eradicate measles in India, full support must be present among its physicians. **Objectives:** The objectives of this study were to investigate and compare attitudes and perceptions of primary health center (PHC) physicians in Uttar Pradesh and Bihar towards measles disease, immunization, and eradication. **Methods:** A subset of secondary data was analyzed from a survey assessing PHC physician attitudes towards polio eradication, measles eradication, and general immunization. The survey instrument was given in-person to PHC physicians from blocks with at least one confirmed polio case during January 2006 to June 2009. **Results:** The majority of PHC physicians support statements that measles eradication is important (93.45%) and likely (90.53%). PHC physicians who reported that unvaccinated children were likely to become severely ill if infected with measles were 2.2 times more likely to state that measles eradication is important. PHC physicians with high perceived MMR vaccine efficacy were 3.39 times more likely to state that measles eradication is important. **Conclusion:** PHC physicians play a critical role in shaping the battle against measles in India. Their high levels of support for measles eradication can be used to leverage political willpower in achieving measles eradication. Barriers to support must be addressed in order to maximize eradication's success.

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Chapter 1: Introduction

Introduction and Rationale:

Measles has plagued the world for centuries. Prior to the introduction of a vaccine, measles infected over 90% of the population and resulted in an estimated annual death toll of 2.6 million people(WHO). Despite the availability of a safe, effective, and affordable vaccine, measles continues to cause the death of approximately 158,000 each year(WHO). Almost half of these deaths occur in India.

Home to just under one fifth of the global population, India is responsible for 47% of the world's measles deaths(WHO, 2012). An estimated 50,000-100,000 children die annually from measles, with complications from measles responsible for 3% of deaths of childhood deaths (Welfare, 2013). The majority of measles cases happen in only a select few states like Uttar Pradesh and Bihar, which face disproportionately high burdens of disease and sub-standard immunization coverage. The DLHS-3 survey found measles immunization coverage to be 54% in Bihar, and 47% in Uttar Pradesh, below the national coverage rate of 68% (Morris et al., 2013). Consequently, Uttar Pradesh (UP) has the greatest number of deaths attributed to measles, losing an estimated 35,000 people annually to the disease, followed by 10,600 measles deaths in Bihar (Morris et al., 2013).

In 2010, the World Health Assembly declared that measles "can and should be eradicated." The successful elimination of measles transmission in India is critical for the success of global measles eradication. Strengthening routine immunization is a fundamental pillar of measles eradication. Primary Health Center (PHC) physicians play a central part in this effort, as they provide healthcare to much of India's historically underserved population. PHC physicians are

responsible for delivering the majority of vaccines to children, and thus they play a critical role in eliminating measles transmission. As such, it is crucial to understand the attitudes and practices of PHC physicians, as well as identify challenges faced in providing full coverage immunization.

2. Problem Statement

Political will is a central tenant to disease eradication, as the effort required to erase a disease from the planet requires immense global cooperation. Until every country has eliminated measles and thus achieved worldwide eradication, countries that have successfully eliminated a disease will continue to face the constant threat of importation and subsequent re-establishment within their population. To circumvent this problem, political will must be in strong support of eradication efforts.

Strong political will is shaped by knowledge of the problem, understanding of the solution, and the determination of those influential to public leaders. Public health initiatives require a strong push from those most intimate with the disease being fought. The leaders and politicians who shape policy and manage health systems may look to medical professionals for input on public health initiatives. Physicians often hold both intellectual and social prestige which can be used as leverage for advocacy, using scientific evidence and personal experience to promote the importance of disease eradication.

In India, PHC physicians serve a majority of the population. They are particularly relied upon in rural areas, whose populations are responsible for 70% of India's measles cases. These physicians are familiar with the nature of measles and play a critical role in routine immunization, a strategy central to measles eradication efforts. Historically, PHC physicians

have demonstrated their importance to eradication initiatives by their contributions to the smallpox and polio eradication campaigns (Thacker et al., 2012).

Despite the primacy of PHC physicians in the battle to eradicate measles, very little is known about the knowledge and attitudes of PHC physicians towards measles eradication efforts and their beliefs surrounding measles vaccine safety and utility. This knowledge is necessary to understand barriers that may prevent PHC physicians from promoting measles eradication in both practice and persuasion.

3. Purpose Statement

This study will examine the factors that have inhibited India's path to measles elimination, looking particularly at how the attitudes and practices of Indian physicians impact India's role in the context of a global plan for eradication

The main objectives of this study are to (1) assess the attitudes of PHC physicians regarding measles disease and vaccination safety and use, (2) assess their attitudes about measles eradication, and (3) identify important barriers to measles eradication.

4. Research Question

How do perceptions surrounding measles, vaccine safety, and vaccine utility affect PHC physicians' attitudes towards measles eradication in India?

5. Significance Statement

Understanding how the knowledge and attitudes of PHC physicians towards measles and immunization affect perceptions of measles eradication efforts will provide the necessary foundation for eliminating barriers to measles eradication. PHC physicians play a critical role in forming the political willpower and motivation needed to pursue measles eradication.

6. Definitions of Terms

CDC – Centers of Disease Control and Prevention

MCV- Measles Containing Vaccine

MMR – Measles, mumps, rubella vaccine

MV – Measles vaccine

PAHO – Pan American Health Organization

PHC – Primary Health Centres

RI – Routine Immunization

SIA – Supplementary Immunization Activity

UIP – Universal Immunization Program

WHO – World Health Organization

Chapter 2: Global Efforts in Measles Control and Eradication

"Immunization is, and should be recognized as, a core component of the human right to health and an individual, community and governmental responsibility... Protected from the threat of vaccine preventable diseases, immunized children have the opportunity to thrive and a better chance of realizing their full potential." Global Vaccine Action Plan (GVAP, 2013, p. B5)

2.1 Measles and worldwide burden of disease

Known as one of the most infectious disease known to mankind, measles has plagued the world for millennia. Infecting more than 90% of whom it comes into contact, it was once thought of as a routine passage of childhood, despite causing an estimated 2.6 million deaths annually prior to widespread immunization (WHO).

The measles virus is an acute viral illness which causes fever and rash, often accompanied by a cough, runny nose, and/ or conjunctivitis. It is characterized by distinctive blue-white spots on the buccal mucosa known as "Koplik spots" (CDC, 2012b). Complications occur in approximately 30% of all measles cases, and may include diarrhea, dehydration, stomatitis, inability to feed, bacterial infections, encephalitis, or death(CDC, 2012b). Complications due to measles are most severe in children younger than 5, adults 20 years and older, and people with AIDS and other immunocompromised individuals. Malnutrition, particularly among those lacking sufficient vitamin A, also amplifies the severity of infection (CDC, 2012b).

Though good supportive care can lighten the severity of measles, it is still estimated that 10-30% of measles cases require hospitalization in industrialized countries with fatality rates in children estimated to be around 0.1% (WHO, 2012). Developing countries face a more grim fate, with case fatality averaging 5-6% of infected children but reaching a devastating 25% in extreme situations(CDC, 2012b; WHO, 2012). Today, measles account for an estimated 20 million cases of disease and 164,000 deaths each year, and is a leading cause of blindness among children in Africa (CDC, 2012b).

The invention and mass administration of a safe and effective vaccine has radically reduced the number of measles cases in the world. The first measles vaccine was developed by Sam Katz in 1958. Though effective in preventing severe disease, the vaccine was found to still cause minor signs of infection. Thus it wasn't until 1963 that the first measles vaccine was licensed in the United States, an attenuated vaccine produced by John Enders and his colleagues. A more attenuated measles vaccine, known as the Moraten strain (*Mor*e *At*tenuated *En*ders) was licensed in 1968. This vaccine has remained the only measles vaccine used in the United States since its original licensure (Philadelphia). In 1971, the measles vaccine was combined with vaccines for mumps and rubella, forming the widely used MMR vaccine (Philadelphia). Today's measles vaccine is safe, heat-stable, effective and inexpensive (WHO, 2012).

