Immunization in Developing Countries: Its Political and Organizational Determinants

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Abstract

This paper uses cross-national social, political, economic, and institutional data to explain why some countries have stronger immunization programs than others, as measured by DTP and measles vaccine coverage rates and the adoption of the hepatitis B vaccine. After reviewing the existing literature on demand- and supply-side factors that affect immunization programs, the paper finds that the elements that most affect immunization programs in low- and middle-income countries involve broad changes in the global policy environment and contact with international agencies. Democracies tend to have lower coverage rates than autocracies, perhaps because bureaucratic elites have an affinity for immunization programs and are granted more autonomy in autocracies, although this effect is not visible in low-income countries. The paper also finds that the quality of a nation's institutions and its level of development are strongly related to immunization rate coverage and vaccine adoption, and that coverage rates are in general more a function of supply-side than demand effects. There is no evidence that epidemics or polio eradication campaigns affect immunization rates one way or another, or that average immunization rates increase following outbreaks of diphtheria, pertussis, or measles.

Introduction

Why do some countries consistently immunize children more effectively than others? Both practical and theoretical concerns motivate the question. Practically, there is little systematic evidence about what policies and vaccination strategies expand immunization coverage. Understanding the relative importance of campaigns versus routine programs, the role of international donors, access to health care facilities, the availability of communication equipment, and other factors will help health policy planners design immunization programs. In addition, a number of foundations, multilateral agencies, governments, and analysts have come to believe that in developing countries vaccines will be necessary to halt the spread of devastating diseases, such as HIV/AIDS and malaria, and that developing countries and their governments, left to themselves, will not buy enough vaccines to stimulate market development of vaccines for those diseases. This paper examines the question of why some developing country governments do not purchase and deliver enough vaccines to their populations, and what might be done about this, both for existing and future vaccines.

The theoretical motivation involves the political sources of social policy. For some policy outcomes, hyper-rational accounts of government choices are not tenable, and political explanations are unavoidable. In the case of vaccines, every society recognizes that immunization is a task for government, the materials cost of the basic six childhood

vaccines is low (less than $1 per fully immunized child), and financial and technical assistance for vaccination is available from international organizations. Despite this, many governments fail to immunize their populations adequately. Related theoretical problems appear in other sectors. Many governments adopt ruinous economic and education policies despite a mountain of evidence regarding their irrationality. Generally, analysts explain these policy outcomes by identifying winners and losers, assessing the political, economic, and cultural resources available to various interest groups, and examining patterns of decisionmaking institutionalized in customs and laws. This paper uses a panel data set of immunization coverage rates and the timing of vaccine adoption in low- and middle-income countries, along with a time series of potential political, economic, social, and institutional determinants, to identify the political and organizational factors associated with strong immunization programs.

The debate over how countries have improved health outcomes has two main camps. One camp emphasizes the role of economic growth and related gains in nutrition (McKeown 1976, Fogel 1984); the other camp, who are writers, point to the importance of public health measures such as communicable disease control and skilled attendance at birth. (Preston 1976). Each group has favored country examples: for the former the United States and Britain and Wales, where public health was weak when mortality rates fell sharply in the nineteenth century, and for the latter Sri Lanka and the Indian state of Kerala, where mortality rates fell in this century despite extremely modest gains in national income. In fact, there is nothing inherently incompatible about the views espoused by the two camps. Public health measures reduce the likelihood of individuals being exposed to pathogens, whereas income and nutrition contribute to their ability to resist or recover from exposure. Achieving a life expectancy over 70 probably requires both a minimal income and nutritional level, as well as a reasonably strong public health system, but at lower life expectancies the two factors might function as substitutes. (Johansson and Mosk 1987) The politics, economics, and history of any given country might make either the income or the public health path to low mortality easier to achieve.

This paper contributes to an emergent literature *within* the public health camp on the political, economic, and social characteristics of countries that are able to achieve low mortality despite low levels of income. That discussion focuses on, to put it simply, how democracy and social mobilization can contribute to the institutionalization of a public health agenda, as in Kerala, Sri Lanka, and Costa Rica, and how hierarchy and revolutionary ideology can create the same, as in Cuba, Vietnam, and China.

Kerala, Sri Lanka, and Costa Rica are autonomous regions whose achievements in raising life expectancy and lowering infant mortality are widely cited. Those societies share several characteristics: small and densely settled populations, a relatively high degree of female autonomy, a respect for education, and the absence of a rigid class structure. At the same time, their governments have historically allocated significant resources to the health care system, and the political histories of the regions are characterized by egalitarianism and a national consensus with marked elements of populism that emerged from political contestation. (Caldwell 1986) Their histories are consistent with theoretical treatments of the impact of democracy on social policy: competitive elections motivate politicians to provide social services to capture the support of the poor, the poor face higher costs in mobilizing for social services in authoritarian governments, and democracies empower interest groups and social movements advocating propoor social policies. (Lake and Baum 2001, McGuire 2001, Weyland 1996) But Vietnam, China, and Cuba are also countries that have improved the health of their citizens dramatically despite relatively low levels of income per capita. In those countries political contestation played no role, but disciplined party organizations structured in a quasi-military fashion and social revolutions followed by high levels of government expenditure on health and social infrastructure did (Bryant 1998, Parish and Whyte 1978). This paper assesses the impact of competitive elections on one clear and measurable facet of public health outcomes, immunization.

Immunization programs differ in some ways from most other kinds of health care. Consensus among technical experts in the field of immunization is stronger, the time-frame for policy reforms is shorter (if "reform" is even the right word for increasing coverage rates or adopting a new vaccine), household demand for it is weaker than for curative health care, and the professional and pecuniary interests of the providers are weaker in comparison to other areas of health reform, such as changes in insurance and provider payment systems. In addition, multinational pharmaceutical corporations operating in an oligopolistic market and the international scientific community have unusually strong influence on the vaccines distributed in developing countries. So the explanation of immunization outcomes in this paper might not be co-extensive with a broader theoretical account of public health programs in developing countries. In particular, there are reasons to believe that the political and organizational determinants of immunization programs might depend less for their effect on the way they either promote or dampen the demands of interest groups and households, which is how institutions are understood to operate in most political economy accounts of social service provision, and more on their direct effect on the actions of political and bureaucratic elites.

There has been little work that disaggregates the categories of public health and examines the political and organizational sources of policies in its subsectors. One noteworthy exception is an historical treatment by Nathanson (1996), whose arguments are suggestive for a comprehensive account of the political economy of public health, which will require case studies in addition to cross-national approaches like that taken in this paper. In the late nineteenth and early part of the twentieth centuries France enacted national legislation for the inspection of wet nurses, paid maternity leave, free medical care during confinement, and obligatory maternity insurance, while the United States lent no federal attention to maternal and child health until maternal health education programs began in 1921 (only to be rescinded in 1929). On the other hand, beginning in 1965 the United States mandated warnings for tobacco consumers, curtailed tobacco advertising, banned smoking during interstate transportation, and raised cigarette excise taxes, which jointly had the effect of lowering U.S. cigarette consumption sharply; but France has not reduced cigarette consumption and has achieved only limited compliance with smoking bans in public facilities. Nathanson uses two main factors to explain why maternal and child health concerns appear unrelated to antismoking efforts in the two countries. First, the French state is more centralized than the American, so resources for service provision are more easily mobilized when there is state consensus. Since improving maternal and child health requires additional resources, it is not surprising that France has a more active record than the United States in that area. Centralization also explains French weakness in antismoking efforts. Alternative channels for social policy change, such as local governments and social movements, are not available when the French state is divided, which it happens to be in this area because government-owned tobacco producers resist controls. In a decentralized country like the United States, alternative government entities, such as state court and legislatures, are available when action at the federal level is blocked, and it is in fact at the state level where the antismoking campaign first gained its momentum. Nathanson's second explanatory factor is the style of risk construction. United States social and political culture tends to construct health risks as dangers to individuals, whereas the French style of risk constructions emphasizes threats to the nation. Consequently, the rights of individual nonsmokers were dispositive for legislative and court action in the United States, and the language of French nationalism was critical for the pronatalism that helped to justify maternal and child health policies in France in the 19th century.

Prevailing Views on the Determinants of Immunization Coverage

Most studies use household surveys and explain variance in childhood immunization "uptake" or "demand" with characteristics of children's mothers and their

households, often but not always including community-level fixed effects. These studies invariably find maternal education and household socioeconomic to be correlated with the probability of childhood immunization, but there are disparate findings concerning the extent to which these are causally related to immunization status, and whether measurable maternal and household characteristics might be proxies for other underlying factors or for characteristics of the communities of residence.

For instance, Desai and Alva (1998) use the first round of data from the Demographic and Health Surveys (DHS) in 22 countries and find that whereas the inclusion of individual-level and community-level fixed effects significantly weakens the relationship between maternal education and childhood health, the link between maternal education and child immunization remains strong. In a survey in two villages near Yogyakarta, Indonesia, Streatfield, Singarimbun, and Diamond (1990) also find that immunization status is related to maternal education, albeit in a U-shaped pattern in which illiterate mothers are more likely to have their children immunized than mothers with a little primary education, but much less likely than mothers with some secondary schooling. They explain the U-shaped pattern by arguing that illiterate mothers comply more often with social norms, but that higher levels of education are associated with knowledge of the functions of the vaccines, which has a strong and independent effect. Their multivariate analysis finds that the effect of formal education disappears when mothers have correct knowledge of the functions of vaccines. In another study, Gage, Sommerfelt, and Piani (1997) find that higher household socioeconomic levels and more maternal education both increase the likelihood of childhood immunization in Nigeria and Niger, and that household structure (living in a nuclear or elementary polygynous family, as opposed to a laterally extended family) negatively affects immunization probabilities in Nigeria, but not in Niger. In a study of family choices for maternal and child health in Guatemala, Pebley, Goldman, and Rodriguez (1996) find that both mother's and father's education are significantly and positively related to childhood immunization status, as is living in urban areas, but that unobserved family and community characteristics are even more influential. They hypothesize that family health beliefs, differing abilities among families to take advantage of available resources, and variance in the intensity of immunization campaigns in different areas might explain these intraclass correlations. In a study of immunization uptake in four rural areas of Bangladesh, Steele, Diamond, and Amin (1996) find that the effect of mother's education on child immunization status disappears once father's education is included, and that the latter became insignificant when village-level dummy variables are added. They find a large amount of unexplained variation at both the household and village levels, which they speculate might be related to immunization accessibility, the attitudes of local leaders, differences in household attitudes and beliefs, and power relationships within

the household. Their study offers evidence for the power relationship interpretation since children who lived with their mothers and paternal grandparents were significantly less likely to be immunized, and children whose mothers belonged to women's social groups were significantly more likely to be immunized.

