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Effect of household relocation on child vaccination and health service utilization in Dhaka, Bangladesh: a cross-sectional community survey

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7 **Effect of household relocation on child vaccination and health service utilization in**
8 **Dhaka, Bangladesh: a cross-sectional community survey**
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Abstract

Objective To explore the relationship between household relocation and use of vaccination and health services for severe acute respiratory illness (ARI) among children in Dhaka, Bangladesh.

Design Analysis of cross-sectional community survey data from a prior study examining the impact of *Haemophilus influenzae* type b vaccine introduction in 2009 on meningitis incidence in Bangladesh.

Setting Communities surrounding two large pediatric hospitals in Dhaka, Bangladesh.

Participants Households with children under 5 years old who either recently relocated \leq 12 months or who were residentially stable living \geq 24 months in their current residence (total n = 10,720) were selected for this study.

Primary outcome measures Full vaccination coverage among 9-59 month old children and visits to a qualified medical provider for severe ARI among children under 5 years old.

Results Using vaccination cards with maternal recall, full vaccination was 80% among recently relocated children (n=3,795) and 85% among residentially stable children (n=4,713) ($p < 0.001$). Among children with ARI in the prior year, 69% of recently relocated children (n=695) had visited a qualified provider compared to 82% of residentially stable children (n=763; $p < 0.001$). After adjusting for demographic and socioeconomic characteristics, recently relocated children were less likely to be fully vaccinated (prevalence ratio [PR] 0.97; 95% confidence interval [CI] 0.95-0.99; $p = 0.016$) and to have visited a qualified provider for ARI (PR 0.88; 95% CI 0.84-0.93; $p < 0.001$).

Conclusions Children in recently relocated households in Dhaka, Bangladesh have decreased use of vaccination and qualified health services for severe acute respiratory illnesses.

Strengths and limitations of this study

- This study examined a rich dataset from prior community surveys in Dhaka, Bangladesh to explore associations between household relocation and utilization of vaccination and qualified child health services.
- Vaccination was evaluated using different measurements and age ranges to explore trends in the relationship between mobility and vaccination.
- Effect of household relocation on use of child health services was found even after adjusting for socioeconomic factors known to impact health-seeking behavior.
- Limitations include lack of detailed data on mobility patterns and costs of health services.

Introduction

Pneumonia or acute respiratory illness (ARI) is the leading cause of death globally in children under 5 years old and caused an estimated 703,000 deaths in 2015.[1] Many causes of ARI are preventable by vaccines such as *Streptococcus pneumoniae* (attributed to 56% of global pneumonia child deaths) and *Haemophilus influenzae* type b (Hib) (8% of deaths).[1] Rapid urbanization is leading to dramatic population growth, with estimated increase of 2.6 billion people in cities by 2050 and 90% of growth projected to occur in Asia and Africa.[2] Urbanization is fueling growth of slums in which residents lack reliable access to housing, clean water, sanitation, education, and health services.[3,4] A 2006 United Nations report highlights that immunization coverage in Niger was only 35% in slums compared to 86% in non-slum urban areas.[5] In Kenya, mortality estimates from 2008-2012 for children under 5 years old were 79.8 deaths per 1,000 in Nairobi slums versus 63.4 per 1,000 in non-slum areas.[6] Multiple factors contribute to poor health in slums including contaminated environments and lack of access to appropriate services.[5,7]

Residential mobility has been recognized as an important contributor to healthcare use in high-income countries, with relocation associated with decreased use of preventive and curative services.[4,8,9] One study using a 1998 United States national health survey found that duration, distance, and frequency of moving were all predictors of decreased use of child health services even after accounting for sociodemographic factors. Households who had moved within 12 months accessed fewer preventive child health services compared to households living in their current residence over 36 months (odds ratio 3.1, 95% confidence interval [CI] 2.5-3.7).[9] Recently relocated households also accessed fewer curative services (odds ratio 3.3, 95% CI 2.6-4.2).[9] Recent migrants are often poorer, less educated, and less connected to local services.[3,4,10-13] Frequent moving also impacts children's long-term cognitive function and behavioral problems into adulthood.[14]

Few studies examine mobility and healthcare utilization in low- and middle-income countries despite high population relevance: approximately 43% of urban residents in middle-

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3 income countries and 78% in low-income countries live in slums.[2,3,8,15,16] One study
4 examining Nigeria's 2003 Demographic and Health Survey found only 9% of rural-to-urban
5 migrant children over 12 months old were fully immunized compared to 15% of urban non-
6 migrant children and 24% of rural non-migrant children.[16] Receipt of first dose of
7 diphtheria, pertussis, and tetanus (DPT) vaccine recommended at 6 weeks of age was only
8 24% in rural-urban migrant children as compared to 47% in urban non-migrant and 63% in
9 rural non-migrant children.[16] This association between migration and vaccination could be
10 explained in part by socioeconomic factors as well as maternal healthcare utilization.[16]

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18 Studying urban health services in Bangladesh is useful because Bangladesh is the
19 world's most densely populated country that is not a city-state: the population of the capital
20 Dhaka will increase from an estimated 16 to 27 million by 2030.[2,17] Furthermore, the
21 government has a strong national Expanded Programme on Immunization (EPI) and active
22 health systems research.[17,18] In 2011, full vaccination rates among children age 12-23
23 months were 80% nationally in Bangladesh, 75% in Dhaka, but only 43-67% in Dhaka
24 slums.[17-21] Prior studies found that household turnover was as high as 50% in one year,
25 comprehensive provider-led vaccination interventions were effective but too expensive to
26 sustain, and street children were very hard to reach with interventions in Dhaka.[19,22,23]

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37 To explore the relationship between residential mobility and healthcare utilization in
38 Dhaka, we used data from a study showing Hib vaccine introduction into Bangladesh's EPI in
39 2009 dramatically reduced rates of Hib meningitis and purulent meningitis in children.[24]
40 We conducted secondary analysis of the Hib impact study's community survey data to
41 determine whether recently relocated children were: 1) less likely to be fully vaccinated per
42 EPI guidelines and 2) less likely to use qualified health services for severe acute respiratory
43 illness than residentially stable children.
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52 Methods

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Study design and setting

Hib conjugate vaccine was introduced into Bangladesh's EPI in 2009, and the Hib impact study conducted pre and post-vaccine surveillance of meningitis in children under 5 years old using hospital records and community surveys surrounding two large pediatric hospitals in Dhaka: Dhaka Shishu and Shishu Shastya Foundation Hospital.[24] Field researchers consecutively enrolled 100 children discharged with a diagnosis of meningitis and/or encephalitis from the two study hospitals, visited households, and recorded household geographical positional system coordinates. The catchment area was defined as the area containing >80% of households with children discharged with meningitis and within one hour of transport to either hospital. Field teams divided the catchment area into 1,748 equal-sized rectangles and randomly selected 100 rectangles as clusters. Teams surveyed each household with a child under 5 years old within 98 clusters. Two clusters were within a military cantonment, thus inaccessible. Households were asked about: 1) routine vaccinations using EPI cards and maternal recall and 2) healthcare use for children with illnesses in the prior 12 months suggestive of meningitis defined as fever plus altered mental status. Data were collected one year before (2008) and after (2010) Hib vaccine introduction.

Study population

We used the Hib impact study's pre-vaccine community surveillance data and included children based on mobility status: 1) children living in their current residence ≤ 12 months who we classified as "recently relocated" and 2) children living ≥ 24 months in their current residence who we classified as "residentially stable". We excluded children living in their current residence 13-23 months who we classified as "intermediately mobile".

Study outcomes

Our two primary outcomes focused on healthcare utilization: 1) full vaccination among 9-59 month old children and 2) visit to a qualified medical provider among children under 5 years old who had severe acute respiratory illness symptoms within the prior 12 months. We defined full vaccination per Bangladesh EPI guidelines in 2008 (before Hib vaccine): 1 dose of Bacillus Calmette-Guérin (BCG) vaccine against tuberculosis; 3 doses of combined vaccine against diphtheria, pertussis, and tetanus (DPT); 3 doses of oral polio vaccine (excluding polio vaccine given at birth); and 1 dose of measles vaccine. We defined severe acute respiratory illness as cough or difficulty breathing plus any danger sign: stridor, chest in-drawing, difficulty drinking/ breastfeeding, vomiting, cyanosis, convulsions, lethargy, or unconsciousness. We defined a qualified medical provider as having a Bachelor of Medicine degree or higher.

Data analysis

We compared sociodemographic and health characteristics between residentially stable and recently relocated households. For continuous variables, we calculated means with standard errors and t-tests adjusting for cluster. For categorical variables, we calculated percentages and χ^2 -tests. To construct a wealth index, we used polychoric principal components analysis (PCA) including: housing (number of rooms; free, rental, or owned housing; main material of roof, walls, and floors), cooking fuel, drinking water, sanitation, and mobile phone ownership.[25–27] We then divided households into wealth quintiles. We did not include durable assets such as furniture items because ownership of these goods could be associated with duration of residency.

To examine the magnitude of association between mobility and study outcomes of vaccination and visit to a qualified provider for severe ARI, we used modified Poisson regression adjusting for cluster to estimate prevalence ratios (PRs). We conducted univariate analyses to estimate individual effects of mobility, demographics, socioeconomics, and health services knowledge (i.e. knowledge of local hospital) on healthcare utilization. Missing data

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3 regarding main study outcome of acute respiratory illness were handled through listwise
4 deletion. Given large number of missing EPI cards, we analyzed vaccination in two ways: 1)
5 using EPI cards plus maternal recall and 2) using EPI cards alone. We conducted multivariate
6 analyses examining the association between mobility and healthcare utilization, adjusting for
7 demographics and socioeconomics known to influence health-seeking behavior.[7,10,11,13]
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15 **Ethics**

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18 The Ethical Review Committee of the International Centre for Diarrhoeal Disease
19 Research, Bangladesh (icddr,b) reviewed and approved the study protocol. Written informed
20 consent was obtained from all participants before taking part in the initial Hib impact study.
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26 **Patient and public involvement**

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28 No participants were directly involved in development of the research questions and
29 outcomes. No participants were involved in the design or conduct of the study. There are no
30 plans to disseminate the results of the research individually to study participants.
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36 **Results**

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38 We surveyed a total of 10,720 households with children less than 5 years old: 42% of
39 households had recently relocated within 12 months, 51% were residentially stable living in
40 their current residence over 24 months, and 7% were intermediately mobile (Figure 1). We
41 excluded the 700 intermediately mobile children from subsequent analyses. For the healthcare
42 utilization analysis, 1,458 children had severe ARI symptoms within the 12 months prior to
43 survey. For the vaccination analysis, 8,508 children were age 9-59 months and thus should
44 have completed all EPI-recommended vaccinations.
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52 Recently relocated families had smaller households, less education, less wealth, and
53 less knowledge of the local hospital compared to residentially stable families (Table 1).
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3 Recently relocated families were poorer: 24% earned less than 5,000 Bangladeshi taka (US
4 \$73) per month compared to 18% of residentially stable families. Household income was
5 missing for 12 out of 10,020 households. For the wealth index analysis, the first principal
6 component accounted for 51% of overall variance, with largest contributions from roof and
7 floor materials, sanitation, and mobile phone ownership (Supplemental Table 1). Among
8 recently relocated families, 48% were in the two poorest wealth quintiles compared to 37% of
9 residentially stable families. Fewer recently relocated caregivers had knowledge of the local
10 hospital, 76%, compared to residentially stable caregivers, 85%. Similar rates of illness in the
11 12 months prior to survey were reported by all households: 14-15% of children with
12 symptoms of severe ARI and 3-4% with symptoms of meningitis/encephalitis.
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22 Full vaccination coverage measured by EPI card plus maternal recall was 83% among
23 all children age 9-59 months (Table 2). Full vaccination was 80% among recently relocated
24 children and 85% among residentially stable children (univariate PR 0.94, 95% CI 0.91-0.97,
25 $p < 0.001$). Vaccination was lower in households with more children and younger children.
26 Socioeconomic factors, especially mother's education, had the strongest association with
27 vaccination. In multivariate analyses, recently relocated children were 3% less likely than
28 residentially stable children to be fully vaccinated even after adjusting for demographic and
29 socioeconomic factors (multivariate PR 0.97, 95% CI 0.95-0.99, $p = 0.016$).
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38 Vaccination was also analyzed using only EPI cards (Table 3). At time of survey,
39 only 43% of all children had EPI cards available. Fewer recently relocated children had EPI
40 cards, 36%, compared to 48% of residentially stable children ($p < 0.001$). Full vaccination per
41 EPI card was 83% among recently relocated children and 86% among residentially stable
42 children ($p = 0.083$). The 9-59 month age range for full vaccination analysis allowed inclusion
43 of a larger sample size of children vulnerable to vaccine-preventable diseases. Narrowing the
44 age range to 9-23 months showed similar results although with smaller sample sizes limiting
45 statistical power to detect mobility-vaccination associations (Supplementary Tables 2 and 3).
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3 In addition, using a 10-month age minimum to account for potential delay in measles
4 vaccination showed the same results as a 9-month age cutoff (data not shown).
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7 Among all children under 5 years old with severe ARI in the past year, 75% visited a
8 qualified medical provider (Table 4). Fewer recently relocated children with severe ARI saw
9 a qualified provider, 69%, as compared to 82% of residentially stable children (univariate PR
10 0.84, 95% CI 0.79-0.90, $p < 0.001$). Socioeconomic factors, especially household wealth, were
11 strongly associated with qualified provider visits.
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17 Health services knowledge was also strongly associated with acute healthcare visits:
18 80% of parents who knew about the local hospital sought ARI treatment from a qualified
19 provider as compared to 51% of parents who did *not* have knowledge of the local hospital
20 (univariate PR 1.57, 95% CI 1.34-1.85, $p < 0.001$). After adjusting for demographic and
21 socioeconomic factors, recently relocated households were 11% less likely than residentially
22 stable households to visit a qualified medical provider for children with severe ARI
23 (multivariate PR 0.88, 95% CI 0.84-0.93, $p < 0.001$).
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32 Discussion

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35 Recently relocated households were less likely to use both acute and preventive child
36 healthcare services in our study in Dhaka, Bangladesh, and these findings support prior
37 literature exploring the effects of mobility on healthcare utilization.[8,9,14,16] Household
38 relocation had a strong association with decreased use of qualified medical services for severe
39 acute respiratory illness. Similarly, household relocation was associated with decreased
40 vaccination rates although this relationship was less robust. Another key finding was that
41 recently relocated parents were less knowledgeable about the local hospital compared to
42 residentially stable parents, and knowledge of the local hospital had as strong an association
43 with acute healthcare visits as some economic factors. Overall, recently relocated children in
44 our study had slightly lower vaccination rates and markedly lower use of acute healthcare
45 services for ARI than residentially stable children.
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3 Study strengths include data focused on urban Bangladesh and exploring vaccination
4 status using different measurements as well as adjusting for socioeconomic factors when
5 examining mobility and health service utilization. Our study used the Hib impact study's
6 rigorous community surveillance data of households living close to tertiary care pediatric
7 hospitals in Dhaka. Dhaka residents have high mobility and many options for healthcare.
8 Unlike in rural areas, physical access to health services is usually *not* a barrier to healthcare
9 use in urban areas. One study found almost all residents in Dhaka lived within 1 kilometer of
10 primary health services.[28] Routine immunizations are provided free by the government of
11 Bangladesh, but acute care services require out of pocket expenditures which can be a barrier
12 to access. Our findings on mobility and child health services use in Dhaka could inform
13 health services work in other urban low- and middle-income country contexts.[2,6,7]

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15 We analyzed vaccination using EPI card data augmented with maternal recall, EPI
16 card data only, and several different age ranges. Vaccination status can be difficult to measure
17 in community surveys. Written documentation of vaccination is objective and easy to
18 measure, but EPI card retention can be affected by parental education, household wealth, age
19 of child, and even household relocation. Although maternal recall can be influenced by
20 education, social desirability bias, and vaccine-specific knowledge, studies in low- and
21 middle-income countries show high correlation between maternal recall and EPI cards.[29–
22 31] Using only EPI cards or narrower age ranges in our vaccination analyses resulted in
23 smaller sample sizes which limited statistical power, but all analyses showed similar effect
24 estimates of increased mobility associated with decreased vaccination. Moreover, the
25 association between increased household relocation and decreased health services use was
26 still seen even after adjusting for socioeconomic factors known to impact healthcare use.