Measles has no cure other than palliative treatment, thus immunization is the best defense against the disease. Measles immunizations given to children at 9 months of life have a lower rate of seroconversion (85%) than those given after 12 months (95%), as maternal antibody may interfere with the body's immune response in younger children. However, this earlier dose is recommended in measles endemic areas given the severity of measles infection in infants (W. A. Orenstein et al., 2000).

Community-wide transmission of measles can only be achieved when 93-95% of the population is immune to the virus (Morris et al., 2013). Given that only 84% of very young children seroconvert upon first vaccination, single administration strategies are insufficient for achieving threshold immunity levels (Ferrari, Grenfell, & Strebel, 2013). Even if the vaccine were first given after the age of 12 months, when 95% of individuals achieve immunity after a single dose, threshold immunity could only be reached in the event of the nearly impossible level of 100% coverage. Accordingly, analysis of 144 country data shows no empirical support for a threshold one-dose vaccination coverage level at which measles transmission is likely to be eliminated (Ferrari et al., 2013).

To counter the inadequacy of the one-dose immunization schedule, the WHO recommends that a second dose of a measles-containing vaccine (MCV2) be given between 15-18 months of age, in order to protect those who did not develop immunity from their initial vaccination. This has the added benefit of reaching children that may have missed the first dose (Morris et al., 2013). Secondary measles vaccinations are given at the age of 12 months or older, when 95% of recipients will achieve immunity upon vaccination. To reach the threshold for herd immunity, coverage at both the first and the second opportunity must be 90% (W. A. Orenstein et al., 2000).

Prior to the introduction of a vaccine, measles caused more than two million deaths and between 15,000-60,000 cases of blindness each year (WHO, 2012). Widespread use of the MMR vaccine has led to a 74% reduction in measles cases worldwide, saving an estimated 10 million children since 2000 (CDC; Nations, 2013). Despite the great success in reducing worldwide measles incidence, progress has not been evenly distributed. In 2010, 47% of the world's estimated deaths occurred in India (WHO, 2012). India's children suffer greatly from the disease, with an

estimated 50,000-100,000 children dying annually from measles. This is equivalent to 3% of the country's childhood deaths (Welfare, 2013).

India has been slow in its fight against measles. The WHO estimates that measles deaths in India decreased by only 36% during 2000-2010, compared to the 78% decrease experienced by the remainder of the WHO South East Asia region(Morris et al., 2013). This incredible burden of disease can be attributed at least in part to an insufficient vaccination program. Prior to 2011, India administered only a single dose of the measles vaccine, and the country lacked any supplementary immunization activities(Burki, 2013). Children in rural areas are especially vulnerable to under-immunization. A disproportionate number of India's 9.4 million non-immunized children reside in rural villages, where it is estimated that a mere 39% of children aged 12-23 months have been fully immunized. This in contrast with the 57% of children claiming full vaccination status in urban areas (Patel & Nowalk, 2010).

Primary Health Centers are responsible for vaccinating the majority of children in rural areas. Physicians at these centers are instrumental in administering the routine immunizations required for the eradication of measles.

2.2 Why should measles be eradicated?

Disease eradication is an incredible feat requiring the intentional removal of an infectious agent from the earth. Human disease eradication has been achieved only once, with global efforts to eradicate smallpox realizing success in 1979(Henderson, 2011). It is hoped that poliomyelitis and guinea worm will soon become the second and third human diseases to be eradicated.

In 2010, the WHO commissioned a global technical consultation to explore the feasibility of global measles eradication. This panel concluded that "measles can and should be eradicated," a declaration endorsed by the WHO Strategic Advisory Group of Experts on Immunization (Goodson et al., 2012). The review included the "biological, technical, socio-political and operational feasibility of measles eradication, the cost-effectiveness of eradication, the adequacy of the global vaccine supply," and the impact that the initiative might have upon immunization services and health systems (WHO, 2012).

Sufficient conditions must exist In order for a disease to be considered eligible for eradication. In 1997, world health experts convened in Berlin, Germany at the 81st Dahlem Workshop on the Eradication of Infectious Diseases to establish the criteria necessary for eradication to be possible. Three necessary conditions for disease were set forth for the consideration of eradication.

1) Humans are the sole pathogen reservoir

2) Accurate diagnostic tests exist that can detect levels of infection that can lead to transmission

3) An effective, practical intervention is available at reasonable cost (Dowdle, 1999; Moss & Strebel, 2011)

It has since been suggested that a fourth criteria be included, requiring evidence that eradication is possible through the achievement of sustained elimination in a large geographical region (W. A. Orenstein et al., 2000).

The WHO commissioned committee upheld that measles met the Dahlem criteria in the following ways:

1. Humans are the sole pathogen reservoir

Measles has no non-human reservoir. The virus is sustained through continuous human-to-human transmission, with no known animal or environmental reservoirs. Though measles has demonstrated the ability to infect nonhuman primates, these exposures have primarily occurred in laboratory settings intended for further study of the virus. Evidence of prior measles infection in free-ranging, nonhuman primates has been found on occasion, but transmission in these cases is generally thought to originate in infected humans. Regardless, nonhuman primates do not organize in such a way as to allow for the population to reach a size critical for the continued transmission of measles, and thus it can be comfortably claimed that humans are the only reservoir for measles(Moss & Strebel, 2011). Furthermore, the acute nature of the measles virus, with infectivity usually lasting little more than a week, is estimated to require a threshold population of several hundred thousand susceptible individuals to sustain transmission, making elimination and eventually eradication a feasible target (W. A. Orenstein et al., 2000).

2. Accurate diagnostic tests exist that can detect levels of infection that can lead to transmission

Measles can be identified using a variety of methods. Clinical diagnoses can be made fairly reliably, with the identification of measles' signature Koplik spots differentiating measles from other rash and fever causing illnesses. Koplik spots have the advantage of appearing in the early stages of infection, and can be detected in 50-70% of measles cases(Steichen & Dautheville, 2009). Clinicians in areas with very low measles incidence may struggle to identify cases due to their unfamiliarity with the disease (Moss & Strebel, 2011).

Serologic testing is the most common form of laboratory diagnostics. Infected individuals produce measles virus-specific immunoglobulin M (IgM) and immunoglobulin G (IgG) antibodies, which can be detected using a single sample of serum or oral fluid. The CDC has developed a capture enzyme-linked immunosorbent assay (ELISA) for IgM on serum that has specificity and sensitivity of at least 95. Kits with similar accuracy and a more accessible ease of use are available commercially (W. A. Orenstein et al., 2000).

Measles can also be confirmed through the isolation of the virus in cell and tissue cultures, and can be further identified using reverse transcriptase-PCR (RT-PCR) amplification of RNA extracted from clinical specimens. However, RNA detection in convalescing individuals can complicate attempts at identifying only acute infections (Moss & Strebel, 2011).

Overall, diagnostic tools used for detecting measles are considered reliable and unlikely to miss outbreaks or the presence of sustained transmission (Moss & Strebel, 2011).

3. *An effective, practical intervention is available at reasonable cost*

Existing vaccines are capable of nearly extinguishing a person's risk of measles infection, particularly when that individual is surrounded by others who have also been vaccinated against measles. Approximately 85% of children will develop protective antibodies when given 1 dose of measles vaccine at 9 months of age, and 90-95% of children respond when vaccinated at the age of 12 months. This improvement is due to the loss of maternal antibodies, which inhibit immunological response in the younger children. An estimated 99% of individuals with two

doses (who have received the first dose no earlier than 1 year of age) will develop serologic evidence of immunity. It is believed that the vaccine confers lifelong immunity(CDC, 2012b).

4. Evidence of interrupted transmission for a prolonged period in a large geographic area

Researchers have proposed a fourth criterion for eradication that demands evidence of ”interrupted transmission for a prolonged period in a large geographic area” to verify the feasibility of eradication (W. A. Orenstein et al., 2000). Elimination, or the prolonged interruption of transmission within a region, has long been established for measles, beginning with the United States.