Anthropological accounts of the demand for or acceptance of immunization center on the relationship between modern germ theory and local beliefs. For example, villagers in South Asia have been reluctant to accept vaccines for smallpox and measles out of a belief that a goddess causes those diseases, and that treating a body that she has inhabited will anger her and only make the disease worse (Caldwell, Reddy, and Caldwell 1983, Nichter 1995). Still others do accept immunization, particularly for smallpox, because they interpret the vaccination mark as a kind of talisman that can ward off the spirit or the goddess. The Sri Lankan Ministry of Health has used this association by placing an amulet on a national vaccination poster. The conflation with talismans can be misleading, however, because these, unlike childhood immunizations, are believed to reduce the severity of afflictions without eliminating their occurrence, and to have a temporary effect. Other reasons for refusing vaccines include the impression that if a vaccinated child is healthy she does not need any more immunizations, the idea that a vaccination protects against all illness and the resulting disappointment if a vaccinated child falls ill, the fear that the side effect from a given vaccine will also occur following all vaccines, the fearful association between the syringe and the Christian cross, and the impression that immunization is related to sterilization efforts or medical experimentation (Nichter 1995). These beliefs make clear how education might work to increase immunization acceptance, not only by providing information, endowing the skills to acquire further information, and strengthening the status of certain household members, but also by creating a sense of identification with the modernity and its associated schools, clinics, and practices (Caldwell 1983, 1986).

It is important to note that the fear of immunization is not a monopoly of developing countries. Classic accounts include Voltaire's mocking portrayal in 1733 of his own countrymen for their suspicion of the British use of smallpox vaccination: "It is inadvertently affirm'd in the Christian Countries of Europe, that the English are Fools and Madmen. Fools, because they give their Children the Small-Pox to prevent their catching it; and Mad-men, because they wantonly communicate a certain and dreadful Distemper to their Children, merely to prevent an uncertain Evil." (*Letters concerning the English nation*, 1733, "Letter XI on Inoculation"). In his *Autobiography*, Benjamin Franklin noted, and regretted, his own similar estimation of the value of inoculation: "In 1736 I lost one of my sons, a fine boy of four years old, by the small-pox, taken in the common way. I long regretted bitterly, and still regret that I had not given it to him by inoculation. This I

mention for the sake of parents who omit that operation, on the supposition that they should never forgive themselves if a child died under it; my example showing that the regret may be the same either way, and that, therefore, the safer should be chosen." An influential pamphlet circulated in Sweden in 1818 argued that vaccination would anger God and make the disease worse (Sköld 1996). A modern form of this argument, in which people fear that immunization can damage health by driving a disease underground, continues to recur in the United States and elsewhere (James 1988), as do persisting concerns that vaccines may increase the likelihood of diseases such as autism, in spite of considerable evidence to the contrary (Taylor and others 1997).

These fears of immunization have had documented negative effects on vaccine coverage rates. Gangarosa and others (1998) reviewed antivaccine movements targeted against the pertussis vaccine in 12 Western countries and found a strong correlation between the timing and strength of the movements and declines in vaccine coverage rates. For example a 1974 report in the United Kingdom ascribed 36 neurological reactions to the whole-cell pertussis vaccine, and although health authorities resisted pressure to withdraw the vaccine during the panic that followed, the DTP coverage rate fell from 81 percent in 1974 to 31 percent after 1976, and a spike in pertussis incidence ensued. When an influential medical leader in Sweden claimed that pertussis had become milder as a result of economic, social, and medical progress and questioned the value of the vaccine, and when Swedish pediatricians lost confidence in the vaccine as a result of those questions and the attribution of some neurological events to the vaccine, the coverage rate plummeted from 90 percent in 1974 to 12 percent in 1979. The pertussis incidence rate in Sweden increased thirtyfold, with rates of serious complications approaching global rates. Potential distrust of immunization is perhaps unavoidable because vaccinations entail, on the face of it, an inversion of the healing paradigm: one goes when healthy to the clinician, who injects a substance in one's arm that causes discomfort and, in rare occasions, an actual case of illness. But it is also true that misleading or misunderstood information, expired and ineffective vaccines, dirty or reused syringes, and poorly trained staff can undermine trust in immunization programs, resulting in lower coverage rates.

Supply-side factors that affect immunization coverage, such as the quality of vaccines, incentives for the cadre of workers who perform vaccination, and the organization of national immunization agencies, have received little attention in the literature. One study in Gujarat state in India argues that the agents who perform vaccines for the Indian public sector, the so-called multi-purpose workers who live in and work from their home villages, were excessively focused on numerical targets, so much so that they did not explain the purposes, benefits, and potential side effects of vaccines to patients, nor did they convey

potentially useful information up to their superiors regarding the obstacles to immunization, such as geographic challenges, caste and gender discrimination, and the influence of mothers-in-law (Streefland 1995). Several accounts of immunization policy have used the concepts of "political will" or "political commitment" to explain the success of moves to improve coverage (UNICEF 1996 pp. 65-66, Madrid 1998a, Widdus 1999a, Justice 2000b, 2000c), conduct polio eradication activities (Hull and Aylward 2001), or introduce new vaccines (Madrid 1998b, Huang and Lin 2000, Miller and Flanders 2000, Wenger 2001). Put simply, the implication is that if political leaders were to make immunization a priority, coverage rates (or polio eradication, or the introduction of new vaccines) would improve as a result. However, as several writers have pointed out, the terms "political will" and "political commitment" are "catch-all culprits" without much analytic content (Grindle and Thomas 1991, Reich 1994). As one commentator put it, "political will [does] not arrive de novo, so it is necessary to understand the elements that contribute to recognition of need, and willingness (or capacity) to pay [for new vaccines]" (Widdus 1999a). Some of these case studies have also pointed to the negative effects of decentralization on immunization rates. (Justice 2000a,b and Madrid 1998a,b). In theory, decentralization might make coordination among local health secretariats more difficult, and it might create a free rider effect in which the incentives for one jurisdiction to immunize its population are negatively related to the strength of the immunization effort in neighboring jurisdictions. But it might also, under certain conditions, improve service delivery by making governments more accountable to and responsive to needs of local populations.

Studies that examine the determinants of vaccine adoption have focused primarily on the informational prerequisites for government decisionmaking. Mahoney and Maynard (1999), reviewing the experience of the International Task Force on Hepatitis B Immunization, found five factors to be significant: (1) the establishment and dissemination of disease burden data and cost-effectiveness computations; (2) vaccine introduction trials and effectiveness evaluations; (3) establishment of an international consensus on recommendations for vaccine use; (4) assurance of an adequate and competitive vaccine supply; and (5) the creation of funding mechanisms to supply vaccine to countries unable to finance their own procurement. Hausdorff (1996), commenting on the rate of new vaccine adoption, suggested that the main determinant is "the extent to which international and bilateral agencies and national governments appreciate the potential value of new vaccines." A study by the General Accounting Office of the United States (1999) drew similar conclusions regarding the importance of locally tailored information, both for new vaccine adoption and for decisions to invest in immunization programs as a whole, and highlighted the role of disease surveillance. Levine and Levine (1997) emphasized the role of information, public perceptions, and the opinions of the medical community, as did

Wenger and others (2000) in their analysis of *H. influenzae* type B vaccine adoption. Wenger (2001), Hausdorff (1996) and GAO (1999) pointed to the importance of price barriers. Widdus (1999b) analyzed both prerequisites (recognition and information on the target disease, the presence of a functioning immunization program) and modifying factors (epidemiologic and demographic variables, cues for action) that jointly shape a "perceived threat of disease" which, in turn, influences decisionmakers' perceptions of the risks, benefits and barriers associated with new vaccine adoption. Miller and Flanders (2000) identified a number of epidemiologic and economic factors associated with the uptake of hepatitis B and *Haemophilus influenzae* type B vaccines into national immunization programs. In their model, variables significantly affecting the odds of adopting the vaccine included GDP per capita (with an odds ratio of 4.4), vaccine cost per dose (OR 4.1), vaccine cost as a fraction of per capita GDP (OR 39.7), current coverage with DTP vaccine (OR 55.1), and years of life lost per 1,000 infants due to the diseases in question (OR 6.9). Using alternative models with composite variables, they find that a variable for potential treatment costs prevented—a composite of data on disease burden, unit treatment costs and immunization coverage rates—has the highest odds ratio, at 127.4. All of these studies, while pointing to the importance of information prerequisites leave unexamined the question of what motivated decisionmakers to conduct epidemiological analyses to begin with, the question of, in other words, the political sources of immunization policy. Where they are consistent with the present analysis is the finding that the role of bureaucratic elites has been important in shaping immunization policies over the past two decades.

The history of smallpox vaccination offers lessons regarding the organization of immunization efforts. The Swedish Crown encountered significant resistance when it tried to implement a campaign for smallpox inoculation in the eighteenth century, even though some 300,000 people died of smallpox between 1750 and 1800; but its subsequent campaign using the vaccine derived from cowpox virus was much more successful. Sweden became one of the first countries to make vaccination compulsory in 1816 and vaccinated 80 percent of newborn children by 1821. Sköld (1996) attributes this to the superiority of vaccination technology, but also to institutional factors, such as the influence of the international press (80 percent of articles published between 1798 and 1801 favored vaccination), the removal of the authority to vaccinate from a physicians' monopoly, the enlistment of the clergy and church assistants, who did most of the vaccinating and received certificates of competence from the district medical officer, free vaccines offered to the poor, and a system of rewards given to the "most skilled" vaccinators. Rigau-Pérez' (1989) study of the introduction of smallpox inoculations to Puerto Rico in 1803 also emphasizes the critical role of the clergy in obtaining the community's trust. In Puerto Rico the colonial authorities had anticipated the Royal Expedition of the Vaccine from Spain and introduced

inoculation techniques with so much community involvement "that children, in their games at school, vaccinated each other." But the initial success of the effort foundered as a result of conflicts between colonial and royal authorities, and Puerto Rico's smallpox program lagged far behind many of its Latin American neighbors, lending an ominously prophetic tone to a comment of the King's emissary, who had said in a letter that he was coming "not only to bring vaccine, but to assure its perpetuation, which is the hardest [task]."

Variables and Sources of Data

Immunization coverage. Data on immunization coverage rates obtained from WHO and UNICEF measure the proportion of children who have received the DTP3 or measles vaccine by one year of age and are based on either service delivery records or, where available, on coverage surveys carried out under the auspices of the EPI program using a standardized 30-cluster sampling technique which collects information directly from households (Henderson and Sundaresan 1982, WHO 1991). [1] Coverage rates are recorded without indication of the specific methods used to collect them, though survey data—which are considered to be more valid than service statistics, particularly in countries where routine reporting systems are not well-developed—are used wherever possible, including from sources outside the EPI system such as the immunization section of the Demographic and Health Surveys (UNICEF 1996).

Several studies have voiced concern over the disparity between coverage rates reported from service delivery records and "actual" coverage rates measured by sample surveys (Boerma and others 1990, UNICEF 1996, WHO 1999). In one study, 30.4 percent of reported figures were considered "unexpected" when assessed against a set of internal and external validation criteria (WHO 1999); in another, reported coverage was found to exceed survey coverage by over 20 percent in a small sample of case-study countries including Uganda, India, and the Philippines (UNICEF 1996). Various explanations are possible for these discrepancies, which may derive from inaccuracies in either reported or survey data. Survey data, while generally considered more valid than data from service records, are not invariably accurate. Case definitions and the method of obtaining data may differ from survey to survey, and other differences in survey methodology—between the EPI's cluster sampling method and the Demographic and Health Surveys (DHS) approach, for example—may also result in different estimates for the same population (Boerma and others 1990). Surveys typically obtain coverage information from maternal recall, immunization cards or both (WHO 1991, Boerma and others 1990, Boerma and Bicego

[1] While immunization schedules vary from country to country, most require the DTP3 vaccine to be given at 3 to 6 months and the measles vaccine at 9 to 12 months. For more details, see WHO (2000).