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28 Study limitations include lack of data on mobility patterns and health services costs.
29 Information on households' prior residences, distances moved, or frequency of moving was
30 not available in our dataset. Households moving from rural Bangladesh to urban Dhaka,
31 moving long distances, or relocating frequently probably have less knowledge and therefore

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3 use of locally available health services.[9] Our findings thus likely underestimate the
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5 association between mobility and healthcare utilization for households with large migration
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7 changes. We were also unable to examine household relocation timing in relation to
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9 healthcare use. Recently relocated households were not asked if healthcare visits occurred
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11 before or after moving. Healthcare visits before moving would not be relevant to how
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13 mobility affects use of health services after moving. Our findings likely underestimate the
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15 association between mobility and health-seeking behavior. Ultimately, our results show a
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17 modest overall association between mobility and healthcare use which could be elucidated by
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19 asking about migration patterns including timing of use of health services.

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21 Our dataset did not contain cost of services, which is a well-known barrier to
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23 healthcare use.[11,20,21] Although vaccinations are provided for free, some non-
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25 governmental and private organizations charge fees for patient registration. Even small fees
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27 could have lowered vaccination rates. Cost of services, willingness to pay, and underlying
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29 finances are strongly linked, thus adjusting for socioeconomic factors of parental education
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31 and wealth in our models should have incorporated some cost effects on healthcare use.
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33 However, costs could affect recently relocated households disproportionately more than
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35 residentially stable households of the same socioeconomic status. One could hypothesize that
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37 immediately after relocating, families would first spend money on household goods before
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39 preventive medicine fees. Without cost data, we can still conclude from our analysis that
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41 increased mobility is associated with decreased healthcare use, but we have limited
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43 understanding of mechanisms through which mobility affects healthcare use.

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45 Barriers and delays to using appropriate healthcare services increase mortality.[11,32]
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47 One study in India of 290 children hospitalized for pneumonia in a tertiary care center found
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49 that delayed hospital referral, defined as three or more days between symptom onset and
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51 hospitalization, was associated with increased mortality (OR 52.1, 95% CI 6.7-402.4,
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53 $p < 0.001$) after adjusting for age, residence in slum, and illness severity.[32] In this study,
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55 incomplete immunization was also associated with increased mortality (OR 12.3, 95% CI 2.2-

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3 69.9, $p=0.005$).[32] Reasons for delayed care-seeking can include access and cost. While cost
4 does influence healthcare use, parents of sick children usually do seek some treatment. In the
5 2014 Bangladesh Demographic and Health Survey, 52% of urban parents with children with
6 ARI symptoms in the 2 weeks prior to survey sought treatment from a health facility, 23%
7 went to pharmacies, and 12% went to traditional practitioners.[33] Only 12% of parents with
8 sick children sought no health care treatment at all.[33] While cost does not seem a large
9 barrier to seeking any treatment at all, cost likely influences choice of health provider.
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16 Household relocation disrupts prior relationships with healthcare providers and
17 results in lack of familiarity with local services. Studies show that continuity of care is
18 associated with increased vaccination, fewer emergency department visits, and decreased
19 hospitalization among children.[9,34–36] People usually move to new areas because of pre-
20 existing social connections through family, friends, or work.[4,37] These social contacts can
21 act as pathways of important local knowledge, including health services, but recently
22 relocated households have fewer social contacts and access fewer information sources. Other
23 studies have also found that parental attitudes and knowledge are critical factors contributing
24 to use of health services.[38–40] One literature review found that *practical* knowledge about
25 vaccination schedule, timing, and logistics had a stronger association with vaccination uptake
26 than scientific knowledge of vaccine names or biologic actions.[40]
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38 Our finding that recently relocated children in Dhaka use fewer qualified health
39 services compared to residentially stable children sheds light on health barriers faced by a
40 growing population of children living in urban centers of low- and middle-income countries.
41 Policymakers working to improve urban child health could invest in accurate counting of
42 children living in communities with high household turnover in order to connect recently
43 relocated households to already existing local health services. Further studies by researchers
44 on patterns and mechanisms through which mobility affects healthcare use could inform
45 critical intervention points. Ultimately, cost-effective and targeted interventions to increase
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3 appropriate healthcare use among recently relocated children could improve health of future
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5 urban populations.
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8 9 **Contributors**

10 SL was the Principal Investigator and involved in every aspect of the study from
11 conceptualization to data analysis to manuscript writing and submission. NS, JA, and LH
12 were involved in data analysis, and LH drafted the written work. All authors collaborated on
13 and approved the final manuscript.
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18 19 20 **Competing interests**

21 None declared.
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26 27 **Provenance and peer review**

28 Not commissioned; externally peer reviewed.
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32 33 **Ethical considerations**

34 The Ethical Review Committee of the International Centre for Diarrhoeal Disease
35 Research, Bangladesh (icddr,b) reviewed and approved the study protocol.
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40 41 **Participant consent**

42 Written informed consent was obtained from all participants before taking part in the
43 initial Hib impact study.
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51 Gates Foundation and the GAVI Hib Initiative (GR-00580). No additional funding was
52 provided for this study.
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Data sharing

Data are available by emailing the corresponding author LH at lhong@stanford.edu.

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References

- 1 Wang H, Naghavi M, Allen C, *et al*. Global, regional, and national life expectancy, all-cause mortality, and cause-specific mortality for 249 causes of death, 1980–2015: a systematic analysis for the Global Burden of Disease Study 2015. *Lancet* 2016;**388**:1459–544.
- 2 United Nations, Department of Economic and Social Affairs, Population Division. World Urbanization Prospects: The 2014 Revision. New York: 2014. <http://esa.un.org/unpd/wup/Publications/Files/WUP2014-Report.pdf> (accessed 3 Feb 2016).
- 3 United Nations Human Settlements Programme. The challenge of slums: global report on human settlements 2003. *UN-HABITAT* 2003.
- 4 Rashid SF. Strategies to reduce exclusion among populations living in urban slum settlements in Bangladesh. *J Health Popul Nutr* 2009;**27**:574–86.
- 5 Habitat UN. State of the World's Cities 2006/7. *New York: United Nations* 2006.
- 6 African Population and Health Research Center (APHRC). Population and health dynamics in Nairobi's informal settlements: report of the Nairobi Cross-sectional Slums Survey (NCSS) 2012. Nairobi: : African Population and Health Research Center (APHRC) 2014.
- 7 Unger A. Children's health in slum settings. *Arch Dis Child* 2013;**98**:799–805. doi:10.1136/archdischild-2011-301621
- 8 Jelleyman T, Spencer N. Residential mobility in childhood and health outcomes: a systematic review. *J Epidemiol Community Health* 2008;**62**:584–92.
- 9 Fowler MG, Simpson GA, Schoendorf KC. Families on the move and children's health care. *Pediatrics* 1993;**91**:934–40.
- 10 Quaiyum MA, Gazi R, Khan AI, *et al*. Programmatic aspects of dropouts in child vaccination in Bangladesh: findings from a prospective study. *Asia Pac J Public Health* 2011;**23**:141–50. doi:10.1177/1010539509342119
- 11 Hussain A, Ali SM, Kvåle G. Determinants of mortality among children in the urban slums of Dhaka city, Bangladesh. *Trop Med Int Health* 1999;**4**:758–64.
- 12 Awoh AB, Plugge E. Immunisation coverage in rural–urban migrant children in low and middle-income countries (LMICs): a systematic review and meta-analysis. *J Epidemiol Community Health* 2016;**70**:305–11.
- 13 Kusuma YS, Kumari R, Pandav CS, *et al*. Migration and immunization: determinants of childhood immunization uptake among socioeconomically disadvantaged migrants in Delhi, India. *Trop Med Int Health* 2010;**15**:1326–32.
- 14 Wood D, Halfon N, Scarlata D, *et al*. Impact of family relocation on children's growth, development, school function, and behavior. *JAMA* 1993;**270**:1334–8.
- 15 Patel RB, Burke TF. Urbanization--an emerging humanitarian disaster. *N Engl J Med* 2009;**361**:741–3. doi:10.1056/NEJMp0810878

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3 16 Antai D. Migration and child immunization in Nigeria: individual-and community-level
4 contexts. *BMC Public Health* 2010;**10**:116.
- 5
6 17 NIPOORT, icddr,b, MEASURE Evaluation. Bangladesh Urban Health Survey 2013 Final
7 Report. 2015. <http://www.cpc.unc.edu/measure/resources/publications/tr-15-117>
8 (accessed 3 Feb 2016).
- 9
10 18 Government of Bangladesh. Bangladesh EPI coverage evaluation survey 2011, Expanded
11 Programme on Immunization. 2011.
12 [http://www.dghs.gov.bd/images/docs/EPI/CES%20Reports/EPI%20Coverage%20Evalua](http://www.dghs.gov.bd/images/docs/EPI/CES%20Reports/EPI%20Coverage%20Evaluation%20Survey%202011.pdf)
13 [tion%20Survey%202011.pdf](http://www.dghs.gov.bd/images/docs/EPI/CES%20Reports/EPI%20Coverage%20Evaluation%20Survey%202011.pdf)
- 14
15 19 Hayford K, Uddin MJ, Koehlmoos TP, *et al.* Cost and sustainability of a successful
16 package of interventions to improve vaccination coverage for children in urban slums of
17 Bangladesh. *Vaccine* 2014;**32**:2294–9. doi:10.1016/j.vaccine.2014.02.075
- 18
19 20 Uddin MJ, Larson CP, Oliveras E, *et al.* Child immunization coverage in urban slums of
20 Bangladesh: impact of an intervention package. *Health Policy Plan* 2010;**25**.
21 doi:10.1093/heapol/czp041
- 22
23 21 Perry H, Weierbach R, Hossain I, *et al.* Childhood immunization coverage in zone 3 of
24 Dhaka City: the challenge of reaching impoverished households in urban Bangladesh.
25 *Bull World Health Organ* 1998;**76**:565–73.
- 26
27 22 Luby SP, Halder AK, Saha SK, *et al.* A low-cost approach to measure the burden of
28 vaccine preventable diseases in urban areas. *Vaccine* 2010;**28**:4903–12.
29 doi:10.1016/j.vaccine.2010.05.040
- 30
31 23 Uddin MJ, Shamsuzzaman M, Horng L, *et al.* Use of mobile phones for improving
32 vaccination coverage among children living in rural hard-to-reach areas and urban streets
33 of Bangladesh. *Vaccine* 2016;**34**:276–83. doi:10.1016/j.vaccine.2015.11.024
- 34
35 24 Sultana NK, Saha SK, Al-Emran HM, *et al.* Impact of introduction of the Haemophilus
36 influenzae type b conjugate vaccine into childhood immunization on meningitis in
37 Bangladeshi infants. *J Pediatr* 2013;**163**:S73–8.
- 38
39 25 Vyas S, Kumaranayake L. Constructing socio-economic status indices: how to use
40 principal components analysis. *Health Policy Plan* 2006;**21**:459–68.
41 doi:10.1093/heapol/czl029
- 42
43 26 Luby SP, Halder AK. Associations among handwashing indicators, wealth, and
44 symptoms of childhood respiratory illness in urban Bangladesh. *Trop Med Int Health*
45 2008;**13**:835–44. doi:10.1111/j.1365-3156.2008.02074.x
- 46
47 27 Sharker MY, Nasser M, Abedin J, *et al.* The risk of misclassifying subjects within
48 principal component based asset index. *Emerg Themes Epidemiol* 2014;**11**:6.
- 49
50 28 Heller LR. Do slums matter? Location and early childhood preventive care choices
51 among urban residents of Bangladesh. *Soc Sci Med* 2013;**94**.
52 doi:10.1016/j.socscimed.2013.06.011
- 53
54 29 Murray CJ, Shengelia B, Gupta N, *et al.* Validity of reported vaccination coverage in 45
55 countries. *Lancet* 2003;**362**:1022–7.

- 1
2
3 30 Miles M, Ryman TK, Dietz V, *et al.* Validity of vaccination cards and parental recall to
4 estimate vaccination coverage: a systematic review of the literature. *Vaccine*
5 2013;**31**:1560–8. doi:10.1016/j.vaccine.2012.10.089
- 6
7 31 Brown J, Monasch R, Bicego G, *et al.* *An assessment of the quality of national child*
8 *immunization coverage estimates in population-based surveys.* MEASURE Evaluation,
9 Carolina Population Center, University of North Carolina at Chapel Hill 2002.
- 10
11 32 Bokade CM, Madhura AD, Bagul AS, *et al.* Predictors of mortality in children due to
12 severe and very severe pneumonia. *Niger Med J* 2015;**56**:287.
- 13
14 33 National Institute of Population Research and Training - NIPORT/Bangladesh, Mitra and
15 Associates, ICF International. *Bangladesh Demographic and Health Survey 2014.* Dhaka,
16 Bangladesh: : NIPORT, Mitra and Associates, and ICF International 2016.
17 <http://dhsprogram.com/pubs/pdf/FR311/FR311.pdf>
- 18
19 34 Christakis DA, Mell L, Wright JA, *et al.* The association between greater continuity of
20 care and timely measles-mumps-rubella vaccination. *Am J Public Health* 2000;**90**:962.
- 21
22 35 Christakis DA, Mell L, Koepsell TD, *et al.* Association of lower continuity of care with
23 greater risk of emergency department use and hospitalization in children. *Pediatrics*
24 2001;**107**:524–9.
- 25
26 36 Van Walraven C, Oake N, Jennings A, *et al.* The association between continuity of care
27 and outcomes: a systematic and critical review. *J Eval Clin Pract* 2010;**16**:947–56.
- 28
29 37 Kuhn R. Identities in motion: Social exchange networks and rural-urban migration in
30 Bangladesh. *Contrib Indian Sociol* 2003;**37**:311–37.
- 31
32 38 Mills E, Jadad AR, Ross C, *et al.* Systematic review of qualitative studies exploring
33 parental beliefs and attitudes toward childhood vaccination identifies common barriers to
34 vaccination. *J Clin Epidemiol* 11;**58**:1081–8. doi:10.1016/j.jclinepi.2005.09.002
- 35
36 39 Rainey JJ, Watkins M, Ryman TK, *et al.* Reasons related to non-vaccination and under-
37 vaccination of children in low and middle income countries: findings from a systematic
38 review of the published literature, 1999–2009. *Vaccine* 2011;**29**:8215–21.
- 39
40 40 Favin M, Steinglass R, Fields R, *et al.* Why children are not vaccinated: a review of the
41 grey literature. *Int Health* 2012;**4**:229–38.
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Tables

Table 1: Mobility status of study households with children age 0-59 months and association with demographic, socioeconomic, and health characteristics using t- and χ^2 -tests

	Residentially stable, ≥ 24 months n=5513		Recently relocated, ≤ 12 months n=4507		p-value
<u>Demographics</u>	<u>mean</u>	<u>SE</u>	<u>mean</u>	<u>SE</u>	
Number of household members	5.40	0.09	4.60	0.10	<0.001
Number of children <5yrs in household	1.28	0.01	1.25	0.01	0.194
Age of index child in months	30.0	0.23	28.7	0.25	<0.001
	<u>n</u>	<u>%</u>	<u>n</u>	<u>%</u>	
Sex of index child: Male	2478	45	2048	45	0.622
<u>Socioeconomics</u>					
Mother's education					<0.001
No education	1133	21	1162	26	
Some schooling	1142	21	1176	26	
Finished secondary	1849	34	1483	33	
> Secondary	1389	25	686	15	
Father's education					<0.001
No education	1261	23	1139	25	
Some schooling	913	17	911	20	
Finished secondary	1525	28	1372	30	
> Secondary	1814	33	1085	24	
Occupation of household head					<0.001
Unemployed or other	482	9	232	5	
Daily labor	916	17	1218	27	
Shopkeeper or merchant	1787	32	1058	23	
Salaried service	2328	42	1999	44	
Monthly household income ^a					<0.001
$\leq 5,000$ taka (US \$73)	971	18	1080	24	

5,001 – 10,000 taka	1634	30	1925	43	
> 10,000 taka (US \$145)	2900	53	1498	33	
Household wealth index ^b					<0.001
Poorest	1092	20	1110	25	
Lower middle	922	17	1021	23	
Middle	966f	18	911	20	
Upper middle	1455	26	1155	26	
Richest	1078	20	310	7	
<u>Health services knowledge</u>					
Knowledge of local hospital	4709	85	3428	76	<0.001
<u>Health outcomes</u>					
Severe acute respiratory illness suffered by index child within 12 months ^c	763	14	695	15	0.026
Meningitis/encephalitis suffered by index child within 12 months ^d	185	3	164	4	0.443

^a12 respondents (8 residentially stable and 4 recently relocated) did not know or did not disclose household income.

^bPolychoric Principal Components Analysis was used to create a household wealth index including structural housing characteristics, cooking fuel, drinking water, and sanitation.