America’s elimination strategy was launched after an increase in measles cases from 1989-1991. This strategy centered on increasing preschool immunization levels and providing every school child with a second dose of the vaccine. Successful, the United States has had an incidence of less than 1 case per million since 1997. The majority of cases that are present have been imported internationally or have been linked to imported cases (W. A. Orenstein et al., 2000). By March 2000, a panel of experts convened by the CDC to review the pattern of measles transmission in the United States concluded that measles was no longer endemic to the country. In other words, measles had successfully been “eliminated” in America (W. A. Orenstein et al., 2000).

Aiding the United States’ goal of eliminating measles within its borders were supporting efforts occurring on a regional scale. In 1990, the Pan American Health Organization (PAHO) set forth a goal of measles elimination in the Americas by the end of 2000 (W. A. Orenstein et al., 2000).

The Western hemisphere reported 250,000 cases of measles in that year, with 300 of those cases incidents of measles importation into the United States. Of these imported cases, 242 cases originated in Latin America (W. A. Orenstein et al., 2000).

PAHO established three stages in the plan to eliminate measles: catch up, keep up, and follow up. The "catch up" strategy heralded a one-time mass vaccination campaign aiming to vaccine all children 9 months through 14 years of age, regardless of prior disease or immunization status. The "keep up" strategy called for high and sustained levels of routine immunization coverage in each successive birth cohort. Finally, the "follow up" strategy conducted mass campaigns every 3-5 year, targeting all children regardless of vaccination status that had been born since the previous campaign(W. A. Orenstein et al., 2000). Both the catch-up and the follow-up campaigns served as opportunities for secondary measles vaccination for those already having received the first dose (W. A. Orenstein et al., 2000). Some countries chose to increase the vaccination age to 12 months after the initial catch-up campaigns to boost vaccine effectiveness (W. A. Orenstein et al., 2000).

The PAHO strategy proved remarkably successful, resulting in a 99% decrease in measles from the 250,000 cases reported in 1990 to 3018 detected cases in 1999 (W. A. Orenstein et al., 2000). By 2002, the Western Hemisphere was declared free of measles. Transmission to the United States from Latin America declined to zero by 1996, signifying the mutual benefits of inter-state cooperation in elimination efforts (W. A. Orenstein et al., 2000). It is estimated that the elimination of measles in the WHO Americas region will result in net savings of over $282

million by 2020 (US $2011). (WHO, 2012) This is despite the high costs incurred by outbreaks of imported measles, a cost that would be eliminated upon eradication.

Despite the excellent immunity conferred to individuals by the measles vaccine, the high infectivity of the virus necessitates coverage levels of 93-95% in order to fully eliminate transmission of infection (Morris et al., 2013; Moss, 2009). These high coverage levels require very high levels of control, and thus global eradication is optimal as eradication theoretically eliminates the need for continued measures of control. Though this necessitates an intense and concentrated expenditure of resources in the short-term, the removal of future costs makes eradication an economically attractive goal (Barrett & Hoel, 2007).

Thus far, smallpox is the only human disease to have ever been fully eradicated. The economic benefit from eradicating this lone disease is estimated to have an annual global benefit of $1.35 billion (using 1967 as a base year). The total cost of eradicating smallpox is estimated to have cost around $300 million, resulting in a benefit-cost ratio of 150:1 for smallpox eradication. The incremental cost of eliminating smallpox from the last remaining countries was an estimated $100 million, giving an even higher cost-benefit ratio of 450:1 (Barrett & Hoel, 2007).

Estimates of the savings from measles eradications vary. Early estimates by Miller *et al* (1998) indicate a net benefit to the US between $500 million and $4 billion (1997 dollars). Carabin and Edmunds (2003) predict savings between $10 million and $623 million in a selection of rich countries (Canada, Denmark, Finland, the Netherlands, Spain, Sweden, and the United Kingdom), lowering previous savings estimates due to the assumption that vaccination would

need to continue at least on some level to counter threats of terrorism(Barrett & Hoel, 2007). Consensus exists, however, that eradicating measles would earn the world a net economic gain (Keegan, Dabbagh, Strebel, & Cochi, 2011; Kennedy, Brown, & Gust, 2005).

Further considerations for eradication

Though eradication has been attempted many times, smallpox and rinderpest are the only two diseases for which eradication has been achieved. Both successes relied heavily upon vaccination, as do current efforts to eradicate polio and the proposed initiative to eradicate measles. Despite the existence of a safe, effective, and cost-effective vaccine for measles, the world continues to see untenable levels of measles death and disease.

Eradication initiatives must consider the socio-political context of a disease in addition to the criteria determined at the Dahlem Workshop. If measles eradication is to be pursued, it must be of global public health importance and be deemed worthy by all levels of society. Universal motivation, unwavering dedication, and perseverance are imperative in performance and funding. Insufficient commitment may result in a loss of credibility and failure in reaching eradication (Dowdle, 1999).

High coverage levels can become hard to sustain once the disease has disappeared from the public's conscious. In this way, highly effective control measures can be viewed as victims of their own success. This can be seen in the recent resurgences of measles in areas previously measles-free. England and Wales reported 2,016 confirmed cases in 2012, the highest annual total since 1994 (Salmon et al., 2004). The United States recorded three times as many measles

cases in 2013 as in previous years (CDC, 2013). Disease eradication efforts may find it necessary to move swiftly in order to avoid fatigue and an increasing emergence of vaccine refusal (Omer, Orenstein, & Koplan, 2013). Failure to achieve eradication risks loss of financial resources and public support, and endangers motivation for future campaigns. Accordingly, it is essential that future disease eradication campaigns be examined exhaustively prior to their declaration.

In addition to declaring measles' eligibility for eradication, the WHO committee also concluded that 1) eradication by 2020 is feasible if measurable progress is made towards the 2015 measles mortality reduction targets already in existence, 2) eradication activities should center around the strengthening of routine immunization services, and 3)measles eradication activities should also promote the control and elimination of rubella and congenital rubella syndrome (CRS)(Goodson et al., 2012). In light of the committee's recommendations, the 63rd World Health Assembly recommended that the global community pursue the global eradication of measles, pending measurable progress in reaching the 2015 global measles targets and regional measles elimination goals (WHO, 2012).

2.3 Global efforts towards eradication

Though eradication goals have only recently been proposed, global efforts to combat measles have been in place for decades. The global community first set goals for reduction in measles morbidity and mortality at the World Health Assembly in 1989 and the World Summit for Children in 1990, operating under the "Plan of Action for Global Measles Control" in the 1990s (WHO, 2001). By the year 2000, the WHO estimated that measles still caused the deaths of 535,000 children under the age of five, accounting for 5% of all under-five mortality. The

majority of these cases were in developing countries (WHO, 2012). Thus the Measles and Rubella Initiative was launched in 2001, with the intention of dramatically reducing measles through mass vaccination campaigns and the introduction of a second measles vaccination opportunity for children worldwide. Its initial goal was to reduce by half the number of measles death worldwide, from 1999 to 2005 (WHO, 2001).

The Measles and Rubella Initiative is endorsed by its five spearheading partners: the American Red Cross, United States Centers for Disease Control and Prevention, United Nations Foundation, and World Health Organization. The initiative also receives heavy support from GAVI Alliance (formerly the Global Alliance for Vaccines and Immunization) (WHO, 2012). The Measles and Rubella Initiative has seen tremendous success. Measles incidence decreased 58%, from 146 to 52 cases per 1 million population during the first decade of the century, with estimated deaths decreasing 71%, from 542,000 to 158,000 during that same time (CDC, 2012a).This contributed to a 23% decline in global deaths for children-under –five between 1990-2008, thus making measles elimination efforts a substantial contributor to the fourth Millennium Development Goal (WHO, 2012). First dose vaccine coverage increased from 72% to 84% of children worldwide from 2001-2011. The provision of a second dose as part of routine immunization strategy increased from 97 countries in 2000 to 141 in 2011. More than 1 billion children were vaccinated in mass vaccination campaigns during this time, with about 225 million immunized in 2011 (Centre, 2013).