1993). “Card plus history” approaches are generally the most accurate, though even these underestimate “true” coverage levels to a small extent. Some surveys use a sampling frame that is limited to “women of child-bearing age,” generally 15 to 49 years, which may additionally underestimate true coverage levels by excluding children in the care of older caregivers—a common occurrence in countries suffering from conflict or, more recently, HIV/AIDS (World Bank 1997). Other methodologic issues have also been discussed, with criticisms of the ±10 percentage point accuracy of the WHO’s cluster sampling method (Lemeshow and others 1985) and discussion of other methods of obtaining coverage information such as modified cluster surveys and Lot Quality Assurance methods (Bennett and others 1991; Lemeshow and Robinson 1985; Lanata and others 1990; Sandiford 1993; Turner, Magnani, and Shuaib 1996; WHO 1996a; WHO 1999; Hoshaw-Woodard 2001). However, given the simplicity and inexpensiveness of the WHO’s 30-cluster survey approach, and the fact that it generally compares well with data from nationally representative surveys such as the DHS (Boerma and others 1990, Boerma and Bicego 1993), this method remains the most common way of obtaining coverage data by survey.

Coverage data from service records are also subject to a wide range of inaccuracies. Like survey data, reported data can suffer from nonsystematic errors such as mistakes in data entry, transcription and analysis. Also, since service records are seldom complete, national coverage levels must be estimated from available data using a variety of assumptions, introducing an additional source of possible error (Boerma and others 1990). Children over the age of one are frequently included in the numerator of reported data, a systematic error that artificially inflates rates and gives an inaccurate picture of true coverage,[2] while data on the target population—the denominator in coverage calculations—are frequently based on projections from old or inaccurate censuses and may seriously over- or under-state the correct denominator in these calculations (UNICEF 1996). Perhaps more serious, however, is the possibility of deliberate rate inflation or data falsification. This is of particular concern in systems where data is collected principally to measure progress against targets rather than to guide program decisions at local or district levels (UNICEF 1996). In such systems, pressure from superiors to reach unrealistic targets or increases in coverage may lead health workers to inflate coverage data, and these in turn may find their way into national and international health statistics, particularly in the absence of effective monitoring and supervision systems.[3] A separate possibility is that overworked front-line

[2] Since the standard definition of coverage is based on a child’s vaccination status at one year of age, including children who have received these vaccines *after* their first year artificially increases the numerator in coverage calculations.

[3] These pressures can originate from international organizations as well as national public health bureaucracies, such as during the last phases of the “Universal Child Immunization” initiative when UNICEF

health workers may neglect immunization responsibilities—especially if other programs come with stronger incentives or are perceived as having greater priority—and may attempt to conceal this by fabricating, falsifying or exaggerating data (UNICEF 1996, Nair and others 2001).[4]

The key question for the present study is the extent to which these considerations may affect the study's analysis. Setting aside random errors, the principal concern is whether there are systematic errors in the coverage data that differ according to other country characteristics such as national income. To examine this, reported data on measles and DPT3 coverage from the WHO database were compared with similar data from DHS surveys for 82 country-years (DHS, 1985 to 1997). Figures 1 and 2 indicate the relationship between WHO and DHS data for these countries, for DTP3 and measles, respectively. There was no significant difference in the average measles coverage data reported in the DHS and WHO datasets, but DPT3 coverage was significantly higher in the WHO data by an average of 4.1 percent ($s=2.04$, $p<0.05$).[5] More importantly, this difference in DPT3 rates was the same across all country income categories for which DHS data were available (low, lower middle and upper middle), suggesting that discrepancies between reported and "actual" rates do not differ according to countries' national income.[6] Since DHS data were not available for any high-income countries, a possible difference there can not be ruled out; but in general, these findings suggest that using reported rates—particularly for measles[7]—as a dependent variable is reasonable, particularly given the absence of any

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itself admitted that "global pressure for achieving UCI" may have adversely affected the accuracy of reported coverage rates in 1990 (UNICEF 1996, page 40).

[4] Nair and others (2001) report performance exaggeration in all programs *other* than immunization in their study of village health workers in Kerala, India. They acknowledge that this might have been an artefact of programmatic factors specific to the Kerala context—in particular, the ability of households to obtain immunization from a wide variety of sources *other* than village health workers—rather than a demonstration of more accurate reporting of immunization figures by the VHWs themselves.

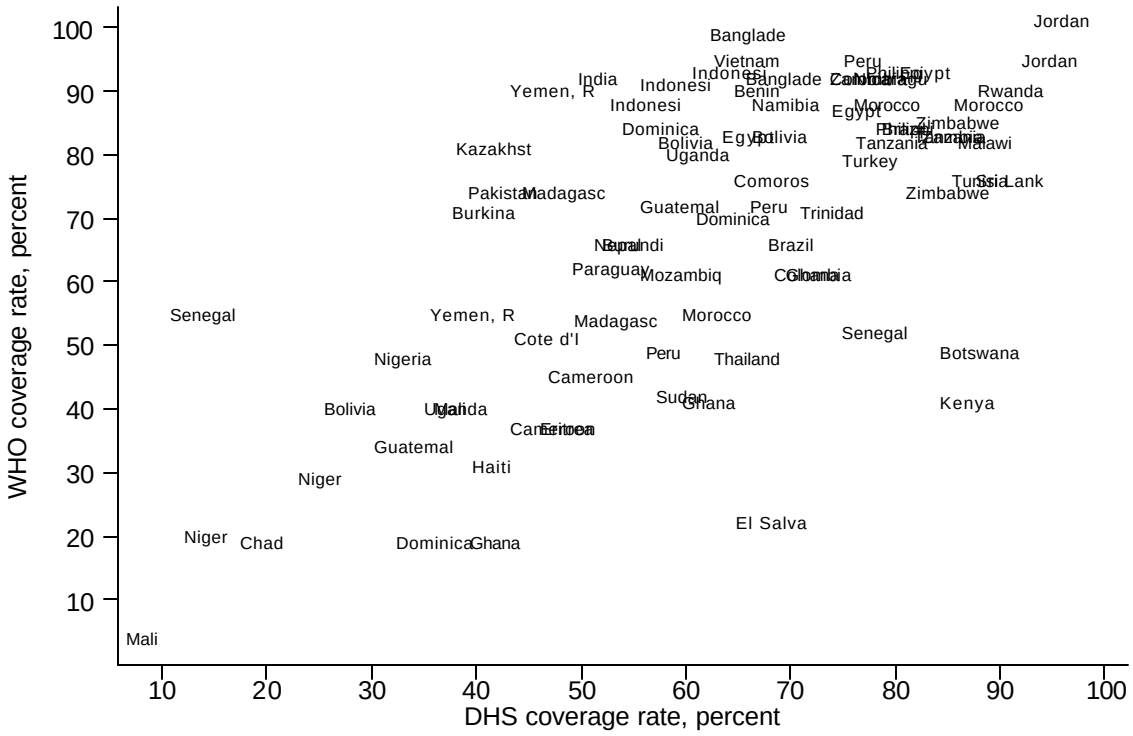
[5] Figures 1 and 2 illustrate these errors as the distance of each country from the line $y=x$. India, Yemen and Bangladesh, for example, report highly exaggerated coverage rates, up to 40 percent higher than the rates found in DHS surveys; while countries such as Kenya and Ghana report rates that are between 20 and 40 percent *lower* than those reported in DHS surveys.

[6] Improbable reports of immunization coverage are also seen in some high income countries. Austria, for example, reports 90 percent coverage with DPT3 in every year since 1980, and reports its measles coverage in strict multiples of five. Apparent inaccuracies in coverage data may also be a result of transcription or data entry errors, such as New Zealand's 114 percent coverage rate for measles in 1991. This was manually corrected to 91 percent, based on its linear relationship with DTP3.

[7] It is interesting to speculate as to why reported measles figures tend to be more accurate than reported figures for DPT3. Since DPT3 requires the successful, timely completion of a course of three vaccinations, the cumulative likelihood of error—both in administering the vaccine and in recording or recalling this event—may be higher than for measles, which only requires a single shot and can also be administered in "catch-up" or "one shot" campaigns. This is borne out by coverage comparisons, in which measles coverage is generally higher than DPT3 coverage. (Boerma et al. 1996) This in itself doesn't explain differences in the *accuracy* of reported data for the two vaccines, however. It is possible that the greater discrepancy between reported and

significant evidence for systematic bias. Further attempts to explain intercountry differences in DPT3 figures between WHO and DHS data found only one variable, the log of total population, to be a significant determinant of these differences (p=0.03). [8]

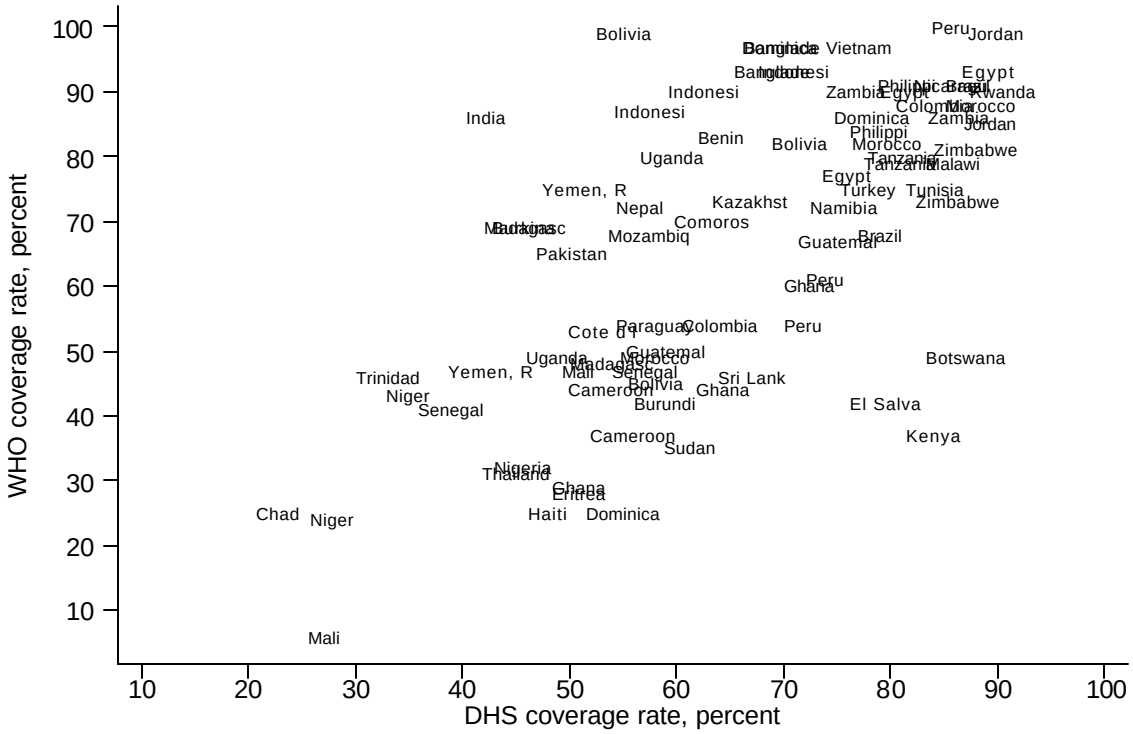
Figure 1: WHO vs. DHS Coverage Rates, DTP3 Vaccine



survey figures for DPT3 represents the cumulative effect of a fixed "tolerance" for error on the part of those who record service statistics, a tolerance that manifests only once with measles but three times for the DTP series. In other words, service recorders may "accept" a DPT3 that comes off-schedule if the previous doses have been administered correctly (or recorded as such), whereas their decision to accept or reject a measles vaccination as correct is based on a single event alone. Both of these are in contrast to survey data, which are generally based on time-specified maternal recall or entries on an immunization card and may therefore be less susceptible to such errors.