^cOne residentially stable respondent did not know if child recently had a severe acute respiratory illness.

^dThree respondents did not know if child recently had a serious illness with mental status changes (2 residentially stable and 1 recently relocated).

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Table 2: Using EPI card plus maternal recall, vaccination coverage among children age 9-59 months and association with mobility status using univariate and multivariate models with modified Poisson regression

	Partial vaccination n=1465 (17%)		Full vaccination ^a n=7043 (83%)		PR ^b	95% CI	p-value
<u>Univariate analyses</u>							
Mobility status	<u>n</u>	<u>%</u>	<u>n</u>	<u>%</u>			
Residentially stable ≥ 24 months	706	15	4007	85	Reference		
Recently relocated ≤ 12 months	759	20	3036	80	0.94	0.91-0.97	<0.001
Demographics	<u>mean</u>	<u>SE</u>	<u>mean</u>	<u>SE</u>			
Number of children <5yrs in household	1.31	0.02	1.25	0.01	0.96	0.93-0.98	0.002
Age of index child in months	32.0	0.44	34.2	0.16	1.002	1.001-1.003	<0.001
Socioeconomics							
Mother's education	<u>n</u>	<u>%</u>	<u>n</u>	<u>%</u>			
No education	629	31	1377	69	Reference		
Some schooling	401	21	1540	79	1.16	1.10-1.21	<0.001
Finished secondary	323	11	2513	89	1.29	1.23-1.36	<0.001
> Higher secondary	112	6	1613	94	1.36	1.30-1.43	<0.001
Occupation of household head							
Unemployed or other	106	17	505	83	Reference		
Daily labor	524	29	1283	71	0.86	0.82-0.90	<0.001
Shopkeeper or merchant	348	14	2084	86	1.04	0.99-1.08	0.112
Salaried service	487	13	3171	87	1.05	1.01-1.09	0.029
Household wealth status (PCA ^c)							
Poorest	596	32	1290	68	Reference		
Lower middle	334	20	1298	80	1.16	1.09-1.24	<0.001
Middle	242	15	1348	85	1.24	1.16-1.32	<0.001
Upper middle	193	9	2043	91	1.34	1.25-1.42	<0.001
Richest	100	9	1064	91	1.34	1.25-1.43	<0.001
Health services knowledge							
Does <i>not</i> have knowledge of local hospital	354	23	1218	77	Reference		
Has knowledge of local hospital	1111	16	5825	84	1.08	1.05-1.12	<0.001

<u>Multivariate analyses with different models</u>			
Mobility, adjusting for demographics (# of children and age of index child)	0.94	0.92-0.97	<0.001
Mobility, adjusting for socioeconomics (education, occupation, and wealth)	0.97	0.95-0.99	0.009
Mobility, adjusting for demographics and socioeconomics	0.97	0.95-0.99	0.016

^aFull vaccination coverage per EPI program includes 1 dose of BCG, 3 doses of polio, 3 doses of DPT, and 1 dose of measles vaccines.

^bPR, Prevalence Ratio.

^cPolychoric Principal Components Analysis was used to create a household wealth index including structural housing characteristics, cooking fuel, drinking water, and sanitation.

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Table 3: Using EPI card only, vaccination coverage among children age 9-59 months who have EPI cards and association with mobility status using univariate and multivariate models with modified Poisson regression

	Partial vaccination n=564 (15%)		Full vaccination ^a n=3085 (85%)		PR ^b	95% CI	p-value
<u>Univariate analyses</u>							
Mobility status	<u>n</u>	<u>%</u>	<u>n</u>	<u>%</u>			
Residentially stable ≥ 24 months	329	14	1948	86	Reference		
Recently relocated ≤ 12 months	235	17	1137	83	0.97	0.93-1.00	0.083
Demographics	<u>mean</u>	<u>SE</u>	<u>mean</u>	<u>SE</u>			
Number of children <5yrs in household	1.26	0.02	1.24	0.01	0.99	0.96-1.02	0.486
Age of index child in months	27.1	0.64	29.6	0.25	1.002	1.001-1.003	0.001
Socioeconomics							
Mother's education	<u>n</u>	<u>%</u>	<u>n</u>	<u>%</u>			
No education	165	28	430	72	Reference		
Some schooling	123	16	654	84	1.16	1.09-1.24	<0.001
Finished secondary	186	14	1158	86	1.19	1.11-1.28	<0.001
> Higher secondary	90	10	843	90	1.25	1.17-1.33	<0.001
Occupation of household head							
Unemployed or other	35	13	238	87	Reference		
Daily labor	148	26	413	74	0.84	0.78-0.91	<0.001
Shopkeeper or merchant	143	13	921	87	0.99	0.94-1.04	0.778
Salaried service	238	14	1513	86	0.99	0.95-1.04	0.704
Household wealth status (PCA ^c)							
Poorest	148	27	401	73	Reference		
Lower middle	131	21	503	79	1.09	1.02-1.16	0.009
Middle	97	15	572	86	1.17	1.09-1.26	<0.001
Upper middle	110	10	1005	90	1.23	1.15-1.32	<0.001
Richest	78	11	604	89	1.21	1.13-1.30	<0.001
Health services knowledge							
Does <i>not</i> have knowledge of local hospital	101	19	434	81	Reference		
Has knowledge of local hospital	463	15	2651	85	1.05	1.01-1.09	0.025

<u>Multivariate analyses with different models</u>			
Mobility, adjusting for demographics (# of children and age of index child)	0.97	0.94-1.01	0.126
Mobility, adjusting for socioeconomics (education, occupation, and wealth)	0.98	0.95-1.02	0.308
Mobility, adjusting for demographics and socioeconomics	0.98	0.95-1.02	0.396

^aFull vaccination coverage per EPI program includes 1 dose of BCG, 3 doses of polio, 3 doses of DPT, and 1 dose of measles vaccines.

^bPR, Prevalence Ratio.

^cPolychoric Principal Components Analysis was used to create a household wealth index including structural housing characteristics, cooking fuel, drinking water, and sanitation.

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Table 4: Qualified provider visits for severe acute respiratory illness within prior year among children < 5 years old and association with mobility using univariate and multivariate models with modified Poisson regression

	No qualified provider for severe ARI ^a n=358 (25%)		Qualified provider for severe ARI ^a n=1100 (75%)		PR ^b	95% CI	p-value
<u>Univariate analyses</u>							
Mobility status	<u>n</u>	<u>%</u>	<u>n</u>	<u>%</u>			
Residentially stable ≥24 months	141	18	622	82	Reference		
Recently relocated ≤12 months	217	31	478	69	0.84	0.79-0.90	<0.001
Demographics	<u>mean</u>	<u>SE</u>	<u>mean</u>	<u>SE</u>			
Number of children <5yrs in household	1.23	0.03	1.25	0.02	1.02	0.97-1.08	0.437
Age of index child in months	29.1	0.83	23.7	0.44	0.994	0.992-0.996	<0.001
Socioeconomics							
Mother's education	<u>n</u>	<u>%</u>	<u>n</u>	<u>%</u>			
No education	134	38	220	62	Reference		
Some schooling	127	32	267	68	1.09	0.96-1.23	0.170
Finished secondary	79	16	425	84	1.36	1.20-1.54	<0.001
> Higher secondary	18	9	188	91	1.47	1.30-1.66	<0.001
Occupation of household head							
Unemployed or other	24	23	82	77	Reference		
Daily labor	139	36	244	64	0.82	0.72-0.94	0.005
Shopkeeper or merchant	89	22	320	78	1.01	0.90-1.14	0.848
Salaried service	106	19	454	81	1.05	0.93-1.18	0.435
Household wealth status (PCA ^c)							
Poorest	154	40	228	60	Reference		
Lower middle	93	30	220	70	1.18	1.02-1.37	0.031
Middle	59	21	220	79	1.32	1.16-1.51	<0.001
Upper middle	37	12	277	88	1.48	1.31-1.67	<0.001
Richest	15	9	155	91	1.53	1.35-1.73	<0.001
Health services knowledge							
Does <i>not</i> have knowledge of local hospital	114	49	118	51	Reference		

Has knowledge of local hospital	244	20	982	80	1.57	1.34-1.85	<0.001
<u>Multivariate analyses with different models</u>							
Mobility, adjusting for demographics (# of children and age of index child)					0.84	0.79-0.89	<0.001
Mobility, adjusting for socioeconomics (education, occupation, and wealth)					0.89	0.84-0.94	<0.001
Mobility, adjusting for demographics and socioeconomics					0.88	0.84-0.93	<0.001

^aARI, Acute Respiratory Illness.

^bPR, Prevalence Ratio.

^cPolychoric Principal Components Analysis was used to create a household wealth index including structural housing characteristics, cooking fuel, drinking water, and sanitation.

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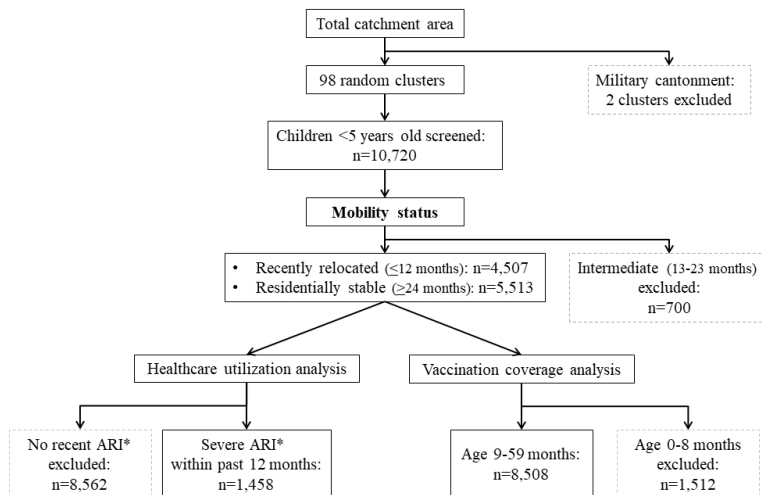


Figure 1: Children sampled by mobility status for healthcare utilization and vaccination coverage analysis

*ARI = Acute Respiratory Illness

Figure 1: Children sampled by mobility status for healthcare utilization and vaccination coverage analysis

338x190mm (96 x 96 DPI)

**Effect of household relocation on child vaccination and health service utilization in Dhaka, Bangladesh:
a cross-sectional community survey**

SUPPLEMENTAL FIGURES AND TABLES

Supplemental Table 1: Household wealth principal components analysis coding and variable loading

Indicator	Coding	Loading
Number of rooms	Continuous	0.337
Housing arrangement	1 = Free 2 = Rental 3 = Owned	0.235
Roof	1 = Natural roof (bamboo/thatch) 2 = Rudimentary roof (tin) 3 = Finished roof (cement/concrete/tiled) 4 = Other	0.392
Walls	1 = Natural walls (jute/bamboo/mud) 2 = Rudimentary walls (wood) 3 = Finished walls (tin/brick/cement) 4 = Other	0.316
Floor	1 = Natural floor (earth/bamboo) 2 = Rudimentary floor (wood) 3 = Finished floor (cement/concrete) 4 = Other	0.377
Cooking fuel	1 = Natural (wood/grass/dung) 2 = Coal/charcoal 3 = Kerosene 4 = Electricity 5 = Gas (liquid/biogas) 6 = Other	0.350
Drinking water	1 = Unimproved (unprotected/surface/bottled) 2 = Improved but not piped 3 = Improved and piped into yard or private dwelling 4 = Other	0.170
Sanitation	1 = Unimproved (open defecation/hanging/open or broken pit) 2 = Improved but not piped	0.374

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	3 = Improved and piped sewer 4 = Other	
Mobile phone ownership	0 = No 1 = Yes	0.380

Note: 51% of overall variance was explained by the first component.

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Supplemental Table 2: Using EPI card plus maternal recall, vaccination coverage among children age 9-23 months and association with mobility status using univariate and multivariate models with modified Poisson regression

	Partial vaccination n=518 (21%)		Full vaccination ^a n=1906 (79%)		PR ^b	95% CI	p-value
<u>Univariate analyses</u>							
Mobility status	<u>n</u>	<u>%</u>	<u>n</u>	<u>%</u>			
Residentially stable ≥ 24 months	243	19	1053	81	Reference		
Recently relocated ≤ 12 months	275	24	853	76	0.93	0.88-0.98	0.009
Demographics	<u>mean</u>	<u>SE</u>	<u>mean</u>	<u>SE</u>			
Number of children <5yrs in household	1.31	0.03	1.24	0.01	0.94	0.89-0.99	0.035
Age of index child in months	14.73	0.20	16.35	0.11	1.02	1.02-1.03	<0.001
Socioeconomics							
Mother's education	<u>n</u>	<u>%</u>	<u>n</u>	<u>%</u>			
No education	207	41	303	59	Reference		
Some schooling	121	22	433	78	1.32	1.18-1.47	<0.001
Finished secondary	141	16	719	84	1.41	1.27-1.56	<0.001
> Higher secondary	49	10	451	90	1.52	1.36-1.69	<0.001
Occupation of household head							
Unemployed or other	26	15	147	85	Reference		
Daily labor	195	38	318	62	0.73	0.66-0.81	<0.001
Shopkeeper or merchant	124	19	538	81	0.96	0.88-1.04	0.287
Salaried service	173	16	903	84	0.99	0.91-1.07	0.752
Household wealth status (PCA ^c)							
Poorest	212	40	321	60	Reference		
Lower middle	114	25	348	75	1.25	1.11-1.40	<0.001
Middle	84	18	382	82	1.36	1.20-1.54	<0.001
Upper middle	59	10	560	90	1.50	1.34-1.69	<0.001
Richest	49	14	295	86	1.42	1.26-1.61	<0.001
Health services knowledge							
Does <i>not</i> have knowledge of local hospital	127	28	324	72	Reference		
Has knowledge of local hospital	391	20	1582	80	1.12	1.05-1.19	<0.001

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<u>Multivariate analyses with different models</u>			
Mobility, adjusting for demographics (# of children and age of index child)	0.93	0.88-0.98	0.007
Mobility, adjusting for socioeconomics (education, occupation, and wealth)	0.96	0.91-1.01	0.136
Mobility, adjusting for demographics and socioeconomics	0.96	0.92-1.01	0.138

^aFull vaccination coverage per EPI program includes 1 dose of BCG, 3 doses of polio, 3 doses of DPT, and 1 dose of measles vaccines.

^bPR, Prevalence Ratio.

^cPolychoric Principal Components Analysis was used to create a household wealth index including structural housing characteristics, cooking fuel, drinking water, and sanitation.

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Supplemental Table 3: Using EPI card only, vaccination coverage among children age 9-23 months who have EPI cards and association with mobility status using univariate and multivariate models with modified Poisson regression

	Partial vaccination n=281 (19%)		Full vaccination ^a n=1222 (81%)		PR ^b	95% CI	p-value
<u>Univariate analyses</u>							
Mobility status	<u>n</u>	<u>%</u>	<u>n</u>	<u>%</u>			
Residentially stable ≥ 24 months	156	18	715	82	Reference		
Recently relocated ≤ 12 months	125	20	507	80	0.97	0.92-1.04	0.469
Demographics	<u>mean</u>	<u>SE</u>	<u>mean</u>	<u>SE</u>			
Number of children <5yrs in household	1.23	0.03	1.21	0.01	0.98	0.93-1.04	0.543
Age of index child in months	14.4	0.27	15.9	0.15	1.02	1.01-1.03	<0.001
Socioeconomics							
Mother's education	<u>n</u>	<u>%</u>	<u>n</u>	<u>%</u>			
No education	94	35	176	65	Reference		
Some schooling	57	17	286	83	1.28	1.15-1.42	<0.001
Finished secondary	93	17	461	83	1.28	1.14-1.43	<0.001
> Higher secondary	37	11	299	89	1.37	1.22-1.52	<0.001
Occupation of household head							
Unemployed or other	14	12	100	88	Reference		
Daily labor	89	33	184	67	0.77	0.68-0.87	<0.001
Shopkeeper or merchant	66	16	352	84	0.96	0.88-1.04	0.327
Salaried service	112	16	586	84	0.96	0.88-1.04	0.297
Household wealth status (PCA ^c)							
Poorest	84	32	179	68	Reference		
Lower middle	67	24	211	76	1.12	0.99-1.25	0.062
Middle	52	17	248	83	1.21	1.08-1.37	0.002
Upper middle	42	10	381	90	1.32	1.18-1.48	<0.001
Richest	36	15	203	85	1.25	1.10-1.41	<0.001
Health services knowledge							
Does <i>not</i> have knowledge of local hospital	55	22	194	78	Reference		
Has knowledge of local hospital	226	18	1028	82	1.05	0.98-1.13	0.141

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<u>Multivariate analyses with different models</u>			
Mobility, adjusting for demographics (# of children and age of index child)	0.98	0.93-1.04	0.582
Mobility, adjusting for socioeconomics (education, occupation, and wealth)	1.00	0.94-1.06	0.948
Mobility, adjusting for demographics and socioeconomics	1.00	0.95-1.07	0.888

^aFull vaccination coverage per EPI program includes 1 dose of BCG, 3 doses of polio, 3 doses of DPT, and 1 dose of measles vaccines.