Though an admirable goal, the eradication of measles is still far from being a reality. WHO measles surveillance data from 2002-2010 found that only 11 of the 144 reviewed countries

reported going one month or more without any detected case of measles (Ferrari et al., 2013). Furthermore, by 2011 the global disparity in measles burden had become abundantly clear. Only eight countries, including India, accounted for 60% of global measles incidence (Centre, 2013; WHO, 2012). Outbreaks in these countries threaten regional elimination efforts, and indicate the renewed need to strengthen health systems in these countries. Despite global progress, an estimated 20 million children did not receive their first dose of measles vaccine in 2011 (Centre, 2013). Approximately 6.7 million of these unvaccinated children resided in India, where 29,339 cases of measles were reported this same year (Centre, 2013). At this point, India remained accountable for nearly half of the world's measles deaths (WHO, 2012).

In 2012, the global community once again declared their commitment to fighting measles in the Measles and Rubella Strategic Plan 2012-2020. The MR Initiative states, "Strategic planning, coordination and cooperation at every level are essential to achieve a world without measles, rubella and congenital rubella syndrome. We must work together" (WHO, 2012, p. 13). All 194 WHO Member states renewed their 2010 commitment to reducing measles deaths by 95% compared to pre-immunization levels by 2015, endorsing an accelerated measles control strategy which aimed for vaccine coverage of $\geq$90% for first dose MCV and $\geq$80% vaccine coverage for every district (Ferrari et al., 2013; WHO, 2012).

The 2012-2020 Strategic Plan for global measles and rubella focuses on the implementation of five core components.

1. Achieve and maintain high levels of population immunity by providing high vaccination coverage with two doses of measles- and rubella-containing vaccines.

2. Monitor disease using effective surveillance, and evaluate programmatic efforts to ensure progress.

3. Develop and maintain outbreak preparedness, respond rapidly to outbreaks and manage cases.

4. Communicate and engage to build public confidence and demand for immunization.

5. Perform the research and development needed to support cost-effective operations and improve vaccination and diagnostic tools (WHO, 2012).

Each of the Strategic Plan's core components requires the cooperation and commitment of physicians. As will be explored later, physicians play a powerful role in building public confidence and maintaining a demand for immunization. They are fundamental in performing disease surveillance, responding to outbreaks, and providing the feedback necessary for improving vaccination and diagnostic tools. Furthermore, the role of physicians as trusted community leaders gives them tremendous influence in forming political will. Given the high expense and demands for commitment necessary in an eradication campaign, physicians must use their social and political capital to push for ever-strengthening efforts to combat measles. Already, dramatic reductions in funding threaten to jeopardize the MR Initiative's success. In 2011, the MR Initiative received only $80 million in funding, in stark contrast to the $160 million it received as the Measles Initiative in 2007 and a symbol of the $171 million shortfall it expects for the next three years (Burki, 2013). While the MR Initiative offers technical and financial support, individual countries still bear primary responsibility for protecting their citizens from the burden of measles (WHO, 2012). Thus a strong motivation to eradicate measles must be present within all countries.

2.4 Challenges to measles eradication

The infectious nature of measles presents a formidable challenge for interrupting its transmission. Coverage levels of 93-95% are estimated to be the necessary threshold for eliminating transmission of measles (Morris et al., 2013; Moss, 2009). Reaching coverage levels of this magnitude can be very difficult, particularly in areas of high mobility, crowding, or in populations with poor access to or distrust of healthcare. Poor infrastructure can also amplify the challenges of effective vaccination campaigns, as areas which struggle with accounting for their population through birth and death records simultaneously face difficulty in establishing reliable coverage estimates (Walter A. Orenstein & Gay, 2004). Additionally, the high cost of coverage is amplified by the need to administer multiple vaccinations to reach threshold immunity, straining resource poor communities (Barrett & Hoel, 2007).

Failure to achieve the necessary immunization coverage can result in outbreaks propelled by "pockets" of non-immunized children and delayed immunizations (Patel & Nowalk, 2010). Studies suggest that outbreaks in rural communities could be prevented through targeted outreach efforts led by community health workers and active identification of non-immunized children, even in communities that have coverage rates below the threshold for herd immunity (Patel & Nowalk, 2010). The WHO and UNICEF report that India's low MCV1 coverage in high burden districts and inconsistent implementation of MCV2 are major challenges for interrupting transmission through herd immunity (Morris et al., 2013).

Eradication efforts require intense financial capital. Smallpox required an extra $300 million in the push to eradicate the disease from the last endemic countries. While successful eradication is

economically advantageous, failure to fully eradicate a disease could be financially disastrous. Measles eradication efforts are thought to cost $5-8 billion, a significant sum of money to expend given failure to complete eradication(Keegan et al., 2011). Complacency following a resource-intensive acceleration of measles elimination efforts could result in a resurgence of measles cases and jeopardize eradication.

The global economic recession has resulted in drastic reductions in funding, which threaten to limit SIAs, increasing pockets of susceptibility and threatening an increased emergence of measles outbreaks. Global commitment must be present in both word and wallet, with world leaders needing to lead the way to measles eradication by providing political and financial support to revitalize immunization systems (W. A. Orenstein et al., 2000). Increased support must be put towards strengthening immunization systems, as routine immunization is a critical component of eradication. National and international agencies must commit to providing the support necessary for comprehensive routine immunization to be achieved and maintained (W. A. Orenstein et al., 2000).

Another very real challenge to measles eradication is resource competition, including ongoing efforts to eradicate polio and the introduction of new vaccines (WHO, 2012). To reduce this barrier, it may be beneficial to link measles elimination efforts with the final stages of polio eradication. Measles elimination strategies mimic those utilized in the quest to eradicate polio. In both cases, strong routine immunization systems are critical to ensure high levels of vaccine coverage. Complementary Supplementary Immunization Activities (SIAs) are necessary to increase population immunity by covering a wide range of ages and locations, and tight

surveillance is key for monitoring outbreaks and directing resources. The bundling of other services with measles vaccine should also be explored (WHO, 2012).

Perhaps one of the most important challenges to measles eradication is lack of political will. Global eradication requires incredible cooperation and commitment from all the world's states. It is especially important that industrial countries fully endorse and prioritize global eradication efforts, as they are needed to provide and support a substantial portion of the resources required for eradication activities (W. A. Orenstein et al., 2000). Unfortunately, eradicating measles may provide little economic benefit to developed countries, which often incorporate measles vaccine into the MMR vaccine and will thus see little savings from stopping measles vaccination. Recent threats of bio-terrorism may reduce this benefit even further, necessitating countries to continue manufacturing and perhaps even administering measles vaccine as a cautionary measure (Barrett & Hoel, 2007). In many of the world's wealthiest countries, measles is currently not seen as a priority for even their own populations. Vaccine coverage rates are well below the threshold level in many industrial nations, particularly those in Europe. If the eradication of measles is to succeed, it is necessary that these countries commit to eliminating the reservoirs of measles virus in their own populations (W. A. Orenstein et al., 2000).

Unsurprisingly, political will is highest in areas that sustain high levels of measles morbidity and mortality. Governments in sub Saharan Africa and South Asia have shown strong commitment to the acceleration of measles control and elimination efforts in their populations (W. A. Orenstein et al., 2000). Challenges facing these countries lie less with will and more in technical challenges, including limited resource, poor health infrastructure, and emergency settings.

Conflict and natural disasters often increase crowding and limit public access to health care, providing opportunity for infectious disease to re-emerge and increasing the difficulties of maintaining routine immunization for the disaster-affected populace. Strong immunization and disease surveillance programs in these situations are critical in maintaining progress towards measles eradication.