[8] The fact that population is a significant determinant of inaccurate reporting may simply reflect the inherent difficulties associated with collecting this type of data in large populations. Perhaps more interesting is the fact that none of the ICRG variables—which included measures of government corruption, bureaucratic quality and the overall quality of governance—were significant, and neither were variables for population density, illiteracy rates and democracy.

Figure 2: WHO vs. DHS Coverage Rates, Measles Vaccine



Introduction of new vaccines. Data on the introduction of hepatitis B and *Haemophilus influenzae* type B vaccines into countries' routine infant immunization programs were obtained from WHO and various sources in the published literature (WHO 1995; WHO 1996b-e; Van Damme, Kane, and Meheus 1997; Vryheid and others 2000; Wenger and others 2000; Van Damme 2001; WHO 2000). These data were converted into two forms: a binary variable indicating whether or not the given vaccine was in use in a particular country-year, and a continuous variable for the observed coverage rate in each country-year. In view of the small number of observations for which actual coverage data were available, the binary measure was used as the dependent variable of choice, with logistic regression to estimate the odds of vaccine adoption.[9] Also, since only 23 countries were reporting routine *Haemophilus influenzae* type B immunization by 1997, the use of

[9] For many countries, information was only available on whether or not routine immunization against hepatitis B or *Haemophilus influenzae* type B had commenced, and not on the coverage rates obtained. The use of a binary outcome variable enabled us to use this information to maximum effect, and was also consistent with our interest in the determinants of vaccine *adoption*, as distinct from countries' ability to rapidly increase their *coverage* with these vaccines. Vryheid and colleagues (2000) point out that the use of government statistics may actually underestimate true coverage rates for new vaccines, since many of these are initially delivered more through the private medical sector than through public channels.

this variable was set aside in favor of the variable for immunization against hepatitis B, for which there were 68 countries reporting routine use by 1997.

Political and institutional variables. Variables for democracy and regime durability were taken from the Polity IV dataset of Marshall and Jaggers (2000). Democracy is measured as a composite of three variables measuring the competitiveness of political participation, the openness and competitiveness of executive recruitment, and the extent of constraints on the chief executive. Munck and Verkuilen (2000), in their comparison of alternative measures of democracy, point out that the democracy variable in Polity IV may be flawed on two grounds. First, they point out that there is no variable for electoral participation, and that the measurement of democracy is therefore biased towards political contestation;[10] and second, they suggest that the use of two related and potentially overlapping variables to measure executive recruitment—one for openness and one for competitiveness—is neither theoretically justified nor empirically valid. Neither of these concerns is of particular relevance to the present study. In the first place, data are used for the years between 1980 and 1997, during which time electoral participation is generally accepted to have been well established in most countries.[11] Also, the data on democracy are presented in both their composite and disaggregated forms, allowing us to test the impacts of the component and aggregate variables separately and to draw our own conclusions as to the effects of each. Regime durability, also from Polity IV, was measured as the number of years since the last regime change or the number of years since 1900, whichever is smaller.

Other political variables were taken from the World Bank's Database of Political Institutions and the State Failure Project of Gurr and colleagues (Beck and others 2000; Gurr, Harff, and Marshall 1997). The DPI provided data on characteristics of the chief executive and on the extent of political decentralization, with variables encompassing the ideology, term, term limits and military affiliation of the chief executive and the presence, nature and authority of subnational authorities. The State Failure Project provided data on the existence of revolutionary or ethnic wars, adverse regime events, and instances of genocide or politicide. In both cases, the data were collected and scrutinized by a single

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[10] This draws on Robert Dahl's description of democracy as having two dimensions: contestation or competition, and participation or inclusiveness (1971: pp. 4-6).

[11] "Indeed, it is fairly accurate to state that after 1945 countries either had or did not have inclusive elections, as the partial extension of the right to vote ceased to be a viable option. Exceptions to this generalization include Switzerland, where women were denied the right to vote until 1971, and many Latin American countries in which women gained the right to vote [already granted to men] in the 1950s. Beyond these cases, women had gained the right to vote in older democracies prior to 1945 and always gained the right to vote in countries that became independent after 1945 at the same time as men did. Class-based restrictions on participation had also disappeared for the most part by 1945." From Munck and Verkuilen (2000, p. 24); see also Ramirez, Soysal, and Shanahan (1997).

research group over the entire period of their development and can therefore be reasonably assumed to be internally consistent, in spite of the subjective nature of some of their measures.

Variables on institutional quality were taken from IRIS 3, a dataset based on the International Country Risk Guide, a rating system established in 1980 to provide annual measures of political, financial and economic risk in 135 countries (Knack and IRIS 2000; PRS Group 2000). This provided six variables, all from the political risk section of the ICRG, including measures of bureaucratic quality, corruption in government, ethnic tensions, risk of expropriation of property, risk of repudiation of government contracts, and strength of the rule of law. With the exception of the variable for ethnic tensions, the remaining variables were highly correlated, so a composite variable for "institutional quality" was created as a weighted combination of these five.[12] Ethnic tension was kept as a separate variable.

Economic variables. Economic variables taken from the World Bank's World Development Indicators (2000a) included measures of national income, government resource availability, sectoral priorities and macroeconomic stability. Countries were grouped into four income categories on the basis of the World Bank classification reported in each year's World Development Report (World Bank 2000b).[13]

Demographic, infrastructure, health and education variables. Information on demographic characteristics, infrastructure, health and education were also obtained from the World Bank's World Development Indicators. These data are typically based on censuses, surveys, registration systems or government reports and accounts, all of which are

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[12] The ICRG dataset included separate entries for North Yemen, also known as the Yemen Arab Republic, and South Yemen, also known as the People's Democratic Republic of Yemen, prior to their reunification in 1991. Since the other variables did not make this distinction, we took the mean value of ICRG variables from North and South Yemen for the years prior to unification, and used these figures in our analysis. Regressions were also carried out using the maximum and minimum values for these variables, but there was no substantial change in the coefficients or their level of significance. Results are therefore presented using the average value of ICRG variables for North and South Yemen for the years prior to 1991, and with the "all Yemen" values thereafter. The ICRG corruption score for Ireland 1982 was set at 6.2 in the original data. This was changed to 6.0, the maximum score. The institutional quality score was created by multiplying by 0.6 the scores for repudiation and expropriation (which are on a 10 point scale), and adding them to the scores for bureaucratic quality, the rule of law, and corruption (which were already on a 6 point scale). Changing the weights had no effect on the results.

[13] For the years prior to 1987, when income categories were not reported in the WDR, countries were allocated to income categories on the basis of their borrowing status, since the definition of these categories (such as "civil works preference" for low income countries, and "IBRD eligible" for upper middle income countries) was seen to correspond to the income thresholds subsequently adopted. For more, see World Bank (2001).

subject to inaccuracies ranging from incomplete data collection and inappropriate survey methodologies to inconsistent case definitions and outright data falsification. In some cases, interpolation of data from existing figures—intercensus estimates of population size and age structure, for example, or estimates of public vs. private health spending—adds a further layer of possible bias, since the quality of these estimates is directly related to the quality of data on which they were originally based. These issues call into the question the reliability and validity of these data and might be of concern to more focused analyses; but for our purposes, the WDI dataset provides perhaps the most complete source of time-series data available on these variables, and it allows us to test our general hypotheses with acceptable validity. Given the nonlinear relationships between immunization coverage and population size, population density, and per capita GDP, these three variables were converted to a (natural) logarithmic form.

Immunization-specific variables. Variables related directly to countries' immunization policies and practices were obtained from a variety of sources. Data on immunization rates and the adoption of new vaccines were obtained from WHO and UNICEF, as described earlier. Data on participation in UNICEF's Vaccine Independence Initiative were also obtained from UNICEF, as were similar data from PAHO on countries' participation in its revolving fund.[14] A period dummy was used to measure the impact of accelerated Universal Child Immunization activities from 1985 to 1990 (UNICEF 1996).

Data on polio incidence and polio vaccine coverage were obtained from WHO, allowing us to examine the relationship between polio eradication activities and coverage rates for DTP3 and measles vaccines. WHO data on the incidence of *other* vaccine

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[14] UNICEF provides two general categories of procurement assistance to countries. Most countries use UNICEF as a procurement intermediary, paying for their vaccines in advance and ordering through UNICEF as a way of assuring vaccine quality and obtaining lower prices. Others participate in the "Vaccine Independence Initiative," a financing mechanism that establishes a revolving fund for each country and enables countries to buy their vaccines in local currency and pay for them only after deliveries have been made. This study used the variable for VII membership. The European Union's ARIVAS program ("Appui au Renforcement de l'Indépendence Vaccinale en Afrique Sahélienne") provides structural adjustment funding for immunization to a number of West African countries by creating a vaccine- or immunization-specific line item in the government budget and providing procurement assistance through UNICEF's Vaccine Independence Initiative. Data for the ARIVAS fund were not available for use in this paper. The PAHO revolving fund, established in 1979, acts as a financing intermediary for almost all countries in Latin America and the Caribbean region. Like UNICEF's VII, the PAHO fund enables countries to buy vaccine in local currency and pay for them once orders are received; but unlike the VII, which establishes a separate revolving fund for each country, the PAHO fund is a single fund from which all participating countries draw. The variable for participation in PAHO's Revolving Fund was set at zero both for non-participating countries and for all countries outside Latin America and the Caribbean region. Of the 208 countries in our dataset, 104 countries procured their vaccines through UNICEF, 22 of which took part in the Vaccine Independence Initiative, and 35 countries were enrolled in PAHO's revolving fund. For more details, see De Roeck and Levin (1998) and Khaleghian (2001).

preventable diseases—those covered by the DTP3 and measles vaccines in particular—were included to study connections between disease incidence and changes in immunization coverage. Data quality issues related to these variables are similar to those discussed in the earlier section on immunization coverage. The measurement of disease incidence, however, is subject to additional inaccuracies, since it relies more on routine surveillance than periodic data collection and can be adversely affected if this surveillance is of poor or variable quality (WHO 1998).