^bPR, Prevalence Ratio.

^cPolychoric Principal Components Analysis was used to create a household wealth index including structural housing characteristics, cooking fuel, drinking water, and sanitation.

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Effect of household relocation on child vaccination and health service utilization in Dhaka, Bangladesh: a cross-sectional community survey

STROBE 2007 (v4) Statement—Checklist of items that should be included in reports of *cross-sectional studies*

Section/Topic	Item #	Recommendation	Reported on page #
Title and abstract	1	(a) Indicate the study's design with a commonly used term in the title or the abstract	1
		(b) Provide in the abstract an informative and balanced summary of what was done and what was found	2
Introduction			
Background/rationale	2	Explain the scientific background and rationale for the investigation being reported	4
Objectives	3	State specific objectives, including any prespecified hypotheses	4
Methods			
Study design	4	Present key elements of study design early in the paper	5
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection	5
Participants	6	(a) Give the eligibility criteria, and the sources and methods of selection of participants	5
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable	7
Data sources/ measurement	8*	For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group	7
Bias	9	Describe any efforts to address potential sources of bias	7
Study size	10	Explain how the study size was arrived at	6
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why	7
Statistical methods	12	(a) Describe all statistical methods, including those used to control for confounding	7
		(b) Describe any methods used to examine subgroups and interactions	7
		(c) Explain how missing data were addressed	7
		(d) If applicable, describe analytical methods taking account of sampling strategy	7

		(e) Describe any sensitivity analyses	8
Results			
Participants	13*	(a) Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed	8
		(b) Give reasons for non-participation at each stage	8
		(c) Consider use of a flow diagram	Figure 1
Descriptive data	14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders	8
		(b) Indicate number of participants with missing data for each variable of interest	9
Outcome data	15*	Report numbers of outcome events or summary measures	9
Main results	16	(a) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included	9
		(b) Report category boundaries when continuous variables were categorized	8
		(c) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period	n/a
Other analyses	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses	9
Discussion			
Key results	18	Summarise key results with reference to study objectives	10
Limitations	19	Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias	11
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence	12
Generalisability	21	Discuss the generalisability (external validity) of the study results	13
Other information			
Funding	22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based	14

*Give information separately for cases and controls in case-control studies and, if applicable, for exposed and unexposed groups in cohort and cross-sectional studies.

Note: An Explanation and Elaboration article discusses each checklist item and gives methodological background and published examples of transparent reporting. The STROBE checklist is best used in conjunction with this article (freely available on the Web sites of PLoS Medicine at <http://www.plosmedicine.org/>, Annals of Internal Medicine at <http://www.annals.org/>, and Epidemiology at <http://www.epidem.com/>). Information on the STROBE Initiative is available at www.strobe-statement.org.

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Effect of household relocation on child vaccination and health service utilization in Dhaka, Bangladesh: a cross-sectional community survey

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Effect of household relocation on child vaccination and health service utilization in

Dhaka, Bangladesh: a cross-sectional community survey

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1 Abstract

2 **Objective** To explore the relationship between household relocation and use of vaccination
3 and health services for severe acute respiratory illness (ARI) among children in Dhaka,
4 Bangladesh.

5 **Design** Analysis of cross-sectional community survey data from a prior study examining the
6 impact of *Haemophilus influenzae* type b vaccine introduction in 2009 on meningitis
7 incidence in Bangladesh.

8 **Setting** Communities surrounding two large pediatric hospitals in Dhaka, Bangladesh.

9 **Participants** Households with children under 5 years old who either recently relocated ≤ 12
10 months or who were residentially stable living ≥ 24 months in their current residence (total n
11 = 10,020) were selected for this study.

12 **Primary outcome measures** Full vaccination coverage among 9-59 month old children and
13 visits to a qualified medical provider for severe ARI among children under 5 years old.

14 **Results** Using vaccination cards with maternal recall, full vaccination was 80% among
15 recently relocated children (n=3,795) and 85% among residentially stable children (n=4,713;
16 $\chi^2=37.2$, $p<0.001$). Among children with ARI in the prior year, 69% of recently relocated
17 children (n=695) had visited a qualified provider compared to 82% of residentially stable
18 children (n=763; $\chi^2=31.9$, $p<0.001$). After adjusting for demographic and socioeconomic
19 characteristics, recently relocated children were less likely to be fully vaccinated (prevalence
20 ratio [PR] 0.97; 95% confidence interval [CI] 0.95-0.99; $p=0.016$) and to have visited a
21 qualified provider for ARI (PR 0.88; 95% CI 0.84-0.93; $p<0.001$).

22 **Conclusions** Children in recently relocated households in Dhaka, Bangladesh have decreased
23 use of vaccination and qualified health services for severe acute respiratory illnesses.

24

25 Strengths and limitations of this study

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3 1 • This study examined a rich dataset from prior community surveys in Dhaka,
4
5 2 Bangladesh to explore associations between household relocation and utilization of
6
7 3 vaccination and qualified child health services.
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9 4 • Vaccination was evaluated using different measurements and age ranges to explore
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11 5 trends in the relationship between mobility and vaccination.
12
13 6 • Effect of household relocation on use of child health services was found even after
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15 7 adjusting for socioeconomic factors known to impact health-seeking behavior.
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17 8 • Limitations include lack of detailed data on mobility patterns and costs of health
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19 9 services.
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1 Introduction

2 Pneumonia or acute respiratory illness (ARI) is the leading cause of death globally in
3 children under 5 years old, and lower respiratory tract infections caused an estimated 652,572
4 child deaths in 2016.[1] Many causes of ARI are preventable by vaccines such as
5 *Streptococcus pneumoniae* (attributed to 52% of global pneumonia child deaths) and
6 *Haemophilus influenzae* type b (Hib) (7% of deaths).[1] The majority of the world's
7 population now lives in urban areas, and this population is expected to grow from 54% in
8 2014 to 66% in 2050, an estimated increase of 2.5 billion people.[2,3] With this increase,
9 90% of growth is projected in Asia and Africa.[3] The population living in urban slums is also
10 expected to increase from 881 million in 2014 to 2 billion in 2030, in large part due to rural-
11 urban migration.[2,4]

12 In many low- and middle-income countries, vaccination and childhood mortality rates
13 among urban poor are worse than among other urban groups and even rural populations.[5,6]
14 In addition, residents of slums have poor health outcomes due to lack of reliable access to
15 housing, clean water, sanitation, education, and health services.[4,5,7–9] In Nigeria, a 2010
16 study examining 2003 Demographic and Health Survey data of 6,029 children 12 months and
17 older found full immunization among 24.3% of rural non-migrant, 15.2% of urban non-
18 migrant, and 8.5% of rural-urban migrant children.[10] In Bangladesh, a comparison study of
19 the 2013 Urban Health Survey and 2014 Demographic and Health Survey found under-5 child
20 mortality rates of 46 per 1,000 livebirths nationally, 41 in Dhaka, 49 in rural areas, and 57 in
21 urban slums.[5] One recent systematic review found community factors associated with
22 vaccination coverage in the urban poor included socio-economic characteristics, vaccination
23 knowledge and beliefs, access to care, and recent rural-urban migration.[6]

24 Residential mobility has been recognized as an important contributor to healthcare
25 use in high-income countries, with relocation associated with decreased use of preventive and
26 curative services.[11,12] One study using a 1998 United States national health survey found
27 that duration, distance, and frequency of moving were all predictors of decreased use of child

1 health services even after accounting for sociodemographic factors. Households who had
2 moved within 12 months accessed fewer preventive child health services compared to
3 households living in their current residence over 36 months (odds ratio 3.1, 95% confidence
4 interval [CI] 2.5-3.7).[12] Recently relocated households also accessed fewer curative
5 services (odds ratio 3.3, 95% CI 2.6-4.2).[12] Frequent moving also impacted children's long-
6 term cognitive function and behavioral problems into adulthood.[13]

7 Few studies examine mobility and healthcare utilization in low- and middle-income
8 countries despite high population relevance: approximately 43% of urban residents in middle-
9 income countries and 78% in low-income countries live in slums.[3,4,6,10,14,15] In the 2010
10 Nigeria study, urban non-migrant children had 1.7 times higher odds of being fully
11 immunized than rural-urban migrants (univariate odds ratio [OR] 1.67, 95% confidence
12 interval [CI] 1.20-2.32).[10] This association between migration and immunization was
13 independent of demographic factors, but was attenuated and partially explained by
14 socioeconomic characteristics and maternal healthcare utilization in multivariable
15 analyses.[10] In this Nigeria study, migrant status was defined as moving within 10 years.[10]
16 A 2010 cross-sectional survey in India examined 746 rural-urban migrant mothers with
17 children under 2 years old: 339 were 'recent' migrants who moved to Delhi within 5 years
18 and 407 were 'settled' migrants in Delhi at least 5 years.[15] For age-appropriate children,
19 81% of settled migrants and 64% of recent migrants were fully immunized per national
20 guidelines.[15] Settled migrant children had 1.9 times higher odds of being fully immunized
21 than recent migrants after adjusting for demographics, socioeconomics, and maternal
22 healthcare utilization (adjusted OR 1.93, 95% CI 1.18-3.14).[15]

23 Studying urban health services in Bangladesh is useful because Bangladesh is the
24 world's most densely populated country that is not a city-state: the population of the capital
25 Dhaka will increase from an estimated 16 to 27 million by 2030.[3,16] Furthermore, the
26 government has a strong national Expanded Programme on Immunization and active health
27 systems research.[16,17] In 2011, full vaccination rates among children age 12-23 months

1 were 80% nationally in Bangladesh, 75% in Dhaka, but only 43-67% in Dhaka slums.[16–20]
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14 Methods

15 Study design and setting

16 Hib conjugate vaccine was introduced into Bangladesh's Expanded Programme on
17 Immunization in 2009, and the Hib impact study conducted pre and post-vaccine surveillance
18 of meningitis in children under 5 years old using hospital records and community surveys
19 surrounding two large pediatric hospitals in Dhaka: Dhaka Shishu and Shishu Shastya
20 Foundation Hospital.[23] Field researchers consecutively enrolled 100 children discharged
21 with a diagnosis of meningitis and/or encephalitis from the two study hospitals, visited
22 households, and recorded household geographical positional system coordinates. The
23 catchment area was defined as the area containing >80% of households with children
24 discharged with meningitis and within one hour of transport to either hospital. Field teams
25 divided the catchment area into 1,748 equal-sized rectangles and randomly selected 100
26 rectangles as clusters. Teams surveyed each household with a child under 5 years old within

1
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3 1 98 clusters. Two clusters were within a military cantonment, thus inaccessible. Households
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5 2 were asked about: 1) routine vaccinations using vaccination cards and maternal recall and 2)
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7 3 healthcare use for children with illnesses in the prior 12 months suggestive of
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9 4 meningoencephalitis defined as: any serious illness with acute onset of fever with either
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11 5 convulsions or unconsciousness or altered mental status.[23] Data were collected one year
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13 6 before (2008) and after (2010) Hib vaccine introduction.
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18 8 **Study population**

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20 9 We used the Hib impact study's pre-vaccine community surveillance data and
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22 10 included children based on mobility status: 1) children living in their current residence ≤ 12
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24 11 months who we classified as "recently relocated" and 2) children living ≥ 24 months in their
25
26 12 current residence who we classified as "residentially stable". This definition of
27
28 13 mobility/migration status has been used in prior studies.[6,12] We excluded children living in
29
30 14 their current residence 13-23 months who we classified as "intermediately mobile".
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36 16 **Study outcomes**

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38 17 Our two primary outcomes focused on healthcare utilization: 1) full vaccination
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40 18 among 9-59 month old children and 2) visit to a qualified medical provider among children
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42 19 under 5 years old who had severe acute respiratory illness symptoms within the prior 12
43
44 20 months. We defined full vaccination per Bangladesh Expanded Programme on Immunization
45
46 21 guidelines in 2008 (before Hib vaccine): 1 dose of Bacillus Calmette-Guérin (BCG) vaccine
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48 22 against tuberculosis; 3 doses of combined vaccine against diphtheria, pertussis, and tetanus
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50 23 (DPT); 3 doses of oral polio vaccine (excluding polio vaccine given at birth); and 1 dose of
51
52 24 measles vaccine. Government guidelines recommended children to receive all these
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54 25 vaccinations before 9 months of age. Any doses of pentavalent vaccine, which includes
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56 26 diphtheria, pertussis, tetanus, hepatitis B, and Hib, were included in vaccination analyses. We
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58 27 defined severe acute respiratory illness as cough or difficulty breathing plus any danger sign:
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1 stridor, chest in-drawing, difficulty drinking/ breastfeeding, vomiting, cyanosis, convulsions,
2 lethargy, or unconsciousness. We defined a qualified medical provider as having a Bachelor
3 of Medicine degree or higher.

4 5 **Data analysis**

6 We compared sociodemographic and health characteristics between residentially
7 stable and recently relocated households. For continuous variables, we calculated means with
8 standard errors and t-tests adjusting for cluster. For categorical variables, we calculated
9 percentages and χ^2 -tests. To construct a wealth index, we used polychoric principal
10 components analysis (PCA) including: housing (number of rooms; free, rental, or owned
11 housing; main material of roof, walls, and floors), cooking fuel, drinking water, sanitation,
12 and mobile phone ownership.[24–26] We then divided households into wealth quintiles. We
13 did not include durable assets such as furniture items because ownership of these goods could
14 be associated with duration of residency.

15 To examine the magnitude of association between mobility and study outcomes of
16 vaccination and visit to a qualified provider for severe ARI, we used modified Poisson
17 regression with robust cluster variance to estimate prevalence ratios (PRs).[27,28] We chose
18 modified Poisson regression to model prevalence ratios for common binary outcomes because
19 logistic regression is more applicable to rare outcomes and because log-binomial regression
20 models may fail to converge. We conducted univariate analyses to estimate individual effects
21 of mobility, demographics, socioeconomics, and health services knowledge (i.e. knowledge of
22 local hospital) on healthcare utilization. Missing data regarding main study outcome of acute
23 respiratory illness were handled through listwise deletion. Given large number of missing
24 vaccination cards, we analyzed vaccination in two ways: 1) using vaccination cards plus
25 maternal recall and 2) using vaccination cards alone. We conducted multivariable analyses
26 examining the association between mobility and healthcare utilization, adjusting for
27 demographics and socioeconomics known to influence health-seeking behavior.[9,15,29–31]

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3 1 Regression diagnostics included checks for influential observations with Cook's distance
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5 2 calculations.

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10 4 **Ethics**

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13 5 The Ethical Review Committee of the International Centre for Diarrhoeal Disease
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15 6 Research, Bangladesh (icddr,b) reviewed and approved the study protocol. Written informed
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17 7 consent was obtained from all participants before taking part in the initial Hib impact study.
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22 9 **Patient and public involvement**

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24 10 No participants were directly involved in development of the research questions and
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26 11 outcomes. No participants were involved in the design or conduct of the study. There are no
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28 12 plans to disseminate the results of the research individually to study participants.
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32 14 **Results**

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35 15 We surveyed a total of 10,720 households with children less than 5 years old: 42% of
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37 16 households had recently relocated within 12 months, 51% were residentially stable living in
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39 17 their current residence over 24 months, and 7% were intermediately mobile (Figure 1). We
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41 18 excluded from subsequent analyses 700 children living in their current residence 13-23
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43 19 months and classified as intermediately mobile. For the healthcare utilization analysis, 1,458
44
45 20 children had severe ARI symptoms within the 12 months prior to survey. For the vaccination
46
47 21 analysis, 8,508 children were age 9-59 months and thus should have completed all Expanded
48
49 22 Programme on Immunization-recommended vaccinations. Household demographics, parental
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51 23 education, occupation, and hospital knowledge were available for all households. Missing
52
53 24 data included: income for 12 households, meningitis symptoms for 3 children, respiratory
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55 25 illness symptoms for 1 child, and vaccination cards for 4,859 children age 9-59 months.
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3 1 Recently relocated families had smaller households, less education, less wealth, and
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5 2 less knowledge of the local hospital compared to residentially stable families (Table 1).
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7 3 Recently relocated families were poorer: 24% earned less than 5,000 Bangladeshi taka (US
8
9 4 \$73) per month compared to 18% of residentially stable families. For the wealth index
10
11 5 analysis, the first principal component accounted for 51% of overall variance, with largest
12
13 6 contributions from roof and floor materials, sanitation, and mobile phone ownership
14
15 7 (Supplemental Table 1). Among recently relocated families, 48% were in the two poorest
16
17 8 wealth quintiles compared to 37% of residentially stable families. Fewer recently relocated
18
19 9 caregivers had knowledge of the local hospital, 76%, compared to residentially stable
20
21 10 caregivers, 85% ($\chi^2=142.3$, $p<0.001$). Similar rates of illness in the 12 months prior to survey
22
23 11 were reported by all households: 14-15% of children with symptoms of severe ARI and 3-4%
24
25 12 with symptoms of meningitis/encephalitis.