Logistics that threaten the success of a measles eradication program include urbanization, air travel, vaccine refusal, and poor infrastructure. The global trend towards urbanization increases the difficulties of eradicating measles. The dense populations found in urban centers provide ideal conditions for measles transmission, challenging the success of even strong immunization policies and programs. High birth rates and an influx of immigrants can allow for the swift accumulation of susceptible individuals (W. A. Orenstein et al., 2000). High population densities increase the likelihood that the virus will encounter a susceptible individual, necessitating very high levels of vaccine coverage to prevent transmission. Though vaccination rates are typically reported higher in urban areas than in rural areas, collecting accurate surveillance data may be challenging in urban areas due to the high mobility of immigrants and travelers (Alan Hinman, 2014).

Air travel makes it possible for a case of measles to travel the world, and threatens imported outbreaks even in areas that have eliminated endemic transmission. Imported measles requires tremendous resources: the 16 imported outbreaks seen in the US in 2011 are estimated to have cost up to $5 million and required investigation of 9,000-17,000 exposed contacts

(FluTrackers.com, 2013). Strong immunization and surveillance systems are needed to minimize the threat posed by the disease's spread via air travel.

Vaccine refusal, magnified by fear of vaccines and the perception that measles is no longer a threat, also serves as a barrier to measles eradication. Vocal pockets of resistance have increasingly emerged in countries throughout the world, forming communities of non or under-immunized people that are highly susceptible to outbreaks. A fraudulent paper that falsely linked the MMR vaccine to autism in 1998 caused a steep drop in vaccination, and continues to fuel anti-vaccine sentiment. Some marginalized populations have objected to the polio vaccination campaign, citing concerns that vaccinations harbor harmful agents and displaying fear that vaccination campaigns are covers for the persecution of Muslims (Grabenstein, 2013). Furthermore, the effectiveness of immunization programs threatens their continued success. It has been well established that vaccine acceptance is influenced by rates of vaccine-preventable diseases (Omer et al., 2013). When low disease incidence decreases vaccination, it endangers the safety created by vaccine-induced herd immunity. This is particularly true with diseases like measles that have a high herd immunity threshold, and which are therefore more vulnerable to outbreaks initiated by non-vaccinated individuals. Vaccine refusal therefore poses a very real threat to measles eradication.

Poor infrastructure can hinder the effectiveness of a vaccination campaign. It is difficult to identify the susceptibility profile of the population in areas that struggle to account for their population through birth and death records, as coverage estimates rely on reliable population data

(Walter A. Orenstein & Gay, 2004). Substandard infrastructure can also pose problems in maintaining a cold chain, and reaching remote populations that may have little access to health care.

Finally, conflict, natural disasters, and other humanitarian emergencies can jeopardize eradication by disrupting routine immunization and increasing crowding. Lessons can be learned from the polio eradication initiative, which has made the importance of continued immunization efforts abundantly clear. In cases of conflict, it has shown essential to negotiate days of peace for vaccine administration. In a time of high mobility, hosting synchronized cross-border SIAs has also proven to be critical for continued progress (WHO, 2012).

2.5 WHO regional goals and progress

In testament to the global cooperation needed for eradication, all six WHO regions have committed to eliminating measles. The Americas have already achieved this goal, having remained free of endemic transmission since 2002. Four of the five remaining regions have set target dates for elimination, and the South East Asia region is considering but has not yet confirmed a target of elimination by 2020 (WHO, 2012).

The WHO western Pacific region has made significant progress towards eliminating measles, despite not achieving elimination by their target date of 2012. Reported cases fell by 93% from 2008-2012, largely attributable to China's remarkable 96% reduction in measles cases during that time. Endemic transmission has now been isolated to four of the region's 37 territories. The establishment of a regional verification commission, individual country reviews, and vast

national immunization campaigns are propelling the western Pacific towards being the second WHO region to be declared free of measles (Burki, 2013).

The African region is attempting to eliminate measles by 2020, though the region faces significant challenges. Poor surveillance, conflict, and a dire lack of resources may constrain their ability to disrupt transmission at the population level.

Europe has declared it will eliminate measles by 2015. The reluctance of its population to vaccinate will make achieving herd immunity the most significant hurdle for the region.

WHO eastern Mediterranean region is also targeting 2015 as the year it will become free of measles. Ongoing conflicts and a scarcity of resources will present the biggest challenges to achieving this goal.

WHO Americas has sustained regional elimination of measles since 2002. The region credits its success to strengthened routine immunization systems and extensive catch-up campaigns across a variety of cohorts.

WHO South East Asia remains the furthest from reaching elimination, and is the only region to have not yet confirmed a date for regional elimination. The high incidence of disease in this region is in large part due to the high burden of measles cases in India. The WHO estimates that measles deaths decreased by only 36% in India during 2000-2010, compared to the 78% decrease experienced by the remainder of the WHO South East Asia region (Morris et al., 2013).

2.6 WHO South East Asia and India – Why is it so far behind?

India is currently the world's second largest country, home to approximately 1.21 billion people (Factbook, 2013). Recognized by the WHO as one of the largest immunization systems in the world, the Universal Immunization Program (UIP) is burdened by the economic constraints inherent in providing healthcare to an enormous number of individuals in what is still largely an impoverished population (Patel & Nowalk, 2010). Unsurprisingly, India's ability to stop the transmission of measles within its borders will play a critical role in a global eradication campaign. However, the country's high burden of disease and historically low vaccine coverage rates pose a challenge to measles elimination.

India accounted for 47% of the world's measles' deaths in 2010 (Simons et al., 2012; WHO, 2012). This incredible burden of disease can be attributed at least in part to an insufficient vaccination program. Prior to 2011, India administered only a single dose of the measles vaccine, and the country lacked any supplementary immunization activities. Measles case-based surveillance had not been established nationwide, resulting in a gross underreporting of morbidity and mortality, and the epidemiology of measles in India needed further documentation (Goodson et al., 2012).

This was amended in 2011, when India significantly strengthened its routine immunization system and recommended nationwide administration of a two dose measles vaccination schedule, in alignment with the Measles and Rubella initiative recommendations: The 1st dose between 9-12 months of age and 2nd dose between 16-24 months. India also implemented massive SIAs. The 14 states with the weakest immunization programs initiated massive catch-up campaigns aimed at vaccinating 134 million children, with 2nd doses introduced after 6 months of the campaign (Burki, 2013; Welfare, 2013).

Still, in 2011 6.7 million children in India did not receive their first dose of measles vaccine. This same year, 29,339 cases of measles were reported (Centre, 2013). The poor access to healthcare afforded to the rural communities of India has led to a disproportionate number of India's 9.4 million non-immunized children residing in rural villages. It is estimated that only 39% of children aged 12-23 months have been fully immunized in rural settings, in contrast with the 57% of children claiming full vaccination status in urban areas(Patel & Nowalk, 2010). Though 70% of the population resides in a rural setting, rural health systems are weak(Morris et al., 2013). In a country where the doctor density is already alarmingly low (6 doctors for every 1000 individuals), the rural doctor to population ratio is lower by six times. Levels of coverage also deviate at local levels according to the income of the family, and education of the mother (John, 2012). Accordingly, the majority of measles cases happened in the states with low immunization rates, as vaccine coverage ranges widely throughout the 28 states and 7 unions of India. The poor access to healthcare goes beyond low vaccine coverage: 66% of the rural population lacks access to critical medicine, and 31% of the rural population must travel over 30 km for medical treatment (Conclave, 2010).