Methods

The cross-sectional time-series data used in this analysis consist of repeated measurements on the same unit, the state or nation, that are "pooled" with those of other units to provide a combination of longitudinal and cross-sectional information. These are typically expressed using the form

$$Y_{it} = b\,\mathbf{X}_{it} + e_{it}$$

where **X** is a vector of observations for unit *i* at time *t* and Y is the dependent variable of interest. Generally speaking, models of this form are not estimated by ordinary least-squares methods due to the presence of spatially- and temporally-correlated errors and the possibility of heteroskedasticity between panels[15]. Analysis of these data therefore requires techniques that are robust to both autocorrelation and panel heteroskedasticity. Generalized least squares (GLS) methods are generally considered the most efficient approach, since they can specify the autocorrelation structure of the data and account for it directly. A wide variety of alternative correlation structures can be used for this purpose, but all of them require more knowledge of the error structure that one typically has, especially in complicated models where neither prior theory nor exploratory analysis provides a basis for selecting a specification.[16]

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[15] Spatially- and temporally-correlated errors are common in cross-sectional time-series data. In most such data, the error terms associated with successive observations on the same unit—the observations for Australia in 1995 and Australia in 1996, for example—are correlated with each other. The same is true of spatially-related units, such as countries in the same geographic region or states that are subject to similar exogenous influences. Heteroskedasticity, or non-equal variance of errors, is also common. Both of these can be demonstrated on the variance-covariance matrix of the disturbance term: autocorrelation as a pattern in which the off-diagonal elements (error term covariances) are non-zero, and heteroskedasticity as a pattern in which these elements are non-equal. (Kennedy 1992).

[16] GLS models can be specified with one of three autocorrelation matrices for within-panel data: independent, autoregressive (AR), or panel-specific autoregressive (PSAR). In the independent specification, within-panel correlation is assumed to be non-existent, and the time values within the panel are ignored. In autoregressive models, serial or "multiplicative" correlation—in which successive correlations are approximately equal, with either a common (AR) or a panel-specific (PSAR) correlation parameter—is

Alternatively, fixed-effects models can be used to estimate coefficients on the basis of within-group data alone, thus eliminating one source of correlation (spatial correlation, correlation between panels); or, if within- and between-group correlations are thought to be equivalent (or "random'", then random effects models can be used instead, with Hausman's test to distinguish between the two. Fixed effects coefficients ('within estimators') describe the time-series information in the data (e.g., "What is the expected *change* in India's immunization coverage if x_1 is changed by 1?"), while "between estimators" describe the cross-sectional information in the data (e.g., "What is the anticipated difference between immunization coverage in India and Costa Rica if they differ in x_1 by 1?") (Gould 2001). The Hausman test is equivalent to testing whether the coefficients from within estimation (i.e., fixed effects) are the same as those from between estimation. If these are equivalent, then the distribution of differences is the same within and between observations and a random effects model is appropriate; but if not, then the analytic method of choice depends on whether one is interested in within effects, between effects, or both.[17]

A problem with this approach is that it leaves open the question of how to adjust for time effects. Given the wide range of time-varying determinants of immunization coverage, from donor preferences to radio ownership to the quality of public institutions, the modeling of these effects becomes an especially important issue. If the pattern of time effects were known or could be estimated, then this could be solved by using a GLS model or generalized estimating equation with the correctly-specified correlation matrix, thus correcting for both time effects and panel heteroskedasticity. In the absence of such knowledge, however, and given our uncertainty over the pattern of time effects, we concluded that a simpler approach—one that would be less dependent on a precise specification of the within-panel correlation structure of the data—would be preferable.[18]

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assumed. Generalized Estimating Equations, an extension of General Linear Models that allow for panel data to be estimated by GLM, expand the range of within panel-correlation structures to include exchangeable, stationary, non-stationary, unstructured, and user-defined specifications. See Stata (1999, pp. 338-369) and Diggle, Liang, and Zeger (1994).

[17] Random effects GLS models produce coefficients that are a matrix-weighted average of the coefficients obtained from the within and between estimations. Fixed effects models are the equivalent of OLS with a dummy variable for each unit of interest. See Kennedy (1992, pp. 222-3) and Stata (1999, pp. 420-40).

[18] A second problem with GLS is that it requires models to be completely specified, and becomes biased in the presence of within-panel correlation. This is problematic for our purposes, since it is highly unlikely that our models are completely specified—at least not in the sense of capturing all the possible time-varying influences on immunization coverage—so the assumption of within-panel homoskedasticity can not be met, even if we include some sort of adjustment for time effects. Using GLS in these circumstances would result in an anticonservative bias in the standard errors (Stata 1999, Wiggins 1999). For a discussion of the relative accuracy of OLS and robust estimation of standard errors vs. GLS models in the analysis of cross-sectional time-series data, see Beck and Katz (1995).

We therefore adopted a simpler, though less efficient, method of analysis. This involved the use of country dummies to adjust for heteroskedasticity between panels as well as unobserved or imperfectly-measured variables at the country level; year dummies to hold constant time-varying effects not captured by the variables included in the model; and OLS regressions with a Huber/White estimator to provide variance estimates robust to both panel-level heteroskedasticity and within-panel correlation. Results are therefore reported for models with fixed country and year effects. Tobit regression was used to censor observations were immunization coverage was less than zero or greater than 100 percent. These estimations could not be relied upon to provide unbiased standard errors in the presence of heteroskedasticity or non-spherical error terms. Since fewer than 12 observations were censored by the tobit regression in each model, and since the parameter estimates from tobit regression were essentially the same as those of the clustered OLS regressions originally conducted, the latter were considered unbiased.[19] The study's results are therefore presented as OLS regressions with robust standard errors, in Table 1. The selected models below were also estimated using GLS specifications, and the results were very similar to the preferred fixed country and fixed time specification.[20] Robustness

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[19] Tobit regression produced eleven right-censored observations for DTP3 and seven right-censored observations for measles.

[20] GLS estimations were carried out with autoregressive and panel-specific specifications, and GEE estimations with autoregressive, unstructured and exchangeable correlation structures. The unstructured specification, while theoretically the most appropriate for complex data with no clear correlation structure, could not be successfully calculated after 10,000 iterations of maximum-likelihood GEE estimation. AR1 and AR2 specifications with GEE provided coefficients that were similar in magnitude and direction to those obtained using the year and country dummies, though their standard errors differed to some extent. As expected, GLS estimations provided exaggerated estimates of significance (with independent, AR1 and PSAR1 specifications and an adjustment for panel heteroskedasticity) as compared with those obtained using year and country dummies, though again, the magnitude and direction of the coefficients were broadly similar. More specifically, in the eight additional regressions undertaken (three with GLS and one with GEE, for both DTP and measles), illiteracy was significant and negative in all eight (as it was in robust OLS with year but not country fixed effects, with coefficients ranging from –0.4 to –0.6), log of GDP was significant and positive in six (with coefficients, when significant, ranging from 1.04 to 1.50), log of population was significant and negative in three, log of population density was significant and positive in five, participation in the UNICEF fund was positive and significant in seven (coefficients 7.61 to 13.11), participation in the PAHO fund was significant and negative in six (it was negative in robust OLS without fixed country effects; GLS and GEE coefficients ranged from –3.25 to –9.04), foreign aid was significant and positive in seven (as it was in robust OLS without fixed country effects, coefficients 0.13 to 0.30), TVs per capita was significant and positive in all eight (as it was in robust OLS without fixed country effects, coefficients 0.04 to 0.06), democracy score was significant and positive in all eight (coefficients 5.14 to 6.77), state failure was never significant, institutional quality was significant and positive in all eight (coefficients 0.94 to 1.69), and the interaction of democracy and log of GDP was significant and negative in al eight (coefficients –0.64 to –1.18). The Durbin-Watson statistic of 0.8857, calculated using Bhargava et al.'s modification for panel data, provided a suggestive but inconclusive indication of the autoregressive character of the data (Bhargava, Franzini, and Narendrananthan 1982; Stata 2001). It was elected to take the more conservative approach using dummy variables for year and country rather than specifying a particular AR pattern.

checks were conducted on the final models, including the exclusion of high leverage observations. Again, the basic findings of the analysis were unchanged.[21]

For the analysis of hepatitis B vaccine adoption, we used a logit model with a binary outcome variable indicating whether or not the vaccine was in use in each country-year. Year dummies were used to fix time effects, in keeping with the logic described

above, but the sample size was too small for the inclusion of country fixed effects. The model specification is the same as for the coverage rate data, with the addition of current year DTP coverage rates as a right-hand-side variable. This was included to test the hypothesis that countries might be more inclined to adopt new vaccines if existing immunization delivery systems are strong. The results are reported as odds ratios with robust standard errors, in Table 2.

Table 1: Determinants of EPI vaccine coverage rates, low- and middle-income countries, 1980-1997

	DTP coverage: robust OLS with fixed country and fixed year effects (n = 963)		*Measles coverage: robust OLS with fixed country and fixed year effects (n = 937)*	
	Coefficient	*SE*	*Coefficient*	*SE*
Illiteracy Rate	0.30	0.30	0.82**	0.35
Log GDP per capita (1995 US$)	12.09**	3.96	19.79**	5.54
Log Population (millions)	–5.79	6.09	0.60	7.15
Log Population Density	–11.12	6.68	–11.45	7.78
Membership: UNICEF Vaccine Fund	8.62**	3.25	10.39**	3.12
Membership: PAHO Revolving Fund	13.67**	3.91	16.93**	4.92
Foreign Aid (% of GDP)	–0.05	0.06	–0.14	0.07
TVs per capita	0.01	0.01	0.00	0.01
Democracy Score (Polity IV)	9.45**	1.22	10.38**	1.36
Existence of State Failure	–3.60**	1.72	–1.21	1.75
Institutional Quality Score (ICRG)	1.14**	0.21	1.06**	0.24
Interaction Term: Log GDP per capita (1995 US$) x Democracy Score	–1.42**	0.17	–1.58**	0.20

**Significant at $p < 0.05$. Regressions include constants.

[21] Dropping high leverage observations leads the variable for state failure to lose significance in the measles estimation with fixed country and fixed year effects. The coefficients and standard errors on the other significant variables change very little. No variable gains or loses significance in the DTP estimation.