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28 13 Full vaccination coverage measured by vaccination card plus maternal recall was
29
30 14 83% among all children age 9-59 months (Table 2). Full vaccination was 80% among recently
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32 15 relocated children and 85% among residentially stable children (univariate PR 0.94, 95% CI
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34 16 0.91-0.97, $p<0.001$). Vaccination was lower in households with more children and younger
35
36 17 children. Socioeconomic factors, especially mother's education, had the strongest association
37
38 18 with vaccination. In multivariable analyses, recently relocated children were 3% less likely
39
40 19 than residentially stable children to be fully vaccinated even after adjusting for demographic
41
42 20 and socioeconomic factors (multivariable PR 0.97, 95% CI 0.95-0.99, $p=0.016$).

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45 21 Vaccination was also analyzed using only vaccination cards (Table 3). At time of
46
47 22 survey, only 43% of all children had vaccination cards available. Fewer recently relocated
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49 23 children had vaccination cards, 36%, compared to 48% of residentially stable children
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51 24 ($\chi^2=126.9$, $p<0.001$). Younger children were more likely to have cards than older children:
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53 25 62% of children 9-23 months old had vaccination cards as compared to 38% of children 24-59
54
55 26 months old ($\chi^2=505.7$, $p<0.001$). Full vaccination per vaccination card was 83% among
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57 27 recently relocated children and 86% among residentially stable children (univariate PR 0.97,
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3 1 95% CI 0.93-1.00, $p=0.083$). The 9-59 month age range for vaccination analysis allowed
4
5 2 inclusion of a larger sample size of children vulnerable to vaccine-preventable disease. In
6
7 3 contrast, routine vaccination schedules focus on children <2 years old and full vaccination
8
9 4 coverage per Expanded Programme on Immunization in Bangladesh and many other countries
10
11 5 is defined in children up to 23 months old.[17,32] Narrowing the age range of vaccination
12
13 6 analysis to 9-23 months showed similar results although with smaller sample sizes limiting
14
15 7 statistical power to detect mobility-vaccination associations (Supplementary Tables 2 and 3).
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17 8 In addition, using a 10-month age minimum to account for potential delay in measles
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19 9 vaccination recommended at 9 months old showed the same results as a 9-month age cutoff
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21 10 (data not shown). Checking for influential observations with Cook's distances identified no
22
23 11 outliers in vaccination analyses (Supplemental Figure 1).[33]

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26 12 Among all children under 5 years old with severe ARI in the past year, 75% visited a
27
28 13 qualified medical provider (Table 4). Fewer recently relocated children with severe ARI saw
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30 14 a qualified provider, 69%, as compared to 82% of residentially stable children (univariate PR
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32 15 0.84, 95% CI 0.79-0.90, $p<0.001$). Socioeconomic factors, especially household wealth, were
33
34 16 strongly associated with qualified provider visits.

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37 17 Health services knowledge was also strongly associated with acute healthcare visits:
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39 18 80% of parents who knew about the local hospital sought ARI treatment from a qualified
40
41 19 provider as compared to 51% of parents who did *not* have knowledge of the local hospital
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43 20 (univariate PR 1.57, 95% CI 1.34-1.85, $p<0.001$). After adjusting for demographic and
44
45 21 socioeconomic factors, recently relocated households were 11% less likely than residentially
46
47 22 stable households to visit a qualified medical provider for children with severe ARI
48
49 23 (multivariable PR 0.88, 95% CI 0.84-0.93, $p<0.001$). One outlier was identified by Cook's
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51 24 distances in healthcare utilization analyses (Supplemental Figure 1). Excluding this outlier
52
53 25 and using robust error variance resulted in similar results to those presented (data not shown).
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57 27 Discussion

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3 1 Recently relocated households were less likely to use both acute and preventive child
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5 2 healthcare services in our study in Dhaka, Bangladesh, and these findings support prior
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7 3 literature exploring the effects of mobility on healthcare utilization.[6,10–13,15] Household
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9 4 relocation had a strong association with decreased use of qualified medical services for severe
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11 5 acute respiratory illness. Similarly, household relocation was associated with decreased
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13 6 vaccination rates although this relationship was less robust. Another key finding was that
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15 7 recently relocated parents were less knowledgeable about the local hospital compared to
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17 8 residentially stable parents, and knowledge of the local hospital had as strong an association
18
19 9 with acute healthcare visits as some economic factors. Overall, recently relocated children in
20
21 10 our study had slightly lower vaccination rates and markedly lower use of acute healthcare
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23 11 services for ARI than residentially stable children.

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26 12 Study strengths include data focused on urban Bangladesh and exploring vaccination
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28 13 status using different measurements as well as adjusting for socioeconomic factors when
29
30 14 examining mobility and health service utilization. Our study used the Hib impact study's
31
32 15 rigorous community surveillance data of households living close to tertiary care pediatric
33
34 16 hospitals in Dhaka. Dhaka residents have high mobility and many options for healthcare.
35
36 17 Unlike in rural areas, physical access to health services is usually *not* a barrier to healthcare
37
38 18 use in urban areas. One study found almost all residents in Dhaka lived within 1 kilometer of
39
40 19 primary health services.[34] Routine immunizations are provided free by the government of
41
42 20 Bangladesh, but acute care services require out of pocket expenditures which can be a barrier
43
44 21 to access. Our findings on mobility and child health services use in Dhaka could inform
45
46 22 health services work in other urban low- and middle-income country contexts.[3,5]

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48
49 23 We analyzed vaccination using vaccination card data augmented with maternal recall,
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51 24 vaccination card data only, and several different age ranges. Accurately measuring
52
53 25 vaccinations in children is a known difficulty in public health programs and research studies,
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55 26 especially in low- and middle-income countries where vaccination cards are frequently *not*
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57 27 available. Some studies have found poor agreement between parental recall, vaccination
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1 cards, and even official health records.[35–37] By contrast, other studies have found good
2 correlation between maternal report and vaccination cards, and maternal recall is routinely
3 used in Demographic and Health Surveys and Multiple Indicator Cluster Surveys.[38,39]
4 Maternal recall can overestimate or underestimate vaccination history based on education,
5 social desirability bias, and vaccine-specific knowledge. Vaccination card retention itself can
6 be affected by parental education, household wealth, age of child, and even household
7 relocation. Our data showed more missing cards among recently relocated households and in
8 older children, thus those groups are subject to more maternal recall bias. Using only
9 vaccination cards or narrower age ranges in our vaccination analyses resulted in smaller
10 sample sizes which limited statistical power, but all analyses showed similar effect estimates
11 of increased mobility associated with decreased vaccination. Moreover, the association
12 between increased household relocation and decreased health services use was still seen even
13 after adjusting for socioeconomic factors known to impact healthcare use.

14 Study limitations include lack of data on mobility patterns and health services costs.
15 Information on households' prior residences, distances moved, or frequency of moving was
16 not available in our dataset. Households moving from rural Bangladesh to urban Dhaka,
17 moving long distances, or relocating frequently probably have less knowledge and therefore
18 use of locally available health services.[12] Several studies show that recent rural to urban
19 migration is associated with lower vaccination coverage in children.[6,10,15] Lack of data on
20 mobility patterns in our study precludes evaluation of how magnitude of relocation affected
21 healthcare use. Our findings likely underestimate the negative association between mobility
22 and healthcare utilization for households with large migration such as rural to urban migrants
23 as compared to households with intra-Dhaka relocation where one would expect minimal
24 change in health-seeking behavior. We were also unable to examine household relocation
25 timing in relation to healthcare use. Recently relocated households were not asked if
26 healthcare visits occurred before or after moving. Healthcare visits before moving would not
27 be relevant to how mobility affects use of health services after moving. Our findings may

1 underestimate the negative association between mobility and health-seeking behavior because
2 our data included healthcare visits before moving which were unrelated to knowledge of the
3 new geographic area. Timing of healthcare visits in relation to acquiring knowledge of
4 hospital services was also not available, thus there may be reverse causality of recently
5 relocated households gaining knowledge of local providers after seeking care. Ultimately, our
6 results show a modest overall association between mobility and healthcare use which could be
7 elucidated by asking about migration patterns including timing of use of health services.

8 Our study results may not be as generalizable to populations in urban areas without
9 tertiary care hospitals. Our sampling scheme focused on community catchment areas
10 surrounding tertiary care pediatric hospitals. Advantages of this study design were that it
11 allowed examination of healthcare utilization for severe disease since advanced services were
12 available within a small physical distance. In addition, it was a low-cost way to examine
13 population-level mobility instead of more resource-intensive active surveillance of migrant
14 populations. However, use of health services generally increases with geographic proximity,
15 and studies show this relationship is influenced by many factors including income and slum
16 versus non-slum locations.[34,40] Recently relocated populations may be even more
17 influenced by proximity than residentially stable populations because of fewer socioeconomic
18 resources and lack of knowledge of health services. This would bias our results towards
19 higher rates of health-seeking behavior among recently relocated households. Recently
20 relocated households in areas without tertiary care services may use health services less
21 because of transport costs and lack of knowledge of health facilities physically distant. In
22 addition, our study included participants who relocated into the study area, but not people
23 who left the study area. In-migrants and out-migrants may be different in their healthcare
24 utilization patterns, which could also affect generalizability.

25 Our dataset did not contain cost of services, which is a well-known barrier to
26 healthcare use.[19,20,30] Although vaccinations are provided for free, some non-
27 governmental and private organizations charge fees for patient registration. Even small fees

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3 1 could have lowered vaccination rates. Cost of services, willingness to pay, and underlying
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5 2 finances are strongly linked, thus adjusting for socioeconomic factors of parental education
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7 3 and wealth in our models should have incorporated some cost effects on healthcare use.
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9 4 However, costs could affect recently relocated households disproportionately more than
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11 5 residentially stable households of the same socioeconomic status. One could hypothesize that
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13 6 immediately after relocating, families would first spend money on household goods before
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15 7 preventive medicine fees. Without cost data, we can still conclude from our analysis that
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17 8 increased mobility is associated with decreased healthcare use, but we have limited
18
19 9 understanding of mechanisms through which mobility affects healthcare use.

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22 10 Barriers and delays to using appropriate healthcare services increase mortality.[30,41]
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24 11 One study in India of 290 children hospitalized for pneumonia in a tertiary care center found
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26 12 that delayed hospital referral, defined as three or more days between symptom onset and
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28 13 hospitalization, was associated with increased mortality (OR 52.1, 95% CI 6.7-402.4,
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30 14 $p < 0.001$) after adjusting for age, residence in slum, and illness severity.[41] In this study,
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32 15 incomplete immunization was also associated with increased mortality (OR 12.3, 95% CI 2.2-
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34 16 69.9, $p = 0.005$).[41] Reasons for delayed care-seeking can include access and cost. While cost
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36 17 does influence healthcare use, parents of sick children usually do seek some treatment. In the
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38 18 2014 Bangladesh Demographic and Health Survey, 52% of urban parents with children with
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40 19 ARI symptoms in the 2 weeks prior to survey sought treatment from a health facility, 23%
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42 20 went to pharmacies, and 12% went to traditional practitioners.[42] Only 12% of parents with
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44 21 sick children sought no health care treatment at all.[42] While cost does not seem a large
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46 22 barrier to seeking any treatment at all, cost likely influences choice of health provider.

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49 23 Household relocation disrupts prior relationships with healthcare providers and
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51 24 results in lack of familiarity with local services. A World Health Organization (WHO)
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53 25 conceptual framework on social determinants of health can explore how mobility relates to
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55 26 healthcare use.[43] In the WHO framework, structural determinants of social, economic, and
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57 27 political contexts influence intermediary determinants of material, behavioral, psychosocial,
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1 and health system factors that ultimately determine an individual's health. Relocation can
2 improve an individual's socioeconomic position in the long term, but mobility often disrupts
3 material resources, psychosocial support, and health care access. Studies show that continuity
4 of care is associated with increased vaccination, fewer emergency department visits, and
5 decreased hospitalization among children.[12,44–46] People usually move to new areas
6 because of pre-existing social connections through family, friends, or work.[7,47] These
7 social contacts can act as pathways of important local knowledge, including health services,
8 but recently relocated households have fewer social contacts and access fewer information
9 sources. Other studies have also found that parental attitudes and knowledge are critical
10 factors contributing to use of health services.[6,48–51] One literature review found that
11 *practical* knowledge about vaccination schedule, timing, and logistics had a stronger
12 association with vaccination uptake than scientific knowledge of vaccine names or biologic
13 actions.[50] One study in India of 210 residents in slums and 100 migrant families of
14 construction workers found 28% of slum residents and 64% of migrants identified lack of
15 knowledge of place or time of services as a reason for decreased immunization.[51] Our study
16 did not ask specifically about knowledge of vaccination services, but future research on
17 knowledge of services could help elucidate how to connect new migrants to care.

18 Our finding that recently relocated children in Dhaka use fewer qualified health
19 services compared to residentially stable children sheds light on health barriers faced by a
20 growing population of children living in urban centers of low- and middle-income countries.
21 Rigorous community surveillance in hospital catchment areas allows for increased
22 understanding of factors affecting access to and use of healthcare services. Policymakers
23 working to improve urban child health could invest in accurate counting of children living in
24 communities with high household turnover in order to connect recently relocated households
25 to already existing local health services. Further studies by researchers on patterns and
26 mechanisms through which mobility affects healthcare use could inform critical intervention

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3 1 points. Ultimately, cost-effective and targeted interventions to increase appropriate healthcare
4
5 2 use among recently relocated children could improve health of future urban populations.
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7 3

9 4 **Contributors**

11 5 SL was the Principal Investigator and involved in every aspect of the study from
12 6 conceptualization to data analysis to manuscript writing and submission. NS, JA, and LH
13 7 were involved in data analysis, and LH drafted the written work. All authors collaborated on
14 8 and approved the final manuscript.
15 9

10 10 **Competing interests**

11 11 None declared.
12 12

13 13 **Provenance and peer review**

14 14 Not commissioned; externally peer reviewed.
15 15

16 16 **Ethical considerations**

17 17 The Ethical Review Committee of the International Centre for Diarrhoeal Disease
18 18 Research, Bangladesh (icddr,b) reviewed and approved the study protocol.
19 19

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21 21 Written informed consent was obtained from all participants before taking part in the
22 22 initial Hib impact study.
23 23

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45 2 **Data sharing**
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78 3 Data are available by emailing the corresponding author LH at lhong@stanford.edu.
9
1011 4
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References

- 1 Troeger C, Blacker B, Khalil IA, *et al.* Estimates of the global, regional, and national morbidity, mortality, and aetiologies of lower respiratory infections in 195 countries, 1990–2016: a systematic analysis for the Global Burden of Disease Study 2016. *Lancet Infect Dis* 2018;**18**:1191–210. doi:10.1016/S1473-3099(18)30310-4
- 2 UN-Habitat. *World Cities Report 2016: Urbanization and Development – Emerging Futures*. New York: UN-Habitat 2016. <https://unhabitat.org/books/world-cities-report/> (accessed 12 Jan 2019).
- 3 United Nations, Department of Economic and Social Affairs, Population Division. *World Urbanization Prospects: The 2014 Revision [Highlights]*. New York: United Nations 2015. <http://esa.un.org/unpd/wup/Publications/Files/WUP2014-Highlights.pdf> (accessed 3 Feb 2016).
- 4 UN-Habitat. *The challenge of slums: global report on human settlements 2003*. New York: UN-Habitat 2003.
- 5 Ezeh A, Oyebo O, Satterthwaite D, *et al.* The history, geography, and sociology of slums and the health problems of people who live in slums. *The Lancet* 2017;**389**:547–58. doi:10.1016/S0140-6736(16)31650-6
- 6 Crocker-Buque T, Mindra G, Duncan R, *et al.* Immunization, urbanization and slums – a systematic review of factors and interventions. *BMC Public Health* 2017;**17**:556. doi:10.1186/s12889-017-4473-7
- 7 Rashid SF. Strategies to reduce exclusion among populations living in urban slum settlements in Bangladesh. *J Health Popul Nutr* 2009;**27**:574–86.
- 8 UN-Habitat. *State of the World's Cities 2006/7*. New York: UN-Habitat 2006.
- 9 Unger A. Children's health in slum settings. *Arch Dis Child* 2013;**98**:799–805. doi:10.1136/archdischild-2011-301621
- 10 Antai D. Migration and child immunization in Nigeria: individual-and community-level contexts. *BMC Public Health* 2010;**10**:116.
- 11 Jelleyman T, Spencer N. Residential mobility in childhood and health outcomes: a systematic review. *J Epidemiol Community Health* 2008;**62**:584–92.
- 12 Fowler MG, Simpson GA, Schoendorf KC. Families on the move and children's health care. *Pediatrics* 1993;**91**:934–40.
- 13 Wood D, Halfon N, Scarlata D, *et al.* Impact of family relocation on children's growth, development, school function, and behavior. *JAMA* 1993;**270**:1334–8.
- 14 Awoh AB, Plugge E. Immunisation coverage in rural–urban migrant children in low and middle-income countries (LMICs): a systematic review and meta-analysis. *J Epidemiol Community Health* 2016;**70**:305–11.
- 15 Kusuma YS, Kumari R, Pandav CS, *et al.* Migration and immunization: determinants of childhood immunization uptake among socioeconomically disadvantaged migrants in Delhi, India. *Trop Med Int Health* 2010;**15**:1326–32.