Uttar Pradesh and Bihar are two of India's most impoverished states, and as such have experienced difficulty achieving adequate significant levels of vaccine coverage. The DLHS-3 survey found measles immunization coverage to be 54% in Bihar, and 47% in Uttar Pradesh, beneath the national coverage rate of 68% (Morris et al., 2013). While this is a significant improvement from the 2002-2004 DLHS-2 study, which reported coverage of 27% and 35% respectively, it remains well beneath what is needed for the protective effects of herd immunity (Morris et al., 2013). Given that vaccine efficacy is only 85% when given at 9 months of age, approximately 46% (31% un-immunized plus 15% failing to seroconvert) of children in each

birth cohort remain susceptible to measles (Welfare, 2013). It is these numbers that make the second dose such an important part of measles control.

The inadequate vaccine coverage has had a profound impact on India's children. A 2005 study shows that measles remains a prominent cause of death in these states for children under 5, accounting for 10.6 deaths in Bihar and 35.3 deaths in Uttar Pradesh per every 1000 live births (Morris et al., 2013). Uttar Pradesh has both the greatest number of measles deaths (35,000)and the highest measles mortality rate (6.1 per 1000 live births), placing it, as well as Bihar and two other states into the Empowered Action Group and Assam (EAGA) cluster of states with poor development indicators (Morris et al., 2013). This group has since been slated to receive additional SIAs to counter the historically low coverage (Welfare, 2013).

The disparity in health access and outcomes has not gone unnoticed. A talk given by Dr. DB Shirole Oration Nashik during the 2011 Annual Conference of Maharashtra Chapter of Indian Academy of Pediatrics harshly criticized the inequality of India's health care system. He cited the drastic regional differences in childhood immunization coverage as evidence of "gross systematic deficiencies" and "political determinants of health that can only be corrected by political agenda and action"(John, 2012). Nashik blamed the vertical model of healthcare delivery, in which the central government sponsors, funds, and manages interventions to be subsequently implemented by the state governments, for the inefficient delivery of health services. Instead, he suggests the creation of an Indian Academy of Pediatrics (IAP) think-tank to assess India's current health management system and vigorously promote public health initiatives, including surveillance of current immunization efforts (John, 2012).

Though problems may remain, India's progress in the last several decades is notable. Until the 1985 expansion of India's immunization program into what is now known as the Universal Immunization Programme (UIP), only an estimated 10% of India's children attained full immunization status. The inception of the UIP extended routine immunization services nationwide, creating a government-financed system for vaccine delivery enabled by indigenous vaccine production and an impressive expansion of the refrigeration system needed to maintain the cold chain (Patel & Nowalk, 2010). Despite efforts, a 2004 review of India's UIP by national and international experts found that the "…basic infrastructure is in place. But, the system is largely failing to deliver (noting poorly performing states were reviewed)" (Patel & Nowalk, 2010, p. 605). Significant obstacles in states with poor levels of coverage included insufficient quantity and quality in the cold chain equipment necessary to maintain vaccine viability, poor coordination and support between the various levels of healthcare, failure to analyze reported data, and inadequate resources. Other challenges faced by the Indian health system include poor morale among healthcare workers burdened by poor working conditions and irregular pay, under-utilization of health care services (particularly among vulnerable populations), and a shortage of high level medical professionals, These problems are particularly severe in rural areas (Patel & Nowalk, 2010).

Today, the Ministry of Health and Social Welfare(MoHSW) attributes areas of low routine immunization coverage to the presence of hard to reach areas, high risk areas, and the persistence of sub-centres with absent or no health workers(Welfare, 2013). India's current health system attempts to provide universal access to healthcare through the placement of community-level

structures on each block known as the Primary Health Center (PHC). Each PHC is responsible for serving a population of 30,000, and overseeing the vaccine operations in several health sub-centers (SCs), which are expected to provide services for 3000-5000 people.

2.7 PHC provider role

Primary Health Center (PHC) physicians are a pillar in these rural communities, providing health care for patients of whom many come from the lower socio-economic strata of society. PHC physicians are responsible for delivering the majority of vaccines to children, and thus they play a critical role in eliminating measles transmission. Routine immunization is a cornerstone to measles eradication, and PHC physician are responsible for ensuring that the children in their communities are properly vaccinated. Missed opportunities, lack of tracking, reminder, or recall systems, and neglecting to adhere to vaccine administration standards are common, physician-led factors in the under-immunization of children (Santoli, Szilagyi, & Rodewald, 1998). Commitment to overcoming these barriers is a foundational piece of measles eradication. Furthermore, providers have been shown to be highly influential in a parent's decision to vaccinate (Gargano et al., 2012). PHC physicians also play an essential role in ensuring that India's surveillance system is strong, providing the necessary data for the tracking of measles throughout the country.

Barriers to immunization in India include a lack of information about immunization and immunization services, parental time constraints, and beliefs that vaccines are not effective (Jain et al., 2006; Kumar, Aggarwal, & Gomber, 2010). In UP and Bihar, both pediatricians and PHC

physicians reported that the greatest barrier to vaccinating children with routine immunizations is a parental lack of awareness of their importance (Gargano et al., 2012). It is essential, then, that PHC physicians use their position as a leader and trusted voice of medical authority to promote immunization and increase parental understanding and acceptance of vaccination.

Manuscript

Attitudes and Perceptions of India's Primary Health Center Physicians Regarding Measles Eradication

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Abstract

Objectives: The objectives of this study were to investigate and compare attitudes and perceptions of primary health center (PHC) physicians in Uttar Pradesh and Bihar towards measles disease, immunization, and eradication.

Methods: A subset of secondary data was analyzed from a survey assessing PHC physician attitudes towards polio eradication, measles eradication, and general immunization. The survey instrument was given in-person to PHC physicians from blocks with at least one confirmed polio case during January 2006 to June 2009.

Results: The majority of PHC physicians support statements that measles eradication is important (93.45%) and likely (90.53%). PHC physicians who reported that unvaccinated children were likely to become severely ill if infected with measles were 2.2 times more likely to state that measles eradication is important. PHC physicians with high perceived MMR vaccine efficacy were 3.39 times more likely to state that measles eradication is important.

Conclusion: PHC physicians play a critical role in shaping the battle against measles in India. Their high levels of support for measles eradication can be used to leverage political willpower in achieving measles eradication. Barriers to support must be addressed in order to maximize eradication's success.

Highlights

- We examine attitudes of PHC physicians towards measles eradication
- The majority of PHC physicians believe measles eradication is important and likely.
- Perceptions of vaccine efficacy and safety impact measles eradication beliefs.
- Perceptions of measles severity impact the belief that eradication is important

Keywords

Measles vaccine, Measles eradication, India, Physicians

Ethics

IRB approval was deemed unnecessary as it was determined that the study did not meet the definition of "Human Subjects Research," instead classified as "Quality Improvement" by both

the Emory University's Institutional Review Board and Maulana Azad Medical College Institutional Ethics Committee. The researchers have no financial obligations to disclose.

1. Introduction

Measles has plagued the world for most of human history. Prior to the introduction of a vaccine, measles infected over 90% of the population before their 15th birthday and resulted in an estimated annual death toll of 2.6 million people (WHO). Despite the availability of a safe, effective, and affordable vaccine, measles continues to cause the death of approximately 158,000 each year (WHO). Almost half of these deaths occur in India.

Home to just under one fifth of the global population, almost half of measles deaths annually occur in India (WHO, 2012). An estimated 50,000-100,000 children die annually from measles, with complications from measles responsible for 3% of deaths of childhood deaths (Welfare, 2013). The majority of measles cases occur in only a select few states like Uttar Pradesh and Bihar, which face disproportionately high burdens of disease and sub-standard immunization coverage. The 2007-2008 District Level Household and Facility Survey (DLHS-3), India's largest ever demographic and health survey , found measles immunization coverage to be 54% in Bihar, and 47% in Uttar Pradesh, below the national coverage rate of 68% (Morris et al., 2013). Accordingly, Uttar Pradesh (UP) has the greatest number of deaths attributed to measles, losing an estimated 35,000 individuals annually to the disease, followed by 10,600 measles deaths in Bihar (Morris et al., 2013).