Table 2: Determinants of Hepatitis B vaccine adoption, low- and middle-income countries, 1980-1997

	Hepatitis B adoption: robust Logit with fixed year effects (n = 922)	
	Odds ratio	Z-score
DTP Coverage Rate	1.03**	2.24
Illiteracy Rate	1.02	1.45
Log GDP per capita (1995 US$)	2.99**	3.09
Log Population	0.75	–1.84
Log Population Density	1.01	0.05
Membership: UNICEF Vaccine Fund	0.05**	–2.18
Membership: PAHO Revolving Fund	0.15**	–4.30
Foreign Aid (% of GDP)	0.96	–1.88
TVs per capita	1.00	–1.64
Democracy Score (Polity IV)	3.65**	3.77
Existence of State failure	0.83	–0.40
Institutional quality score (ICRG)	1.34**	4.62
Interaction Term: Log GDP per capita (1995 US$) x Democracy Score	0.83**	–3.97

**Significant at $p < 0.05$.

Table 3: Determinants of EPI vaccine coverage rates, DHS data

	DTP coverage: robust OLS with fixed year effects(n = 71)		*Measles coverage: robust OLS with fixed year effects(n = 71)*	
	Coefficient	SE	Coefficient	SE
Illiteracy Rate	–0.46**	0.10	–0.28**	0.08
Log GDP per capita (1995 US$)	9.06**	3.78	9.42**	3.15
Log Population (millions)	–2.44	2.23	–0.87	1.96
Log Population Density	2.01	1.67	0.17	1.60
Membership: UNICEF Vaccine Fund	12.70	6.55	10.50	6.03
Membership: PAHO Revolving Fund	–9.20	6.16	–0.56	4.98
Foreign Aid (% of GDP)	0.44**	0.15	0.45**	0.15
TVs per capita	0.03	0.03	–0.01	0.03
Democracy Score (Polity IV)	7.78**	3.61	3.87	3.60
Existence of State Failure	4.30	4.93	6.41	3.92
Institutional Quality Score (ICRG)	1.98**	0.63	1.17**	0.47
Interaction Term: Log GDP per capita (1995 US$) x Democracy Score	–1.18**	0.55	–0.72	0.54

**Significant at $p < 0.05$. Regressions include constants.

Table 4: Summary statistics for estimation sample using WHO data

	Mean	*SD*	*n*	*Correlations with vaccine coverage (DTP, Measles) and adoption (Hep B)*		
Variables used in the regressions				DTP	Measles	Hep B
Illiteracy rate	32.71	24.94	2158	–0.43	–0.41	–0.08
GDP per capita (log)	7.05	1.17	2338	0.37	0.36	0.19
Population (log)	15.16	2.11	2922	–0.06	–0.05	–0.09
Population density (log)	3.85	1.52	2553	0.15	0.08	0.01
Participation in VII	0.02	0.12	3148	0.06	0.08	–0.04
Participation in PAHO Fund	0.19	0.39	3148	0.00	0.07	–0.17
Foreign aid (% GDP)	10.04	15.18	2156	–0.10	–0.08	–0.08
TVs per capita	126.29	141.56	2675	0.47	0.49	0.30
Democracy score	3.06	3.78	2017	0.23	0.23	–0.03
State failure	0.16	0.37	3148	–0.08	–0.11	–0.08
Institutional quality	15.84	5.00	1482	0.53	0.51	0.38
Democracy x Log(GDP)	25.06	29.53	1769	0.24	0.25	–0.03
Missing variable frequencies						
Illiteracy rate missing	0.31	0.46		0.11	0.10	0.12
GDP per capita missing	0.26	0.44		–0.02	–0.02	0.03
Population missing	0.07	0.26		0.10	0.08	0.00
Population density missing	0.19	0.39		0.10	0.11	0.04
Participation in VII missing	0	0				
Participation in PAHO missing	0	0				
Foreign aid missing	0.32	0.46		0.14	0.11	–0.01
TVs per capita missing	0.15	0.36		0.03	–0.03	0.06
Democracy score missing	0.36	0.48		0.12	0.07	0.15
State failure missing	0	0				
Institutional quality missing	0.53	0.50		–0.05	–0.08	0.03
Democracy x Log(GDP) missing	0.44	0.50		0.08	0.03	0.11

Findings

The models in Tables 1 and 2 were identified using a combination of forward and backward selection. A number of economic, social, demographic, political, and programmatic variables were not included in the final models either because the variables were not significant, or because the inclusion of the variables reduced the sample size to a point where the findings did not appear robust to small changes in the data or the specification. As a result, the verdicts on some hypotheses that this analysis was intended to examine, such as the impact of decentralization on immunization coverage, and the effects of paved roads, health spending, and access to health care facilities and health personnel, were inconclusive. There were 3,148 potential observations in the dataset (country-years from 1980-1997 among low- and middle-income countries). Dropping observations with missing data for GDP per capita and immunization coverage shrunk the potential dataset to

1,983 observations for DTP, 1,897 observations for measles, and 2,195 observations for hepatitis B adoption. The final models include about half that number of observations because of countries with missing data for the variables selected. The correlations between observations with missing data flags and coverage rates were generally weak (Table 4), suggesting that deleted observations are not biasing the results.

The c-statistic for the hepatitis B vaccine adoption model presented in Table 2 is 93 percent. In that model the coefficient for the DTP coverage rate variable is significant, and the odds ratio is, with a 95 percent confidence interval, 1.002 to 1.061, much lower than that found by Miller and Flanders (2000), who report an odds ratio for current DTP coverage rates of, with 95 percent confidence, 10.4 to 292.6. The reason for this is that Miller and Flanders do not include measures of the underlying political and institutional determinants of current coverage rates, including those (such as democracy, institutional quality and membership in procurement assistance schemes) that are found to be significant in the present study. Here, those variables are included separately, and the influence of DTP coverage on the adoption of new vaccines is commensurately reduced. Countries with strong institutions, autonomous public health agencies, and contacts with international donors are probably also those with the epidemiological and economic capacities necessary to justify new vaccine adoption, such as by calculating the years of life lost due to a disease or estimating treatment costs averted by a vaccination program.

This might explain why Miller and Flanders find these epidemiological and economic measures to be significant determinants of new vaccine adoption. However, a fuller understanding of this process will require more detailed qualitative research such as Muraskin's (1995) analysis of the adoption of hepatitis B vaccine in New Zealand and the work of Wenger and colleagues in Qatar, Chile, Uruguay and Kuwait (2000).

The model used in Tables 1 and 2 was also tested on the much smaller sample of countries with coverage rate data taken from DHS surveys, the results of which are presented in Table 3. The sample size was too small for the inclusion of fixed country effects, but the regression did include fixed year effects. Table 3 shows that, given the differences in sample size, the magnitudes of the coefficients and their significance levels are generally consistent with estimates based on the larger sample of countries with WHO data. Among the differences are the fact that in the regressions based on DHS data the illiteracy and foreign aid variables are significant negative and positive, respectively, and that the sign of the PAHO variable is negative. All three differences also appear, however, in regressions using WHO data without fixed country effects (not shown), suggesting that

this is probably not due to measurement errors in the dependent variables. The main substantive findings of this paper are described below.

Finding 1: The global policy environment significantly affected immunization coverage rates in countries at all income levels.

Figures 3 and 4 show that low-, middle-, and high-income countries all increased their average immunization coverage from 1981 to the early 1990s, when the rate of increase began to level off. Figure 5 shows the same phenomenon by region. Gains were apparent in the great majority of countries: of the 197 countries for which some DTP vaccine coverage rate data were available, only 26 countries had final recorded rates that were lower than their first recorded rate (22 for measles), and in 12 of those the last recorded rate was no more than three percentage points lower than the first. It is true that coverage rates fell sharply in some places. For instance, coverage with the DTP vaccine in Comoros fell from 82 percent in 1989 to 48 percent in1997, and the measles coverage rate declined in the Republic of Congo from 49 percent in 1981 to 18 percent in 1997. Still, the upward trend is visible among countries at all income levels and almost all regions of the world,[22] and the trend effect remains significant in the estimation equations when variables that were also increasing over the period (national income, population, democracy, institutional quality, etc.) are included. Year fixed effects by themselves explain 28 percent of the variance in DTP coverage rates in low income countries, 36 percent in middle income countries, and 17 percent in high income countries; and they account for 24 percent of the variance in the logit estimates of the introduction of the hepatitis B vaccine in low- and middle-income countries. The slowdown in the 1990s is understandable because the last people immunized are the hardest to reach, but the reason why immunization rates among disparate countries were almost all increasing to begin with is less obvious.

[22] The major exception is Eastern Europe, where average coverage rates hovered around 95 percent until 1991, when they started to fall, reaching 87 percent in 1994, before climbing back to around 95 percent in 1996 and 1997. By contrast, average coverage rates in countries of the former Soviet Union fluctuated from 1980 until 1994, when they began to climb.