- 1
2
3 1 16 NIPORT, icddr,b, MEASURE Evaluation. Bangladesh Urban Health Survey 2013 Final
4 2 Report. 2015. <http://www.cpc.unc.edu/measure/resources/publications/tr-15-117>
5 3 (accessed 3 Feb 2016).
6
7 4 17 Government of Bangladesh. Bangladesh EPI coverage evaluation survey 2011, Expanded
8 5 Programme on Immunization. 2011.
9 6 [http://www.dghs.gov.bd/images/docs/EPI/CES%20Reports/EPI%20Coverage%20Evalua](http://www.dghs.gov.bd/images/docs/EPI/CES%20Reports/EPI%20Coverage%20Evaluation%20Survey%202011.pdf)
10 7 [tion%20Survey%202011.pdf](http://www.dghs.gov.bd/images/docs/EPI/CES%20Reports/EPI%20Coverage%20Evaluation%20Survey%202011.pdf)
11
12 8 18 Hayford K, Uddin MJ, Koehlmoos TP, *et al.* Cost and sustainability of a successful
13 9 package of interventions to improve vaccination coverage for children in urban slums of
14 10 Bangladesh. *Vaccine* 2014;**32**:2294–9. doi:10.1016/j.vaccine.2014.02.075
15
16 11 19 Uddin MJ, Larson CP, Oliveras E, *et al.* Child immunization coverage in urban slums of
17 12 Bangladesh: impact of an intervention package. *Health Policy Plan* 2010;**25**.
18 13 doi:10.1093/heapol/czp041
19
20 14 20 Perry H, Weierbach R, Hossain I, *et al.* Childhood immunization coverage in zone 3 of
21 15 Dhaka City: the challenge of reaching impoverished households in urban Bangladesh.
22 16 *Bull World Health Organ* 1998;**76**:565–73.
23
24 17 21 Luby SP, Halder AK, Saha SK, *et al.* A low-cost approach to measure the burden of
25 18 vaccine preventable diseases in urban areas. *Vaccine* 2010;**28**:4903–12.
26 19 doi:10.1016/j.vaccine.2010.05.040
27
28 20 22 Uddin MJ, Shamsuzzaman M, Horng L, *et al.* Use of mobile phones for improving
29 21 vaccination coverage among children living in rural hard-to-reach areas and urban streets
30 22 of Bangladesh. *Vaccine* 2016;**34**:276–83. doi:10.1016/j.vaccine.2015.11.024
31
32 23 23 Sultana NK, Saha SK, Al-Emran HM, *et al.* Impact of introduction of the Haemophilus
33 24 influenzae type b conjugate vaccine into childhood immunization on meningitis in
34 25 Bangladeshi infants. *J Pediatr* 2013;**163**:S73–8.
35
36 26 24 Vyas S, Kumaranayake L. Constructing socio-economic status indices: how to use
37 27 principal components analysis. *Health Policy Plan* 2006;**21**:459–68.
38 28 doi:10.1093/heapol/czl029
39
40 29 25 Luby SP, Halder AK. Associations among handwashing indicators, wealth, and
41 30 symptoms of childhood respiratory illness in urban Bangladesh. *Trop Med Int Health*
42 31 2008;**13**:835–44. doi:10.1111/j.1365-3156.2008.02074.x
43
44 32 26 Sharker MY, Nasser M, Abedin J, *et al.* The risk of misclassifying subjects within
45 33 principal component based asset index. *Emerg Themes Epidemiol* 2014;**11**:6.
46
47 34 27 Zou G. A modified poisson regression approach to prospective studies with binary data.
48 35 *Am J Epidemiol* 2004;**159**:702–6.
49
50 36 28 Chen W, Shi J, Qian L, *et al.* Comparison of robustness to outliers between robust
51 37 poisson models and log-binomial models when estimating relative risks for common
52 38 binary outcomes: a simulation study. *BMC Med Res Methodol* 2014;**14**:82.
53 39 doi:10.1186/1471-2288-14-82
54
55
56
57
58
59
60

- 1
2
3 1 29 Quaiyum MA, Gazi R, Khan AI, *et al.* Programmatic aspects of dropouts in child
4 2 vaccination in Bangladesh: findings from a prospective study. *Asia Pac J Public Health*
5 3 2011;**23**:141–50. doi:10.1177/1010539509342119
6
7 4 30 Hussain A, Ali SM, Kvåle G. Determinants of mortality among children in the urban
8 5 slums of Dhaka city, Bangladesh. *Trop Med Int Health* 1999;**4**:758–64.
9
10 6 31 Hidalgo B, Goodman M. Multivariate or Multivariable Regression? *Am J Public Health*
11 7 2012;**103**:39–40. doi:10.2105/AJPH.2012.300897
12
13 8 32 Restrepo-Méndez MC, Barros AJ, Wong KL, *et al.* Inequalities in full immunization
14 9 coverage: trends in low- and middle-income countries. *Bull World Health Organ*
15 10 2016;**94**:794–805B. doi:http://dx.doi.org/10.2471/BLT.15.162172
16
17 11 33 Fox J, Weisberg S. *An R Companion to Applied Regression. Chapter 6: Diagnosing*
18 12 *Problems in Linear and Generalized Linear Models.* SAGE Publications 2011.
19 13 https://us.sagepub.com/sites/default/files/upm-binaries/38503_Chapter6.pdf
20
21 14 34 Heller LR. Do slums matter? Location and early childhood preventive care choices
22 15 among urban residents of Bangladesh. *Soc Sci Med* 2013;**94**.
23 16 doi:10.1016/j.socscimed.2013.06.011
24
25 17 35 Miles M, Ryman TK, Dietz V, *et al.* Validity of vaccination cards and parental recall to
26 18 estimate vaccination coverage: a systematic review of the literature. *Vaccine*
27 19 2013;**31**:1560–8. doi:10.1016/j.vaccine.2012.10.089
28
29 20 36 Murray CJ, Shengelia B, Gupta N, *et al.* Validity of reported vaccination coverage in 45
30 21 countries. *Lancet* 2003;**362**:1022–7.
31
32 22 37 Luman ET, Ryman TK, Sablan M. Estimating vaccination coverage: validity of
33 23 household-retained vaccination cards and parental recall. *Vaccine* 2009;**27**:2534–9.
34 24 doi:10.1016/j.vaccine.2008.10.002
35
36 25 38 Brown J, Monasch R, Bicego G, *et al.* *An assessment of the quality of national child*
37 26 *immunization coverage estimates in population-based surveys.* MEASURE Evaluation,
38 27 Carolina Population Center, University of North Carolina at Chapel Hill 2002.
39
40 28 39 Khan A, Khan A. Validating measures of immunization coverage: lessons from
41 29 international experience. USAID 2012.
42 30 [http://www.resdev.org/files/policy_brief/10/Policy%20brief%2010%20-](http://www.resdev.org/files/policy_brief/10/Policy%20brief%2010%20-%20Validation%20of%20Immunization%20Literature.pdf)
43 31 [%20Validation%20of%20Immunization%20Literature.pdf](http://www.resdev.org/files/policy_brief/10/Policy%20brief%2010%20-%20Validation%20of%20Immunization%20Literature.pdf) (accessed 2 Oct 2015).
44
45 32 40 Fujita M, Sato Y, Nagashima K, *et al.* Impact of geographic accessibility on utilization of
46 33 the annual health check-ups by income level in Japan: A multilevel analysis. *PLoS One*
47 34 2017;**12**:e0177091. doi:10.1371/journal.pone.0177091
48
49 35 41 Bokade CM, Madhura AD, Bagul AS, *et al.* Predictors of mortality in children due to
50 36 severe and very severe pneumonia. *Niger Med J* 2015;**56**:287.
51
52 37 42 National Institute of Population Research and Training - NIPORT/Bangladesh, Mitra and
53 38 Associates, ICF International. *Bangladesh Demographic and Health Survey 2014.* Dhaka,
54 39 Bangladesh: NIPORT, Mitra and Associates, and ICF International 2016.
55 40 <http://dhsprogram.com/pubs/pdf/FR311/FR311.pdf>
56
57
58
59
60

- 1
2
3 1 43 World Health Organization. *A conceptual framework for action on the social*
4 2 *determinants of health*. Geneva: WHO 2010.
5 3 http://apps.who.int/iris/bitstream/10665/44489/1/9789241500852_eng.pdf (accessed 27
6 4 Feb 2017).
- 8 5 44 Christakis DA, Mell L, Wright JA, *et al*. The association between greater continuity of
9 6 care and timely measles-mumps-rubella vaccination. *Am J Public Health* 2000;**90**:962.
- 11 7 45 Christakis DA, Mell L, Koepsell TD, *et al*. Association of lower continuity of care with
12 8 greater risk of emergency department use and hospitalization in children. *Pediatrics*
13 9 2001;**107**:524–9.
- 15 10 46 Van Walraven C, Oake N, Jennings A, *et al*. The association between continuity of care
16 11 and outcomes: a systematic and critical review. *J Eval Clin Pract* 2010;**16**:947–56.
- 18 12 47 Kuhn R. Identities in motion: Social exchange networks and rural- urban migration in
19 13 Bangladesh. *Contributions to Indian Sociology* 2003;**37**:311–37.
20 14 doi:10.1177/006996670303700113
- 22 15 48 Mills E, Jadad AR, Ross C, *et al*. Systematic review of qualitative studies exploring
23 16 parental beliefs and attitudes toward childhood vaccination identifies common barriers to
24 17 vaccination. *J Clin Epidemiol* 11;**58**:1081–8. doi:10.1016/j.jclinepi.2005.09.002
- 26 18 49 Rainey JJ, Watkins M, Ryman TK, *et al*. Reasons related to non-vaccination and under-
27 19 vaccination of children in low and middle income countries: findings from a systematic
28 20 review of the published literature, 1999–2009. *Vaccine* 2011;**29**:8215–21.
- 30 21 50 Favin M, Steinglass R, Fields R, *et al*. Why children are not vaccinated: a review of the
31 22 grey literature. *International Health* 2012;**4**:229–38. doi:10.1016/j.inhe.2012.07.004
- 33 23 51 Sharma V, Singh A, Sharma V. Provider’s and User’s Perspective about Immunization
34 24 Coverage among Migratory and Non-migratory Population in Slums and Construction
35 25 Sites of Chandigarh. *J Urban Health* 2015;**92**:304–12. doi:10.1007/s11524-015-9939-2

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Figures and Tables

Table 1: Mobility status of study households with children age 0-59 months and association with demographic, socioeconomic, and health characteristics using t- and χ^2 -tests

	Residentially stable, ≥ 24 months n=5513		Recently relocated, ≤ 12 months n=4507		p-value
<u>Demographics</u>	<u>mean</u>	<u>SE</u>	<u>mean</u>	<u>SE</u>	
Number of household members	5.40	0.09	4.60	0.10	<0.001
Number of children <5yrs in household	1.28	0.01	1.25	0.01	0.194
Age of index child in months	30.0	0.23	28.7	0.25	<0.001
	<u>n</u>	<u>%</u>	<u>n</u>	<u>%</u>	
Sex of index child: Male	2478	45	2048	45	0.622
<u>Socioeconomics</u>					
Mother's education					<0.001
No education	1133	21	1162	26	
Some schooling	1142	21	1176	26	
Finished secondary	1849	34	1483	33	
> Secondary	1389	25	686	15	
Father's education					<0.001
No education	1261	23	1139	25	
Some schooling	913	17	911	20	
Finished secondary	1525	28	1372	30	
> Secondary	1814	33	1085	24	
Occupation of household head					<0.001
Unemployed or other	482	9	232	5	
Daily labor	916	17	1218	27	
Shopkeeper or merchant	1787	32	1058	23	
Salaried service	2328	42	1999	44	
Monthly household income ^a					<0.001
$\leq 5,000$ taka (US \$73)	971	18	1080	24	

5,001 – 10,000 taka	1634	30	1925	43	
> 10,000 taka (US \$145)	2900	53	1498	33	
Household wealth index ^b					<0.001
Poorest	1092	20	1110	25	
Lower middle	922	17	1021	23	
Middle	966f	18	911	20	
Upper middle	1455	26	1155	26	
Richest	1078	20	310	7	
<u>Health services knowledge</u>					
Knowledge of local hospital	4709	85	3428	76	<0.001
<u>Health outcomes</u>					
Severe acute respiratory illness suffered by index child within 12 months ^c	763	14	695	15	0.026
Meningitis/encephalitis suffered by index child within 12 months ^d	185	3	164	4	0.443

^a12 respondents (8 residentially stable and 4 recently relocated) did not know or did not disclose household income.

^bPolychoric Principal Components Analysis was used to create a household wealth index including structural housing characteristics, cooking fuel, drinking water, and sanitation.

^cOne residentially stable respondent did not know if child recently had a severe acute respiratory illness.

^dThree respondents did not know if child recently had a serious illness with mental status changes (2 residentially stable and 1 recently relocated).

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Table 2: Using vaccination card plus maternal recall, vaccination coverage among children age 9-59 months and association with mobility status using univariate and multivariable models with modified Poisson regression

	Partial vaccination n=1465 (17%)		Full vaccination ^a n=7043 (83%)		PR ^b	95% CI	p-value
<u>Univariate analyses</u>							
Mobility status	<u>n</u>	<u>%</u>	<u>n</u>	<u>%</u>			
Residentially stable ≥24 months	706	15	4007	85	Reference		
Recently relocated ≤12 months	759	20	3036	80	0.94	0.91-0.97	<0.001
Demographics	<u>mean</u>	<u>SE</u>	<u>mean</u>	<u>SE</u>			
Number of children <5yrs in household	1.31	0.02	1.25	0.01	0.96	0.93-0.98	0.002
Age of index child in months	32.0	0.44	34.2	0.16	1.002	1.001-1.003	<0.001
Socioeconomics							
Mother's education	<u>n</u>	<u>%</u>	<u>n</u>	<u>%</u>			
No education	629	31	1377	69	Reference		
Some schooling	401	21	1540	79	1.16	1.10-1.21	<0.001
Finished secondary	323	11	2513	89	1.29	1.23-1.36	<0.001
> Higher secondary	112	6	1613	94	1.36	1.30-1.43	<0.001
Occupation of household head							
Unemployed or other	106	17	505	83	Reference		
Daily labor	524	29	1283	71	0.86	0.82-0.90	<0.001
Shopkeeper or merchant	348	14	2084	86	1.04	0.99-1.08	0.112
Salaried service	487	13	3171	87	1.05	1.01-1.09	0.029
Household wealth status (PCA ^c)							
Poorest	596	32	1290	68	Reference		
Lower middle	334	20	1298	80	1.16	1.09-1.24	<0.001
Middle	242	15	1348	85	1.24	1.16-1.32	<0.001
Upper middle	193	9	2043	91	1.34	1.25-1.42	<0.001
Richest	100	9	1064	91	1.34	1.25-1.43	<0.001
Health services knowledge							
Does <i>not</i> have knowledge of local hospital	354	23	1218	77	Reference		
Has knowledge of local hospital	1111	16	5825	84	1.08	1.05-1.12	<0.001

<u>Multivariable analyses with different models</u>			
Mobility, adjusting for demographics (# of children and age of index child)	0.94	0.92-0.97	<0.001
Mobility, adjusting for socioeconomics (education, occupation, and wealth)	0.97	0.95-0.99	0.009
Mobility, adjusting for demographics and socioeconomics	0.97	0.95-0.99	0.016

^aFull vaccination coverage per Expanded Programme on Immunization includes 1 dose of BCG, 3 doses of polio, 3 doses of DPT, and 1 dose of measles vaccines.