In 2010, the World Health Assembly declared that measles "can and should be eradicated." The successful elimination of measles transmission in India is critical for the success of global measles eradication. Strengthening routine immunization is a fundamental pillar of measles eradication. Primary Health Center (PHC)[1] physicians play a central part in this effort, as they provide healthcare to much of India's historically underserved population. They are particularly relied upon in rural areas, whose populations represent 70% of India's measles cases and for whom PHC physicians are responsible for delivering the majority of vaccines to children. These physicians are familiar with the nature of measles and play a critical role in routine immunization, a strategy central to measles eradication efforts.

Historically, PHC physicians have demonstrated their importance to eradication initiatives through their contributions to the smallpox and polio eradication campaigns (Thacker et al., 2012). In possession of both social and political capital, medical professionals are looked to by the leaders and politicians who shape policy and manage health systems for their input on public health initiatives. Their influence is particularly critical in disease eradication campaigns, which require immense political will.

Despite the importance of PHC physicians in the battle to eradicate measles, very little is known about the knowledge and attitudes of PHC physicians towards measles eradication efforts. This study will examine how the perceptions surrounding measles, vaccine safety, and vaccine effectiveness affect PHC physician's belief in the importance and likelihood of measles

[1]PHC: Primary Health Centre

eradication. Understanding how the knowledge and attitudes of PHC physicians towards measles and immunization affect perceptions of measles eradication efforts will provide the necessary foundation for eliminating barriers to measles eradication.

2. Methods

2.1 Data Access

The data was obtained from a survey instrument used to assess PHC physician knowledge, perceptions, and attitudes regarding polio eradication, measles eradication, and general immunization in Uttar Pradesh and Bihar. The initial survey was conducted by researchers representing Emory University and the Indian Academy of Pediatrics. The data pertaining to PHC physician perceptions and attitudes regarding measles vaccination and measles eradication was used for analysis as secondary data for this sub-study.

2.2 Study population

The study population sampled included Public Health Center (PHC) physicians from blocks with at least one confirmed case of polio from January 2006-June 2009. PHC physicians were chosen as they provide health care for patients in both rural and urban areas, working primarily with patients from the lower socio-economic strata of society. PHC physicians hold positions of respect and leadership within their community, thus their perceptions regarding measles eradication are instrumental for success with measles elimination in India. Additionally, PHC physicians are responsible for delivering the majority of vaccines to children, especially those in historically underserved populations.

2.3 Study design

The study was conducted as a cross-sectional analysis. Surveys were given by in-person researchers to 614 Public Health Center (PHC) physicians sampled randomly from UP and Bihar.

2.4 Sampling

PHC physicians were selected using blocks, or district sub-sections, as the primary sampling unit. Blocks typically contain one block primary health/community health center and cover a population of 100,000 or more. Blocks were selected in UP and Bihar based on the detection of at least one virologically confirmed case of polio between January 2006-2009. A total of 275 blocks in UP and 132 blocks in Bihar were selected from the 26 UP districts and 12 Bihar districts that met selection criteria. The sampling frame was developed by enumerating the PHCs from selected blocks and forming a list from which individuals could be randomly sampled. 614 PHCs were selected in UP with 159 PHCs selected in Bihar. The response rate for PHC physicians was 95% in UP (581/614) and 87% in Bihar (138/159). Overall, 93% of PHC physicians completed the survey (719/773).

The PHC physician present upon the arrival of the researcher was asked to participate in the in-person survey, giving verbal consent to avoid the need for individual identifier retention.

2.5 Survey

The survey was formulated using input from PHC physicians in the context of focus group discussions (FGDs). FGDs shaped the contents of the survey instrument and helped assess the possible utility of the data. A pilot test was run on PHC physicians in Delhi, using verbal consent to avoid the need for individual identifier retention.

The original survey provided a five point Likert scale – this was reduced to three after the pilot. The survey assessed knowledge, attitudes and practices associated with vaccines and measles eradication. The 30 minute survey consisted of 27 questions, asking respondents to answer based on three-point Likert scales ranging from 1-3. It was given in-person to the PHC physician present when the researcher arrived.

2.6 Outcome and Variable Definitions

The primary outcomes of this study are the following:

- PHC physicians' perception of the importance of measles eradication in India (e.g., How important is measles eradication?) ("important" to "not important")
- PHC physicians' perception of the likelihood of measles eradication in India (e.g., How likely is it that measles will be eradicated from India?) ("likely" to "not likely").

The outcomes will be assessed for association with the following attitudes, beliefs, and practices regarding immunization:

- *Perceived disease susceptibility* (e.g., How likely do you think a child in India under 5 years of age who has received no vaccine when due is to get the following diseases within the next year),

- *Perceived disease severity* (e.g., If a child under 1 year of age gets the following diseases, how likely is that child to be seriously ill?) ("likely" to "not likely"),
- *Perceived vaccine efficacy* (e.g., How protective do you think each of these vaccines is against disease?) ("protective" to "not very protective"),
- *Perceived vaccine safety* (e.g., How safe do you think these vaccines are?) ("safe" to "unsafe").

2.7 Analysis

The data for UP and Bihar were assessed both individually and as a collective data set. The information was assessed using only data indicating "likely" or "not likely," "important" or "not important," etc to create dichotomous variables. Descriptive analyses were conducted to calculate the distribution of variables assessing PHC physicians' knowledge, attitudes, and practices. Logistic regression analyses were performed to assess associations between PHC physicians perceptions of measles susceptibility, measles and MMR vaccine safety, and measles and MMR vaccine efficacy, using a p-value of <0.05 to indicate significance.

All analysis was performed using SAS 9.3 (The SAS Institute, Cary NC).

3. Results

3.1 Attitudes about measles disease, measles vaccine safety, and use

A majority of PHC physicians in both Uttar Pradesh (85.71%) and Bihar (82.98%) believe that measles is likely to cause disease in an unvaccinated child. A majority (77%) also believe that

measles is likely to make an unvaccinated child severely ill. It is generally believed that the vaccine is protective (84.76%) and safe (92%).

PHC physicians in Bihar report slightly lower beliefs in the safety and efficacy of the measles vaccine than their UP counterparts. They also appear less likely to believe that an unvaccinated child will become ill with measles, and that the illness will be severe (Table 1).

3.2 Perceptions regarding the likelihood and importance of measles eradication

The importance of eradicating measles in India received tremendous support from PHC physicians in UP (94%) and Bihar (89%). Slightly fewer PHC physicians in UP believed measles eradication in India to be likely (90%), while an equal number of PHC physicians in Bihar (89%) believed eradication in India to be important and to be likely (Table 2).

3.3 Associations for attitudes towards the likelihood and importance of measles eradication

PHC physicians who expressed high perceived disease severity in unvaccinated children were 2.29 times more likely (OR 2.29 95% CI 1.00, 5.25 p= 0.049) to believe that measles eradication is important. PHC physicians with high perceived MMR vaccine efficacy were 3.39 times more likely (OR 3.39 95% CI 1.38, 8.34 p=0.08) to state that measles eradication is important. Stating that measles vaccine is safe is associated with being 3.62 times more likely to state that measles eradication is likely (OR 3.62 95% 1.41, 9.27 p=0.0073) (Table 3).

Perceptions regarding disease susceptibility, disease severity in infants, measles vaccine efficacy, and the safety of the MMR vaccine did not appear to be significantly associated with beliefs in the importance and likelihood of measles eradication.

4. Discussion

PHC physicians in Bihar and Uttar Pradesh generally support the ideas that measles eradication is important and that measles eradication is likely. The widespread belief in the importance and likelihood of measles eradication reinforces claims about the feasibility and importance of an eradication campaign. Intensive public health initiatives like measles eradication require a strong push from those most intimate with the disease. PHC physicians are responsible for serving a majority of the population, are familiar with the nature of measles, and play a critical role in administering immunizations.