Figure 3: DTP3 coverage rates by income level, 1980 to 1997

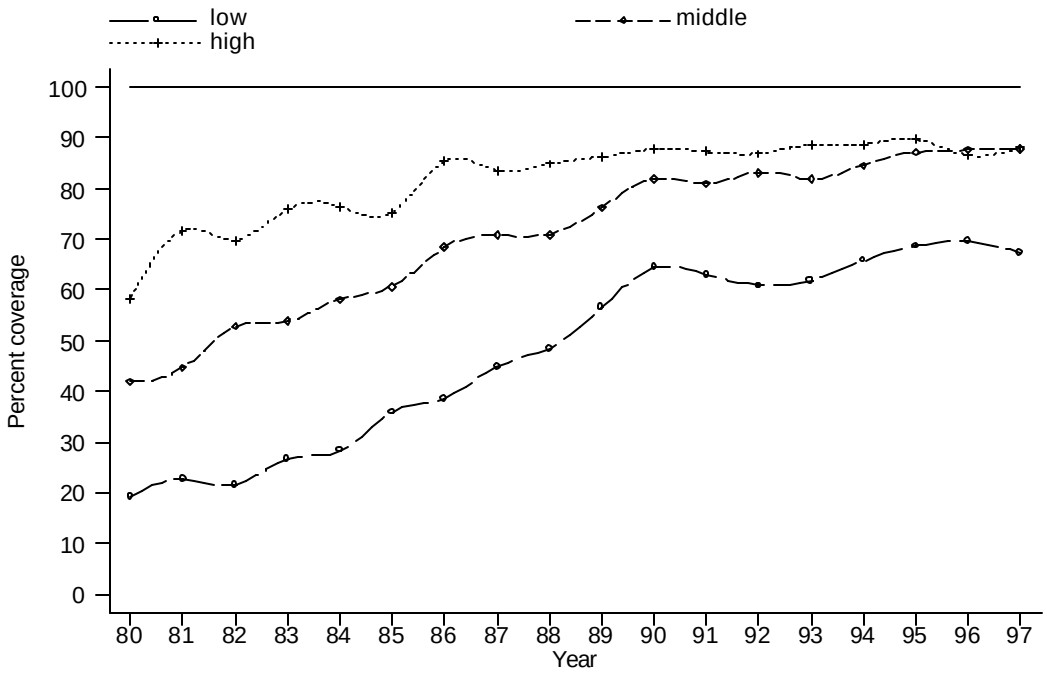


Figure 4: Measles coverage rates by income level, 1980 to 1997

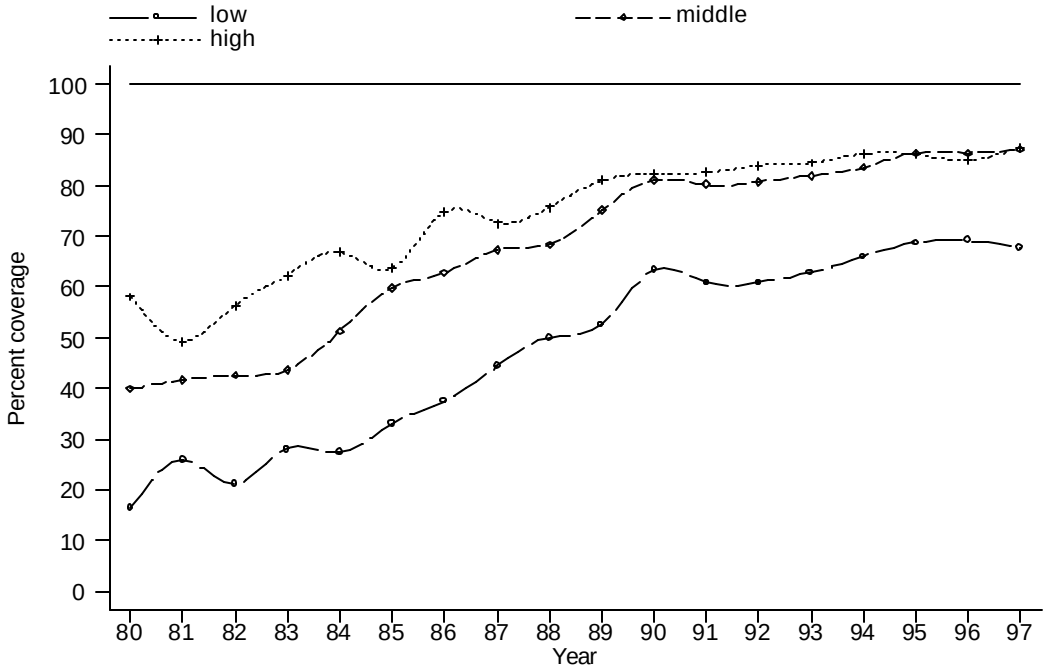
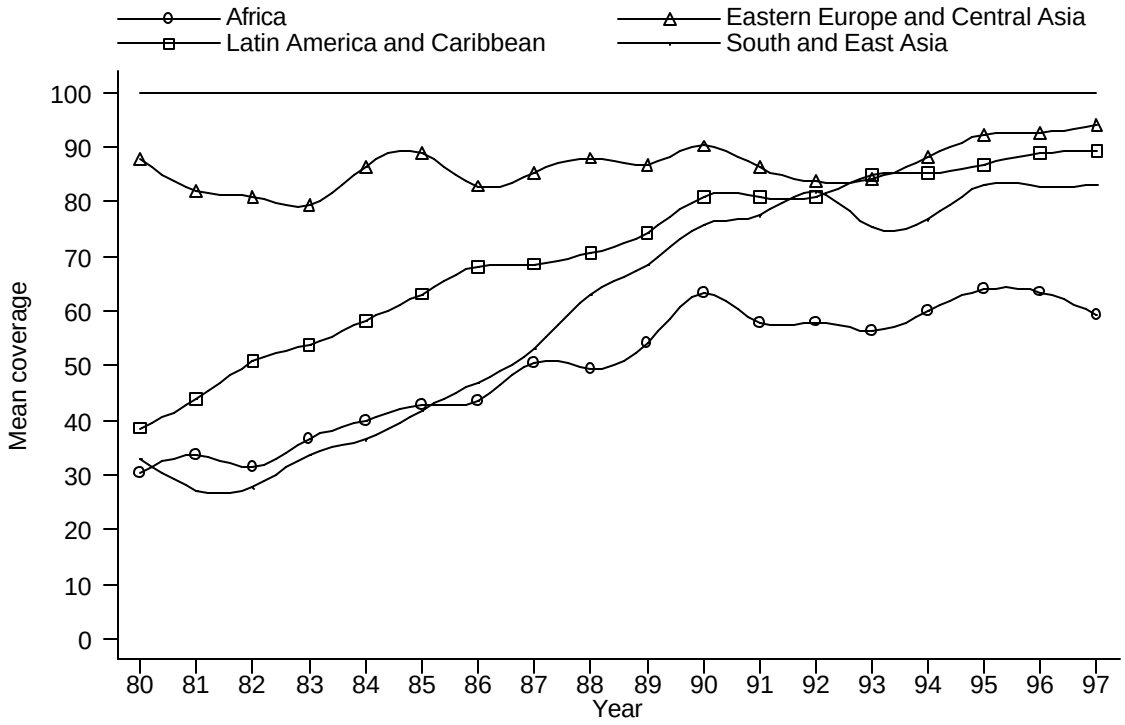


Figure 5: Immunization coverage rates by region, 1980-1997, average of DTP and measles



There are at least two potential explanations. First, it is possible the technology of vaccine production or delivery improved, and increased coverage rates are the result of simultaneous, uncoordinated choices on the part of governments to provide more immunization at a lower cost (and, where private consumption is significant, of individuals to purchase more at a lower price). The evidence, however, does not support this explanation. Prices for DTP and measles vaccines actually increased sharply over the time period in question, and while a number of important advances did occur in vaccine research and development, none affected the heat stability of EPI vaccines, reduced the number of doses required, or created an alternative to injected delivery, which are the most important technical impediments to their use in developing countries.[23,24]

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[23] The cost of EPI vaccines rose precisely during the period when immunization rates were increasing most quickly in low-, middle-, and high-income countries. The cost of the DTP vaccine to UNICEF went from $0.40 per vial in 1986 to $1.15 per vial in 1992 (20 doses per vial), while the cost of a vial of measles vaccine went from $0.68 to $1.60 over the same period (10 doses per vial). (Foster 1993) The per dose cost of the measles vaccine to the U. S. Centers for Disease Control went from $3.43 in 1986 to $9.93 in 1997. The CDC's per dose cost for DTP went from $3.01 to $14.06 over the same period, although in this case the comparison is not exact because in 1997 the formulation included acellular pertussis. (Historical price lists obtained from CDC, 2001) The reason for the increase in EPI vaccine prices are probably related to the departure of a number of manufacturers from the market over the past two decades, partly motivated by liability concerns. Several developing countries now produce EPI vaccines for their own consumption and for export, but it is unclear whether they do so at lower cost than the few remaining producers in industrialized

The more plausible explanation entails a coordinated international policy effort. The WHO's Expanded Program on Immunization, launched in 1974, and UNICEF's Universal Childhood Immunization Campaign (UCI), from 1985–1990, are credited with dramatically increasing immunization coverage rates in developing countries. They raised the profile of immunization in developing countries, provided technical assistance to developing country programs, and raised substantial contributions from multilateral and bilateral donors for vaccines, refrigerators, vehicles, and other immunization program inputs. Dummy variables for the pre- and post-UCI periods by themselves account for 20 percent and 24 percent of the variance in DTP and measles coverage rates, respectively (of the 24 percent and 27 percent altogether that can be attributed to fixed year effects). What is more surprising, however, is that the same trends are observable in high-income countries, where UNICEF activities were not operative. In fact, the pre- and post-UCI variables explain 7 percent of the variance for DTP and 21 percent for measles vaccine coverage in Western Europe. The United Kingdom saw its DTP and measles vaccine rates go from 44 and 52 percent, respectively, in 1981, to 95 percent each in 1997. This worldwide trend suggests that the WHO and UNICEF campaigns were parts of a broader worldwide change in the international policy environment. Professional exchanges and the transfer of knowledge across countries affected immunization in countries at every income level. Understanding how the diffusion worked, and whether patterns of communication regarding immunization were primarily contacts among key individuals, or whether some critical mass in society was required to expand immunization programs, requires more detailed historical research. (Valente 1995)

The focus on policy networks and donors suggests a second reason that pace of improvements slowed in the 1990s (in addition to the inevitable slowdown as countries rates approach the upper limit of 100 percent): international donors changed their priorities. Many reduced their support for routine immunization programs once the UCI period came to an end and new priorities, such as polio eradication, arose. UNICEF, for example, reduced its immunization funding from US$182 million to US$51.4 million between 1990 and 1998, and increased the proportion of funds spent on vaccine procurement (as opposed

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countries. Domestic production could conceivably create political incentives to consume vaccines domestically. One promising delivery vehicle for developing country EPI programs, not yet developed, is an inhaleable measles vaccine.

[24]Price does appear to be a significant factor in delaying the adoption of new vaccines, however, which are several times more expensive than EPI vaccines. (GAO 1999 pp.14-15, Wenger 2001) Like other agents, governments and donors seem to take more account of the prices of goods they have not yet purchased, in this case the newer vaccines, than price changes for goods they are already purchasing, EPI vaccines, because the latter have become institutionalized in public health programs and have bureaucratic and political constituencies.

to other forms of immunization support) from 25 percent in 1990 to 80 percent in 1998 (General Accounting Office 1999).

Finding 2: Contact with donor agencies raised coverage rates for EPI vaccines, but slowed adoption of new vaccines.

The parameter estimates for variables denoting membership in the PAHO and UNICEF revolving funds are significant, positive, and large in magnitude in the cases of measles and DTP. Other things being equal, belonging to the UNICEF fund raised a country's coverage rate for DTP, under 95 percent confidence intervals, by 2.2 – 15.0 percentage points, for measles by 4.3 – 16.5 percentage points. Membership in the PAHO fund raised DTP coverage 6.0 – 21.3 points and measles by 7.3 – 26.6 points. Even though most Latin American and Caribbean countries are members of the PAHO fund, the PAHO variable itself was the key explanatory factor: when an indicator variable for the Latin American and Caribbean region was included in the regression above, it was found to be insignificant while the parameter estimate on the PAHO variable remained unchanged.

In these "revolving funds" countries repay the donor agencies for vaccines purchased on their behalf or, in the case of some UNICEF and one or two PAHO countries, repay them with funds obtained from another donor. Vaccine prices that manufacturers offer UNICEF and PAHO tend to be somewhat lower than those the countries could obtain on their own, and member countries can repay the donors in local currency, so membership in the funds does include pecuniary benefits. But because the materials cost of EPI vaccines is small both in absolute terms (around $0.50-$1.00 for all doses of all six vaccines) and relative to overall program costs, the principal benefits of participation involve assistance in procurement, quality checks on the vaccines, and the associated technical and programmatic assistance that the donor agencies provide. A variety of donors make other financial contributions to the immunization programs of low- and middle-income countries, and it is possible that these less institutionalized, one-off grants, donations, and loans to countries do not have the same effect as membership in these funds. The fact that the coefficient on the foreign aid variable is not significant in the estimations is consistent with the idea that revenue assistance per se does not affect coverage rates.

One cannot rule out the idea that the political or economic characteristics that lead a country to join a donor fund drive up coverage rates, rather than activities of the donor agencies per se. But this possibility is hard to square with the fact that membership in both funds delayed adoption of the hepatitis B vaccine. It is hard to imagine a political characteristic of a country that would lead it to join a vaccine fund *and* compel it to delay

the incorporation of a new vaccine. It is more likely that the donor agencies themselves played an active role in the process. In this case, the donors had first promoted vaccination for high-risk groups. WHO recommended universal vaccination for hepatitis B in 1992, after evidence regarding its efficacy and cost-effectiveness became available, and called for the incorporation of it into all national immunization programs by 1997. (Hallauer 1995). Evidence on the effectiveness of hepatitis B from clinical trials and studies of hepatitis B endemicity and transmission in Chile and elsewhere was persuasive for Latin American and Caribbean countries (Fay 1990, Hurtado and others 1993). Cost and financing issues may also have been relevant to donors. UNICEF and PAHO did not begin to purchase the hepatitis B vaccine until 1993 and 1994 respectively, by which time several competing manufacturers had begun to produce the vaccine and its price had fallen from over $30 per dose to less than a dollar. And while UNICEF issued a formal policy in 1998, encouraging its country-level offices to take a leading role in introducing new vaccines in their countries, additional funds were not provided for this purpose. (General Accounting Office 1999) Thus, whether for reasons of epidemiological caution, cost concerns, or an inability to provide the necessary funds, donors seem to have slowed the adoption of hepatitis B vaccine in countries over which they had influence

Finding 3: Democratic government lowered coverage rates, but this effect was not observed at low income levels.