^bPR, Prevalence Ratio.

^cPolychoric Principal Components Analysis was used to create a household wealth index including structural housing characteristics, cooking fuel, drinking water, and sanitation.

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Table 3: Using vaccination card only, vaccination coverage among children age 9-59 months who have vaccination cards and association with mobility status using univariate and multivariable models with modified Poisson regression

	Partial vaccination n=564 (15%)		Full vaccination ^a n=3085 (85%)		PR ^b	95% CI	p-value
<u>Univariate analyses</u>							
Mobility status	<u>n</u>	<u>%</u>	<u>n</u>	<u>%</u>			
Residentially stable ≥24 months	329	14	1948	86	Reference		
Recently relocated ≤12 months	235	17	1137	83	0.97	0.93-1.00	0.083
Demographics	<u>mean</u>	<u>SE</u>	<u>mean</u>	<u>SE</u>			
Number of children <5yrs in household	1.26	0.02	1.24	0.01	0.99	0.96-1.02	0.486
Age of index child in months	27.1	0.64	29.6	0.25	1.002	1.001-1.003	0.001
Socioeconomics							
Mother's education	<u>n</u>	<u>%</u>	<u>n</u>	<u>%</u>			
No education	165	28	430	72	Reference		
Some schooling	123	16	654	84	1.16	1.09-1.24	<0.001
Finished secondary	186	14	1158	86	1.19	1.11-1.28	<0.001
> Higher secondary	90	10	843	90	1.25	1.17-1.33	<0.001
Occupation of household head							
Unemployed or other	35	13	238	87	Reference		
Daily labor	148	26	413	74	0.84	0.78-0.91	<0.001
Shopkeeper or merchant	143	13	921	87	0.99	0.94-1.04	0.778
Salaried service	238	14	1513	86	0.99	0.95-1.04	0.704
Household wealth status (PCA ^c)							
Poorest	148	27	401	73	Reference		
Lower middle	131	21	503	79	1.09	1.02-1.16	0.009
Middle	97	15	572	86	1.17	1.09-1.26	<0.001
Upper middle	110	10	1005	90	1.23	1.15-1.32	<0.001
Richest	78	11	604	89	1.21	1.13-1.30	<0.001
Health services knowledge							
Does <i>not</i> have knowledge of local hospital	101	19	434	81	Reference		
Has knowledge of local hospital	463	15	2651	85	1.05	1.01-1.09	0.025

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3 Multivariable analyses with different models

4 Mobility, adjusting for demographics (# of children and age of index child)	0.97	0.94-1.01	0.126
5 Mobility, adjusting for socioeconomics (education, occupation, and wealth)	0.98	0.95-1.02	0.308
6 Mobility, adjusting for demographics and socioeconomics	0.98	0.95-1.02	0.396

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8 ^aFull vaccination coverage per Expanded Programme on Immunization includes 1 dose of BCG, 3 doses of polio, 3 doses of DPT, and 1 dose of measles vaccines.

9 ^bPR, Prevalence Ratio.

10 ^cPolychoric Principal Components Analysis was used to create a household wealth index including structural housing characteristics, cooking fuel, drinking water, and sanitation.

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Table 4: Qualified provider visits for severe acute respiratory illness within prior year among children < 5 years old and association with mobility using univariate and multivariable models with modified Poisson regression

	No qualified provider for severe ARI ^a n=358 (25%)		Qualified provider for severe ARI ^a n=1100 (75%)		PR ^b	95% CI	p-value
<u>Univariate analyses</u>							
Mobility status	<u>n</u>	<u>%</u>	<u>n</u>	<u>%</u>			
Residentially stable ≥ 24 months	141	18	622	82	Reference		
Recently relocated ≤ 12 months	217	31	478	69	0.84	0.79-0.90	<0.001
Demographics	<u>mean</u>	<u>SE</u>	<u>mean</u>	<u>SE</u>			
Number of children <5yrs in household	1.23	0.03	1.25	0.02	1.02	0.97-1.08	0.437
Age of index child in months	29.1	0.83	23.7	0.44	0.994	0.992-0.996	<0.001
Socioeconomics							
Mother's education	<u>n</u>	<u>%</u>	<u>n</u>	<u>%</u>			
No education	134	38	220	62	Reference		
Some schooling	127	32	267	68	1.09	0.96-1.23	0.170
Finished secondary	79	16	425	84	1.36	1.20-1.54	<0.001
> Higher secondary	18	9	188	91	1.47	1.30-1.66	<0.001
Occupation of household head							
Unemployed or other	24	23	82	77	Reference		
Daily labor	139	36	244	64	0.82	0.72-0.94	0.005
Shopkeeper or merchant	89	22	320	78	1.01	0.90-1.14	0.848
Salaried service	106	19	454	81	1.05	0.93-1.18	0.435
Household wealth status (PCA ^c)							
Poorest	154	40	228	60	Reference		
Lower middle	93	30	220	70	1.18	1.02-1.37	0.031
Middle	59	21	220	79	1.32	1.16-1.51	<0.001
Upper middle	37	12	277	88	1.48	1.31-1.67	<0.001
Richest	15	9	155	91	1.53	1.35-1.73	<0.001
Health services knowledge							
Does <i>not</i> have knowledge of local hospital	114	49	118	51	Reference		

Has knowledge of local hospital	244	20	982	80	1.57	1.34-1.85	<0.001
<u>Multivariable analyses with different models</u>							
Mobility, adjusting for demographics (# of children and age of index child)					0.84	0.79-0.89	<0.001
Mobility, adjusting for socioeconomic (education, occupation, and wealth)					0.89	0.84-0.94	<0.001
Mobility, adjusting for demographics and socioeconomic					0.88	0.84-0.93	<0.001

^aARI, Acute Respiratory Illness.

^bPR, Prevalence Ratio.

^cPolychoric Principal Components Analysis was used to create a household wealth index including structural housing characteristics, cooking fuel, drinking water, and sanitation.

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Figure 1: Children sampled by mobility status for healthcare utilization and vaccination coverage analysis

Note: *ARI = Acute Respiratory Illness

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Supplemental Figure 1: Cook's distance calculations to examine influential observations

Cook's distance plots of multivariable models examining mobility, demographics, and socioeconomics for: vaccination using card plus maternal recall among children 9-59 months (A), vaccination using card only among children 9-59 months (B), qualified provider visits for respiratory infections among children <5 years old (C), vaccination using card plus maternal recall among children 9-23 months (D), and vaccination using card only among children 9-23 months (E). The red lines indicate threshold value of $4/n$ where n =number of observations.

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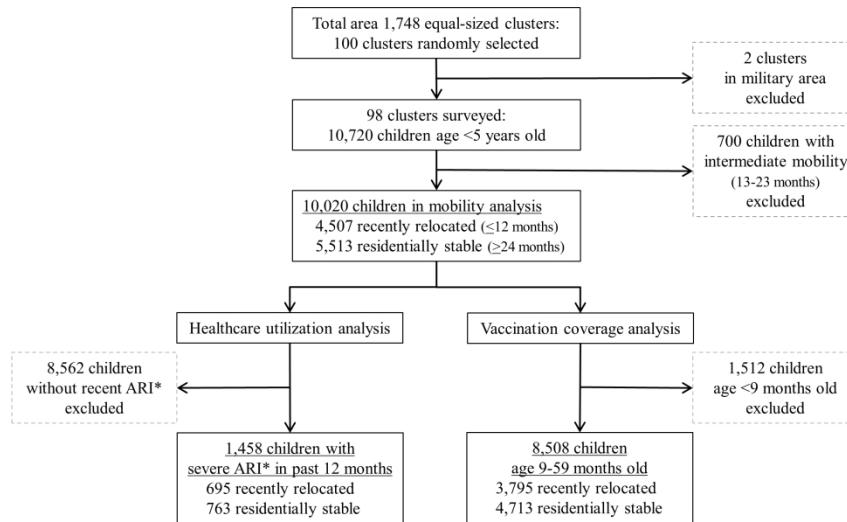


Figure 1: Children sampled by mobility status for healthcare utilization and vaccination coverage analysis
 Note: *ARI = Acute Respiratory Illness

Figure 1: Children sampled by mobility status for healthcare utilization and vaccination coverage analysis
 Note: *ARI = Acute Respiratory Illness

254x190mm (300 x 300 DPI)

**Effect of household relocation on child vaccination and health service utilization in Dhaka, Bangladesh:
a cross-sectional community survey**

SUPPLEMENTAL FIGURES AND TABLES

Supplemental Table 1: Household wealth principal components analysis coding and variable loading

Indicator	Coding	Loading
Number of rooms	Continuous	0.337
Housing arrangement	1 = Free 2 = Rental 3 = Owned	0.235
Roof	1 = Natural roof (bamboo/thatch) 2 = Rudimentary roof (tin) 3 = Finished roof (cement/concrete/tiled) 4 = Other	0.392
Walls	1 = Natural walls (jute/bamboo/mud) 2 = Rudimentary walls (wood) 3 = Finished walls (tin/brick/cement) 4 = Other	0.316
Floor	1 = Natural floor (earth/bamboo) 2 = Rudimentary floor (wood) 3 = Finished floor (cement/concrete) 4 = Other	0.377
Cooking fuel	1 = Natural (wood/grass/dung) 2 = Coal/charcoal 3 = Kerosene 4 = Electricity 5 = Gas (liquid/biogas) 6 = Other	0.350
Drinking water	1 = Unimproved (unprotected/surface/bottled) 2 = Improved but not piped 3 = Improved and piped into yard or private dwelling 4 = Other	0.170
Sanitation	1 = Unimproved (open defecation/hanging/open or broken pit) 2 = Improved but not piped	0.374

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	3 = Improved and piped sewer 4 = Other	
Mobile phone ownership	0 = No 1 = Yes	0.380

Note: 51% of overall variance was explained by the first component.

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Supplemental Table 2: Using vaccination card plus maternal recall, vaccination coverage among children age 9-23 months and association with mobility status using univariate and multivariable models with modified Poisson regression

	Partial vaccination n=518 (21%)		Full vaccination ^a n=1906 (79%)		PR ^b	95% CI	p-value
<u>Univariate analyses</u>							
Mobility status	<u>n</u>	<u>%</u>	<u>n</u>	<u>%</u>			
Residentially stable ≥ 24 months	243	19	1053	81	Reference		
Recently relocated ≤ 12 months	275	24	853	76	0.93	0.88-0.98	0.009
Demographics	<u>mean</u>	<u>SE</u>	<u>mean</u>	<u>SE</u>			
Number of children <5yrs in household	1.31	0.03	1.24	0.01	0.94	0.89-0.99	0.035
Age of index child in months	14.73	0.20	16.35	0.11	1.02	1.02-1.03	<0.001
Socioeconomics							
Mother's education	<u>n</u>	<u>%</u>	<u>n</u>	<u>%</u>			
No education	207	41	303	59	Reference		
Some schooling	121	22	433	78	1.32	1.18-1.47	<0.001
Finished secondary	141	16	719	84	1.41	1.27-1.56	<0.001
> Higher secondary	49	10	451	90	1.52	1.36-1.69	<0.001
Occupation of household head							
Unemployed or other	26	15	147	85	Reference		
Daily labor	195	38	318	62	0.73	0.66-0.81	<0.001
Shopkeeper or merchant	124	19	538	81	0.96	0.88-1.04	0.287
Salaried service	173	16	903	84	0.99	0.91-1.07	0.752
Household wealth status (PCA ^c)							
Poorest	212	40	321	60	Reference		
Lower middle	114	25	348	75	1.25	1.11-1.40	<0.001
Middle	84	18	382	82	1.36	1.20-1.54	<0.001
Upper middle	59	10	560	90	1.50	1.34-1.69	<0.001
Richest	49	14	295	86	1.42	1.26-1.61	<0.001
Health services knowledge							
Does <i>not</i> have knowledge of local hospital	127	28	324	72	Reference		
Has knowledge of local hospital	391	20	1582	80	1.12	1.05-1.19	<0.001

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<u>Multivariable analyses with different models</u>			
Mobility, adjusting for demographics (# of children and age of index child)	0.93	0.88-0.98	0.007
Mobility, adjusting for socioeconomics (education, occupation, and wealth)	0.96	0.91-1.01	0.136
Mobility, adjusting for demographics and socioeconomics	0.96	0.92-1.01	0.138

^aFull vaccination coverage per Expanded Programme on Immunization includes 1 dose of BCG, 3 doses of polio, 3 doses of DPT, and 1 dose of measles vaccines.

^bPR, Prevalence Ratio.

^cPolychoric Principal Components Analysis was used to create a household wealth index including structural housing characteristics, cooking fuel, drinking water, and sanitation.

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Supplemental Table 3: Using vaccination card only, vaccination coverage among children age 9-23 months who have vaccination cards and association with mobility status using univariate and multivariable models with modified Poisson regression

	Partial vaccination n=281 (19%)		Full vaccination ^a n=1222 (81%)		PR ^b	95% CI	p-value
<u>Univariate analyses</u>							
Mobility status	<u>n</u>	<u>%</u>	<u>n</u>	<u>%</u>			
Residentially stable ≥ 24 months	156	18	715	82	Reference		
Recently relocated ≤ 12 months	125	20	507	80	0.97	0.92-1.04	0.469
Demographics	<u>mean</u>	<u>SE</u>	<u>mean</u>	<u>SE</u>			
Number of children <5yrs in household	1.23	0.03	1.21	0.01	0.98	0.93-1.04	0.543
Age of index child in months	14.4	0.27	15.9	0.15	1.02	1.01-1.03	<0.001
Socioeconomics							
Mother's education	<u>n</u>	<u>%</u>	<u>n</u>	<u>%</u>			
No education	94	35	176	65	Reference		
Some schooling	57	17	286	83	1.28	1.15-1.42	<0.001
Finished secondary	93	17	461	83	1.28	1.14-1.43	<0.001
> Higher secondary	37	11	299	89	1.37	1.22-1.52	<0.001
Occupation of household head							
Unemployed or other	14	12	100	88	Reference		
Daily labor	89	33	184	67	0.77	0.68-0.87	<0.001
Shopkeeper or merchant	66	16	352	84	0.96	0.88-1.04	0.327
Salaried service	112	16	586	84	0.96	0.88-1.04	0.297
Household wealth status (PCA ^c)							
Poorest	84	32	179	68	Reference		
Lower middle	67	24	211	76	1.12	0.99-1.25	0.062
Middle	52	17	248	83	1.21	1.08-1.37	0.002
Upper middle	42	10	381	90	1.32	1.18-1.48	<0.001
Richest	36	15	203	85	1.25	1.10-1.41	<0.001
Health services knowledge							
Does <i>not</i> have knowledge of local hospital	55	22	194	78	Reference		
Has knowledge of local hospital	226	18	1028	82	1.05	0.98-1.13	0.141

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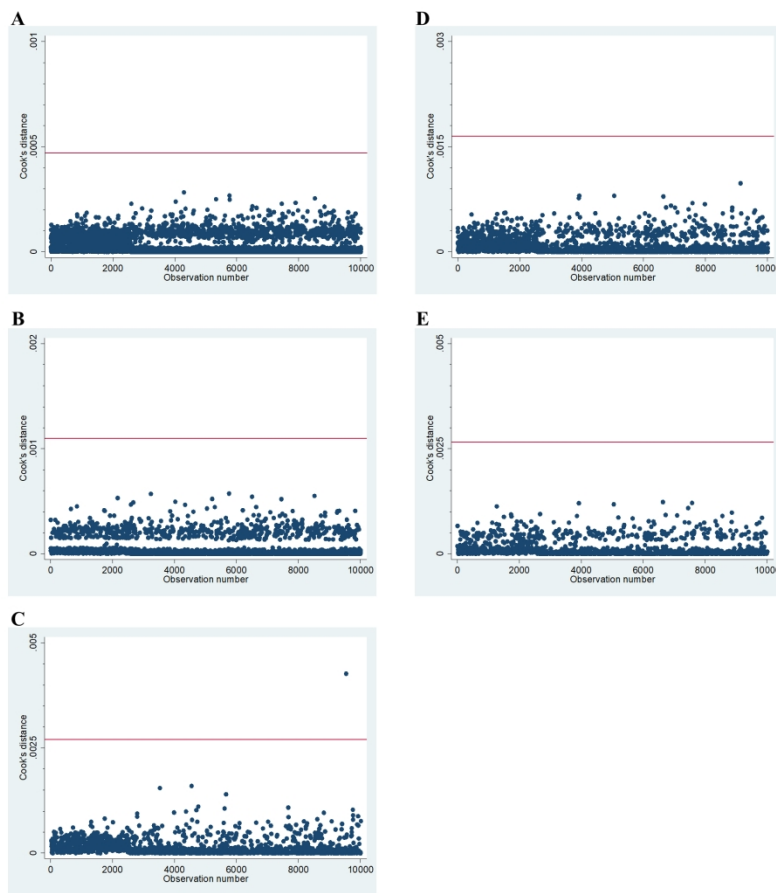
<u>Multivariable analyses with different models</u>			
Mobility, adjusting for demographics (# of children and age of index child)	0.98	0.93-1.04	0.582
Mobility, adjusting for socioeconomics (education, occupation, and wealth)	1.00	0.94-1.06	0.948
Mobility, adjusting for demographics and socioeconomics	1.00	0.95-1.07	0.888

^aFull vaccination coverage per Expanded Programme on Immunization includes 1 dose of BCG, 3 doses of polio, 3 doses of DPT, and 1 dose of measles vaccines.