Concerns that unvaccinated children ages 1 to 5 will become seriously ill if infected with measles are also associated with a belief in the importance of measles eradication. This is an important concept. It seems likely that physicians who treat seriously ill children will be more concerned with eradicating the agent of disease. Consequently, it is important that measles eradication efforts be conducted in a serious and intensive manner. If eradication occurs too slowly, the risk of apathy among physicians rises as their exposure to the disease diminishes. The dangers of complacency can be seen in the rise of vaccine-preventable diseases occurring in parts of the developed world. Concerns surrounding vaccine safety have displaced fears of near-forgotten diseases in some pockets of the population, leaving these communities susceptible to disease and threatening the re-establishment of transmission. In order to avoid a similar situation, India must orchestrate a swift and powerful eradication campaign.

PHC physicians report a very high level of support for measles eradication, believing it to be both important and likely. PHC physicians should act upon their belief in the importance of eradication to influence policy makers in prioritizing measles elimination. The Indian government has shown commitment to fighting measles with the recent introduction of a second routine dose of measles vaccine and accelerated SIAs in under-immunized areas. India's polio eradication campaign was an initiative supported by nearly 100% of PHC physicians (Thacker et al., 2012),and its success should energize the Ministry of Health's dedication to eliminating disease.

PHC physicians must also champion measles eradication in their own communities. As community leaders, it is important that PHC physicians are vocal about their commitment to measles eradication. Providers have repeatedly been shown to be highly influential in a parent's decision to vaccinate, and should therefore capitalize on their leverage to insist on administering childhood vaccinations. In addition to counseling parents in favor of vaccination, providers should also take steps to avoid the common, physician-led gaps in vaccination delivery that lead to lower coverage levels. This includes missed opportunities, lack of tracking, reminder, and recall systems, and failure to adhere to the recommended vaccination schedule. By making the commitment to increase measles vaccination coverage in their communities, PHC physicians will be leading the way for measles eradication in India.

Eradication is a "global public good," requiring cooperation and coordination from all nations. If even one country refuses to participate in eradication efforts, success is threatened. Without total eradication, even countries that have successfully eliminated a disease face the constant threat of

its importation and subsequent re-establishment among the population. It is therefore critical that all states fully support eradication and are willing to put forth intensive efforts to sustain high levels of immunization coverage, even when the disease burden is very low. The expenses and difficulties associated with retaining high levels of control, particularly in instances with no or low disease, imbues global eradication initiatives with an elevated sense of importance. PHC physicians must put forth a strong argument for a powerful measles eradication campaign to protect the health of Indians and of those throughout the world.

4.1 Limitations

The surveys given to PHC physicians were delivered in-person, which could have resulted in desirability bias skewed towards supporting measles eradication. Additionally, the small sample size available for PHC physician responses in Bihar may have reduced the validity of the analyses.

5. Conclusion

PHC physicians play an essential role in eliminating the transmission of measles. Their high level of support for measles eradication is powerful, and can be used to inform a successful campaign. India has made notable progress in expanding immunization, and has demonstrated incredible strength in its ability to eliminate polio. Understanding how the knowledge and attitudes of PHC physicians towards measles disease and measles immunization affect their perceptions of eradication efforts provides the necessary foundation for eliminating barriers to measles eradication. PHC physicians play a critical role in shaping the battle against measles, and their support for measles eradication lays the groundwork for its success.

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Appendix

Table 1: PHC physicians' perceptions of measles morbidity, vaccine effectiveness, and vaccine safety

	Measles is likely in unvaccinated child N (%)	Measles is likely to make an unvaccinated child <1 year seriously ill N (%)	Measles is likely to make an unvaccinated child 1 to <5 years seriously ill N (%)	Measles vaccine is protective N (%)	MMR vaccine is protective N (%)	Measles vaccine is safe N (%)	MMR vaccine is safe N (%)
UP	498 (85.71)	452 (77.8)	455 (78.31)	497 (85.54)	481 (82.79)	543 (93.46)	528 (90.88)
Bihar	117 (82.98)	108 (76.6)	104 (73.76)	115 (81.56)	104 (73.76)	123 (87.23)	109 (77.3)
Total	615 (85.18)	560 (77.56)	559 (77.42)	612 (84.76)	585 (81.02)	666 (92.24)	637 (88.23)

Table 2: PHC Physicians' perceptions of eradicating measles and likelihood of achieving measles eradication

	It is important that measles is eradicated from India N (%)	It is likely that measles will be eradicated from India N (%)
UP	549 (94.49)	528 (90.88)
Bihar	122 (89.05)	122 (89.05)
Total	671 (93.45)	650 (90.53)

Table 3: Correlates of attitudes towards measles eradication by PHC physicians

	Total			
	Eradication is important		Eradication is likely	
	OR (95% CI)	P value	OR (95% CI)	P value
Perceived disease severity for a child	**2.29 (1.00, 5.25)**	**0.049**	0.92 (0.36, 2.36)	0.865
Perceived MMR vaccine efficacy	**3.39 (1.38, 8.34)**	**0.008**	0.67 (0.22, 2.03)	0.4776
Perceived measles vaccine safety	2.05 (0.70, 6.00)	0.1892	**3.62 (1.41. 9.27)**	**0.0073**

Bolded values are significant at $p < 0.05$

Chapter 4: Conclusion and Recommendations

A majority of PHC physicians support the idea that measles eradication is important. Similar numbers believe that it is likely that measles will be eradicated from India. As community leaders, PHC physicians are in a position to leverage their social and political capital in support of a measles eradication campaign. As such, measles eradication depends on their widespread support. While strong, however, support for measles eradication among PHC physicians is not universal. These barriers to support must be further explored and addressed.

PHC physicians that believe that the measles vaccine is safe are 3.62 (CI 1.41, 9.27) times as likely to believe that eradication is important. Those that believe that the MMR vaccine is protective are 3.39 (3.39 CI 1.38, 8.34 more likely to believe that measles eradication is important. Approximately 10% of PHC physicians in Bihar and UP express disbelief that the measles vaccine is safe. Furthermore, only 83% of PHC physicians in UP and 74% in Bihar believe that the MMR vaccine is protective. This amounts to a large number of PHC physicians who express discomfort with measles vaccines.

Concerns surrounding vaccines must be addressed twofold.

1. Ensure that the vaccines are safe and effective.
    - Maintain proper oversight of vaccine production facilities, including routine testing to ensure the vaccines meet standards.
    - Strengthen cold chain systems via structural improvements in cold chain capabilities (refrigerators, generators, etc.) as well as via education on cold chain

maintenance (No food in the fridge, store vaccines in the body rather than in the door, etc.).

- Investigate vaccine handling, storage, and administration in Bihar and UP to explore other factors that may contribute to unsafe or ineffective vaccines.
- Establish a surveillance system to detect adverse events following immunization (AEFI).

2. Address concerns that arise from misperceptions or lack of education
    - Strengthen immunization curriculum for health professionals, particularly those serving in Bihar and UP.
    - Include information about vaccine safety and efficacy with distributed vaccines.
    - Detail vaccine safety and efficacy information alongside the UIP recommended vaccine schedule.
    - Distribute results from AEFI surveillance system to show levels of adverse effects and assuage unfounded fears about vaccine safety.

A third factor associated with a PHC physician's belief that it is important to eradicate measles in India is the perceived severity of disease in an unvaccinated child. Those that believe children will become seriously ill are over twice as likely to believe that measles eradication is likely. To this extent, it is important that PHC physicians are adequately trained in the complications that can occur from measles. Establishing the surveillance of measles and distributing results to healthcare workers may further impress the true morbidity and mortality associated with measles in India, and increase their beliefs in the importance of measles eradication.

PHC physician support for measles eradication is critical, and every effort should be made to address concerns that prevent PHC physicians from believing that measles eradication is likely and important. The current widespread support for eradication, as illustrated by this study, should be leveraged to influence policy and strengthen the routine immunization practices needed to eradicate measles transmission in India.

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