The parameter estimates on democratic government and on its interaction with the logarithm of per capita GDP were significant and had relatively small standard errors, and were strikingly robust to a variety of specifications in the DTP and measles models. A typical low-income country in 1997, with a GDP per capita of $400, had a DTP coverage rate that was, given a 95 percent confidence interval, 0.5 – 1.0 percentage points *higher* for each one point increase in its democracy score (which ranged from 0 to 10), controlling for time trends and other effects. To illustrate the scale of the democracy variable, the departure of Bangladesh's General Ershad from power in 1990 and the country's first competitive elections in 1991 moved that country's democracy score from 0 in 1990 to 6 in 1991. Bangladesh's DTP coverage rate increased (a much higher than expected) 18 percentage points between those two years. On the other hand, a typical middle income country in 1997, with a GDP per capita of $2,850, had a DTP coverage rate that was 1.7 – 2.5 percentage points *lower* for each one point increase in its democracy score. Peru's democracy score fell from 8 in 1991 to 2 in 1992 as President Fujimori closed Congress and suspended the judiciary, and Peru's DTP coverage rate increased from 71 percent to 83 percent between those two years. The income level at which the net democracy effect turns negative, for both measles and DTP, is $735 per capita (in constant 1995 U.S. dollars),

close to the cut-off point between low- and lower-middle income countries in 1997. The logit estimate for the odds of adopting hepatitis B vaccine also had a positive, significant coefficient for democracy score and a negative, significant coefficient on the interaction term with log GDP per capita; and, strikingly, since the model and the source of the data were different from those for the DTP and measles regressions, the hepatitis B estimates had a similar income level at which the net democracy effect turned negative, $990 per capita. (Table 2 shows odds ratios, not coefficients).

To explain this kind of democracy effect, two things need to be accounted for: why democratic governments achieve lower immunization coverage rates, and why that effect is not observed at low income levels. There are at least three explanations for why democracies might provide immunization services at relatively low rates in low- and middle-income countries. First, because democratic governments are more responsive to the demands of their constituents, and because the demand for hospitals, pharmaceuticals, and 'curative' medical care is stronger than the demand for vaccines, democracies might be more likely to reallocate health resources away from immunization and toward curative services, especially when consumer demand for health services increases alongside gains in income. A second and related reason is that the bureaucratic elites who run public health agencies, and who often favor vertical programs such as immunization, are granted more autonomy in autocratic regimes. Bureaucratic elites also utilize that autonomy more effectively as national income grows. Brazil's former public health agency, SUCAM, was established during the military dictatorship and was organized in quasi-military 'brigades' which, sporting uniforms and arm bands, led 'campaigns' to bring public health services into the Brazilian interior. Its martial organizational structure and culture became less attractive as Brazil democratized, and it was eventually restructured out of existence in 1991. Although it cannot be attributed to any single event, it is worth pointing out that DTP coverage in Brazil was 67 percent and 65 percent in 1984 and 1985, respectively, and 58 percent and 57 percent in 1986 and 1987, the years following the regime transition. Media interest, which tends to be higher in democratic countries, amplified concerns over the side-effects of immunization and led to declines in coverage rates in two democratic countries in the 1970s, the United Kingdom and Sweden. It is important to add the caveat that quasi-military organization, though arguably beneficial for EPI vaccine coverage over this time period, could hinder other public health objectives. For instance, the rigidity of the SUCAM was one reason why Brazil did not promptly shift malaria control strategies after evidence mounted that its mosquito eradication program of the 1980s was failing. More famously, free media and public scrutiny have helped democracies avoid famines (Sen 2000). Third, communist regimes, which historically have almost never permitted political contestation, might have an ideological affinity for immunization programs. The faith in government

control, while retarding productivity in most industries, might be valuable in activities where public sector action is called for, such as immunization. Vietnam, Cuba, and China had coverage rates over 90 percent by the early 1990s, and most of Eastern Europe had achieved similar rates in the early 1980s. Historical coverage rates in those countries might be somewhat exaggerated; but high levels of immunization coverage would be consistent with the widely acknowledged commitment to public health service provision in the Communist bloc.

There are two reasons why the negative relationship between democracy and immunization might not be observed in low-income countries. First, at low-income levels autocracy might be associated with political and societal isolation, and information regarding immunization that would otherwise accompany professional exchanges, foreign aid, and media contact is almost entirely blocked. Autocracy in poor countries might also be associated with outright theft of public resources more often than with technocratic leadership. Second, the democracy variable might be associated with trust, which is perhaps particularly important when the political capacity to mobilize communities is weak. While plausible, this explanation appears inconsistent with the results of the hepatitis B adoption model, in which the democracy effect is found to have the same magnitude and sign as in the coverage rate models, suggesting that the democracy effect operates primarily through government decisionmaking and not by increasing social trust in government programs.

Finding 4: The quality of a country's institutions and its level of development influence immunization coverage rates, but several variables related to the demand for vaccines do not.

Other things being equal, each one point increase in the quality of a country's institutions raised coverage rates by 0.6 – 1.5 percentage points (95 percent confidence interval), and made it 18 – 52 percent more likely that a country incorporated the hepatitis B vaccine into its immunization protocol. A 50 percent increase in the per capita income of a typical low-income country, going form $400 to $600 per capita, would raise DTP and measles coverage rates 1.7 – 8.0 and 3.6 – 14.8 percentage points, respectively. While the influence of a country's institutions would operate by increasing the efficiency of the distribution system, the effect of national income might work through both supply and demand channels. Note that the effect of joining an international revolving fund for vaccines is larger than a 50 percent increase in national income. Instances of ethnic or revolutionary war, or other adverse regime events and instances of genocide and politicide, all captured in the state failure variable, were, unsurprisingly, negatively associated with

coverage rates and vaccine adoption; but the variable was significant only for DTP coverage, and it lost significance when high leverage variables were dropped.

A variety of other variables thought to be related to immunization demand, most notably the illiteracy rate, were found not to be significant. (Table 1 shows that illiteracy is significantly and positively related to the measles coverage rate, but this appears to be a spurious correlation: deleting two outlier observations, Cameroon in 1983 and 1984, makes the illiteracy insignificant while leaving the coefficients and the standard errors on the other variables unchanged). The penetration of modern media also was not related to coverage rates: a measure of TVs per capita was not significant, and the same was true in earlier regressions that included variables for radios and newspapers per capita. Female labor force participation, related to women's empowerment, was not significant in earlier regressions and was not included in the final model. Given the importance attached to demand, educational levels, and trust in studies of immunization outcomes at the household level, these results might be surprising. The interpretation offered here is that immunization efforts at the national level between 1980 and 1997 were principally supply-side investments. This is consistent with available studies that find that immunization programs in the in the past two decades invested little in information, education, and communication activities,[25] with accounts of the weakness of social mobilization and community participation in such programs (UNICEF 1996 pp. 87-90),[26] and with findings in the present study that point to the importance of contact with donor agencies for raising coverage rates. Historical practice does not imply optimality, however, and it possible that immunization programs in developing countries might have been more efficient and more sustainable had there been greater emphasis on information and education. (Nichter 1995; Streefland 1995; UNICEF 1996; Levine, Rosenmöller, and Khaleghian 2001).

Finally, it was thought that changes in disease incidence in previous years might affect demand for vaccines in the current year, and earlier regressions included changes in diphtheria, pertussis, and measles incidence between the current and the previous current (incidence in year t minus incidence in year t-1), and changes in incidence lagged one year (incidence in year t-1 minus incidence in year t-2). Disease incidence was significant in just one of the six resulting regressions (change in measles incidence between current and the previous year), but the sign of the coefficient on the incidence variable was in the wrong direction (it was negative), and after eliminating one outlying observation it lost statistical

[25] In one series of case studies, IEC and social mobilization accounted for less than 0.8 percent of immunization program costs in Morocco (0.15 percent), Bangladesh (0.80 percent), Côte d'Ivoire (0.39 percent) and Ghana (0.51 percent) (Kaddar and others 2000, Levin and others 2001).

[26] An extreme example is Somalia, where army soldiers "mobilized" mothers and generated "demand" during immunization campaigns! (UNICEF 1996, p.88).

significance at $p<0.05$. The models used in this paper predict the level of immunization coverage rates, and it possible that changes in disease incidence are reflected not in overall coverage rates at the national level but in *changes* in coverage rates, so additional regressions (not shown) examined first differences in coverage as a function of first differences in incidence, and of the latter variable lagged. Again, none of the variables for changes in incidence was significant. There has also been a debate in the immunization community regarding the impact of polio eradication campaigns, in which the polio vaccine is widely distributed, on "routine" EPI vaccine programs. Using the change in polio incidence over the previous year as an indirect measure of the strength of campaigns to eradicate polio (and the same variable lagged one year), no relationship was found between polio campaigns and routine immunization.

Conclusions

Accounts of service delivery usually adopt a standard political economy approach. The resources of different interest groups, combined with the institutional landscape in which their resources are brought to bear, determine the outcomes of reform efforts. In that framework, regimes, institutions, and other "rules of the game" determine the objective of political actors—votes in most models of contested democracies, power or utility in other cases—and therefore also determine the channels through which the financial, organizational, and ideological resources of interest groups flow. That framework is useful in explaining why changes in the national system of health financing might be voted down, or why efforts to link teacher pay to performance founder. But the framework misses the role institutions and regimes play in facilitating the transfer of knowledge and motivating political and bureaucratic actors. These functions of institutions are especially important in services for which consumer demand and the material interests of providers are both weak, services which, though important, operate "below the radar" of most interest groups. Among the most important of these is the provision of basic vaccines for childhood diseases.

The factors that most affect immunization coverage rates in low- and middle-income countries involve broad changes in the global policy environment and contact with international agencies. Democracies tend to have lower coverage rates than autocracies, perhaps because bureaucratic elites in military governments and Leninist parties have an affinity for immunization programs, or perhaps because they are granted more autonomy and more resources than in democracies, although this effect is not visible in low-income countries. The reason for these effects, and the mechanisms through which they operate, warrant clarification in further quantitative and qualitative research. It is more

straightforward to understand why the quality of a nation's institutions and its level of development are related to immunization rate coverage. The evidence presented suggests that national coverage rates are in general more a function of supply-side than demand effects. There is no evidence that epidemics or polio eradication campaigns affect immunization rates one way or another, or that average immunization rates increase following outbreaks of diphtheria, pertussis, or measles.

Targeting immunization efforts on autocratic regimes is not the correct inference to draw from this analysis.[27] Rather, the findings underscore the importance of the exchange of professional knowledge, autonomy for public health managers, the quality of national institutions, and the involvement of international agencies in raising immunization coverage rates. The negative effect of democratic governance and the weakness of demand presuppose the existing structure of immunization programs, which generally include relatively small expenditures on information, education, and communication. Larger and more sustained efforts to motivate people to get vaccinated could create a new dynamic in which demand-side variables have more noticeable effects on coverage rates.

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[27] Nor is discouraging democracy so as to raise immunization rates (!).

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