^bPR, Prevalence Ratio.

^cPolychoric Principal Components Analysis was used to create a household wealth index including structural housing characteristics, cooking fuel, drinking water, and sanitation.

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Supplemental Figure 1: Cook's distance calculations to examine influential observations
 Cook's distance plots of multivariable models examining mobility, demographics, and socioeconomic factors for: vaccination using card plus maternal recall among children 9-59 months (A), vaccination using card only among children 9-59 months (B), qualified provider visits for respiratory infections among children <5 years old (C), vaccination using card plus maternal recall among children 9-23 months (D), and vaccination using card only among children 9-23 months (E). The red lines indicate threshold value of $4/n$ where n =number of observations.

190x254mm (300 x 300 DPI)

Effect of household relocation on child vaccination and health service utilization in Dhaka, Bangladesh: a cross-sectional community survey

STROBE 2007 (v4) Statement—Checklist of items that should be included in reports of *cross-sectional studies*

Section/Topic	Item #	Recommendation	Reported on page #
Title and abstract	1	(a) Indicate the study’s design with a commonly used term in the title or the abstract	1
		(b) Provide in the abstract an informative and balanced summary of what was done and what was found	2
Introduction			
Background/rationale	2	Explain the scientific background and rationale for the investigation being reported	4
Objectives	3	State specific objectives, including any prespecified hypotheses	6
Methods			
Study design	4	Present key elements of study design early in the paper	6
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection	6
Participants	6	(a) Give the eligibility criteria, and the sources and methods of selection of participants	7
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable	7
Data sources/ measurement	8*	For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group	7
Bias	9	Describe any efforts to address potential sources of bias	8
Study size	10	Explain how the study size was arrived at	7
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why	8
Statistical methods	12	(a) Describe all statistical methods, including those used to control for confounding	8
		(b) Describe any methods used to examine subgroups and interactions	8
		(c) Explain how missing data were addressed	8
		(d) If applicable, describe analytical methods taking account of sampling strategy	8

		(e) Describe any sensitivity analyses	8
Results			
Participants	13*	(a) Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed	9
		(b) Give reasons for non-participation at each stage	9
		(c) Consider use of a flow diagram	Figure 1
Descriptive data	14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders	9
		(b) Indicate number of participants with missing data for each variable of interest	9
Outcome data	15*	Report numbers of outcome events or summary measures	9
Main results	16	(a) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included	10
		(b) Report category boundaries when continuous variables were categorized	9
		(c) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period	n/a
Other analyses	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses	10
Discussion			
Key results	18	Summarise key results with reference to study objectives	11
Limitations	19	Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias	13
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence	15
Generalisability	21	Discuss the generalisability (external validity) of the study results	14
Other information			
Funding	22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based	17

*Give information separately for cases and controls in case-control studies and, if applicable, for exposed and unexposed groups in cohort and cross-sectional studies.

Note: An Explanation and Elaboration article discusses each checklist item and gives methodological background and published examples of transparent reporting. The STROBE checklist is best used in conjunction with this article (freely available on the Web sites of PLoS Medicine at <http://www.plosmedicine.org/>, Annals of Internal Medicine at <http://www.annals.org/>, and Epidemiology at <http://www.epidem.com/>). Information on the STROBE Initiative is available at www.strobe-statement.org.

BMJ Open

Effect of household relocation on child vaccination and health service utilization in Dhaka, Bangladesh: a cross-sectional community survey

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Primary Subject Heading:	Global health
Secondary Subject Heading:	Epidemiology, Paediatrics, Public health, Infectious diseases
Keywords:	Community child health < PAEDIATRICS, PUBLIC HEALTH, Public health < INFECTIOUS DISEASES, Paediatric infectious disease & immunisation < PAEDIATRICS, EPIDEMIOLOGY

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7 **Effect of household relocation on child vaccination and health service utilization in**
8 **Dhaka, Bangladesh: a cross-sectional community survey**
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13 Lily M. Horng^{1*}, Nadira K. Sultana², Jaynal Abedin², Stephen P. Luby^{1,2}

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Abstract

Objective To explore the relationship between household relocation and use of vaccination and health services for severe acute respiratory illness (ARI) among children in Dhaka, Bangladesh.

Design Analysis of cross-sectional community survey data from a prior study examining the impact of *Haemophilus influenzae* type b vaccine introduction in 2009 on meningitis incidence in Bangladesh.

Setting Communities surrounding two large pediatric hospitals in Dhaka, Bangladesh.

Participants Households with children under 5 years old who either recently relocated ≤ 12 months or who were residentially stable living ≥ 24 months in their current residence (total n = 10,020) were selected for this study.

Primary outcome measures Full vaccination coverage among 9-59 month old children and visits to a qualified medical provider for severe ARI among children under 5 years old.

Results Using vaccination cards with maternal recall, full vaccination was 80% among recently relocated children (n=3,795) and 85% among residentially stable children (n=4,713; $\chi^2=37.2$, $p<0.001$). Among children with ARI in the prior year, 69% of recently relocated children (n=695) had visited a qualified provider compared to 82% of residentially stable children (n=763; $\chi^2=31.9$, $p<0.001$). After adjusting for demographic and socioeconomic characteristics, recently relocated children were less likely to be fully vaccinated (prevalence ratio [PR] 0.97; 95% confidence interval [CI] 0.95-0.99; $p=0.016$) and to have visited a qualified provider for ARI (PR 0.88; 95% CI 0.84-0.93; $p<0.001$).

Conclusions Children in recently relocated households in Dhaka, Bangladesh have decreased use of vaccination and qualified health services for severe acute respiratory illnesses.

Strengths and limitations of this study

- This study examined a rich dataset from prior community surveys in Dhaka, Bangladesh to explore associations between household relocation and utilization of vaccination and qualified child health services.
- Vaccination was evaluated using different measurements and age ranges to explore trends in the relationship between mobility and vaccination.
- Effect of household relocation on use of child health services was found even after adjusting for socioeconomic factors known to impact health-seeking behavior.
- Limitations include lack of detailed data on mobility patterns and costs of health services.

Introduction

Pneumonia or acute respiratory illness (ARI) is the leading cause of death globally in children under 5 years old, and lower respiratory tract infections caused an estimated 652,572 child deaths in 2016.[1] Many causes of ARI are preventable by vaccines such as *Streptococcus pneumoniae* (attributed to 52% of global pneumonia child deaths) and *Haemophilus influenzae* type b (Hib) (7% of deaths).[1] The majority of the world's population now lives in urban areas, and this population is expected to grow from 54% in 2014 to 66% in 2050, an estimated increase of 2.5 billion people.[2,3] With this increase, 90% of growth is projected in Asia and Africa.[3] The population living in urban slums is also expected to increase from 881 million in 2014 to 2 billion in 2030, in large part due to rural-urban migration.[2,4]

In many low- and middle-income countries, vaccination and childhood mortality rates among urban poor are worse than among other urban groups and even rural populations.[5,6] In addition, residents of slums have poor health outcomes due to lack of reliable access to housing, clean water, sanitation, education, and health services.[4,5,7–9] In Nigeria, a 2010 study examining 2003 Demographic and Health Survey data of 6,029 children 12 months and older found full immunization among 24.3% of rural non-migrant, 15.2% of urban non-migrant, and 8.5% of rural-urban migrant children.[10] In Bangladesh, a comparison study of the 2013 Urban Health Survey and 2014 Demographic and Health Survey found under-5 child mortality rates of 46 per 1,000 livebirths nationally, 41 in Dhaka, 49 in rural areas, and 57 in urban slums.[5] One recent systematic review found community factors associated with vaccination coverage in the urban poor included socio-economic characteristics, vaccination knowledge and beliefs, access to care, and recent rural-urban migration.[6]

Residential mobility has been recognized as an important contributor to healthcare use in high-income countries, with relocation associated with decreased use of preventive and curative services.[11,12] One study using a 1998 United States national health survey found that duration, distance, and frequency of moving were all predictors of decreased use of child

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3 health services even after accounting for sociodemographic factors. Households who had
4 moved within 12 months accessed fewer preventive child health services compared to
5 households living in their current residence over 36 months (odds ratio 3.1, 95% confidence
6 interval [CI] 2.5-3.7).[12] Recently relocated households also accessed fewer curative
7 services (odds ratio 3.3, 95% CI 2.6-4.2).[12] Frequent moving also impacted children's long-
8 term cognitive function and behavioral problems into adulthood.[13] Moving can impact
9 health through various social determinants. In one conceptual framework by the World Health
10 Organization (WHO), structural determinants of social, economic, and political contexts
11 influence intermediary determinants of material, behavioral, psychosocial, and health system
12 factors that ultimately shape an individual's health.[14] Relocation can improve an
13 individual's socioeconomic position in the long term, but mobility often disrupts material
14 resources, psychosocial support, and health care access.

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Few studies examine mobility and healthcare utilization in low- and middle-income countries despite high population relevance: approximately 43% of urban residents in middle-income countries and 78% in low-income countries live in slums.[3,4,6,10,15,16] In the 2010 Nigeria study, urban non-migrant children had 1.7 times higher odds of being fully immunized than rural-urban migrants (univariate odds ratio [OR] 1.67, 95% confidence interval [CI] 1.20-2.32).[10] This association between migration and immunization was independent of demographic factors, but was attenuated and partially explained by socioeconomic characteristics and maternal healthcare utilization in multivariable analyses.[10] In this Nigeria study, migrant status was defined as moving within 10 years.[10] A 2010 cross-sectional survey in India examined 746 rural-urban migrant mothers with children under 2 years old: 339 were 'recent' migrants who moved to Delhi within 5 years and 407 were 'settled' migrants in Delhi at least 5 years.[16] For age-appropriate children, 81% of settled migrants and 64% of recent migrants were fully immunized per national guidelines.[16] Settled migrant children had 1.9 times higher odds of being fully immunized

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3 than recent migrants after adjusting for demographics, socioeconomics, and maternal
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5 healthcare utilization (adjusted OR 1.93, 95% CI 1.18-3.14).[16]
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7 Studying urban health services in Bangladesh is useful because Bangladesh is the
8
9 world's most densely populated country that is not a city-state: the population of the capital
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11 Dhaka will increase from an estimated 16 to 27 million by 2030.[3,17] Furthermore, the
12
13 government has a strong national Expanded Programme on Immunization and active health
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15 systems research.[17,18] In 2011, full vaccination rates among children age 12-23 months
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17 were 80% nationally in Bangladesh, 75% in Dhaka, but only 43-67% in Dhaka slums.[17-21]
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19 Prior studies found that household turnover was as high as 50% in one year, comprehensive
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21 provider-led vaccination interventions were effective but too expensive to sustain, and street
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23 children were very hard to reach with interventions in Dhaka.[19,22,23]
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26 To explore the relationship between residential mobility and healthcare utilization in
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28 Dhaka, we used data from a study showing Hib vaccine introduction into Bangladesh's
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30 Expanded Programme on Immunization in 2009 dramatically reduced rates of Hib meningitis
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32 and purulent meningitis in children.[24] We conducted secondary analysis of the Hib impact
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34 study's community survey data to determine whether recently relocated children were: 1) less
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36 likely to be fully vaccinated per Expanded Programme on Immunization guidelines and 2)
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38 less likely to use qualified health services for severe acute respiratory illness than residentially
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40 stable children.
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45 Methods

46 Study design and setting

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49 Hib conjugate vaccine was introduced into Bangladesh's Expanded Programme on
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51 Immunization in 2009, and the Hib impact study conducted pre and post-vaccine surveillance
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53 of meningitis in children under 5 years old using hospital records and community surveys
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55 surrounding two large pediatric hospitals in Dhaka: Dhaka Shishu and Shishu Shastya
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3 Foundation Hospital.[24] Field researchers consecutively enrolled 100 children discharged
4 with a diagnosis of meningitis and/or encephalitis from the two study hospitals, visited
5 households, and recorded household geographical positional system coordinates. The
6 catchment area was defined as the area containing >80% of households with children
7 discharged with meningitis and within one hour of transport to either hospital. Field teams
8 divided the catchment area into 1,748 equal-sized rectangles and randomly selected 100
9 rectangles as clusters. Teams surveyed each household with a child under 5 years old within
10 98 clusters. Two clusters were within a military cantonment, thus inaccessible. Households
11 were asked about: 1) routine vaccinations using vaccination cards and maternal recall and 2)
12 healthcare use for children with illnesses in the prior 12 months suggestive of
13 meningoencephalitis defined as: any serious illness with acute onset of fever with either
14 convulsions or unconsciousness or altered mental status.[24] Data were collected one year
15 before (2008) and after (2010) Hib vaccine introduction.
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34 **Study population**

35 We used the Hib impact study's pre-vaccine community surveillance data and
36 included children based on mobility status: 1) children living in their current residence \leq 12
37 months who we classified as "recently relocated" and 2) children living \geq 24 months in their
38 current residence who we classified as "residentially stable". This definition of
39 mobility/migration status has been used in prior studies.[6,12] We excluded children living in
40 their current residence 13-23 months who we classified as "intermediately mobile".
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50 **Study outcomes**

51 Our two primary outcomes focused on healthcare utilization: 1) full vaccination
52 among 9-59 month old children and 2) visit to a qualified medical provider among children
53 under 5 years old who had severe acute respiratory illness symptoms within the prior 12
54 months. We defined full vaccination per Bangladesh Expanded Programme on Immunization
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3 guidelines in 2008 (before Hib vaccine): 1 dose of Bacillus Calmette-Guérin (BCG) vaccine
4 against tuberculosis; 3 doses of combined vaccine against diphtheria, pertussis, and tetanus
5 (DPT); 3 doses of oral polio vaccine (excluding polio vaccine given at birth); and 1 dose of
6 measles vaccine. Government guidelines recommended children to receive all these
7 vaccinations before 9 months of age. Any doses of pentavalent vaccine, which includes
8 diphtheria, pertussis, tetanus, hepatitis B, and Hib, were included in vaccination analyses. We
9 defined severe acute respiratory illness as cough or difficulty breathing plus any danger sign:
10 stridor, chest in-drawing, difficulty drinking/ breastfeeding, vomiting, cyanosis, convulsions,
11 lethargy, or unconsciousness. We defined a qualified medical provider as having a Bachelor
12 of Medicine degree or higher.
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27 **Data analysis**

28 We compared sociodemographic and health characteristics between residentially
29 stable and recently relocated households. For continuous variables, we calculated means with
30 standard errors and t-tests adjusting for cluster. For categorical variables, we calculated
31 percentages and χ^2 -tests. To construct a wealth index, we used polychoric principal
32 components analysis (PCA) including: housing (number of rooms; free, rental, or owned
33 housing; main material of roof, walls, and floors), cooking fuel, drinking water, sanitation,
34 and mobile phone ownership.[25–27] We then divided households into wealth quintiles. We
35 did not include durable assets such as furniture items because ownership of these goods could
36 be associated with duration of residency.
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47 To examine the magnitude of association between mobility and study outcomes of
48 vaccination and visit to a qualified provider for severe ARI, we used modified Poisson
49 regression with robust cluster variance to estimate prevalence ratios (PRs).[28,29] We chose
50 modified Poisson regression to model prevalence ratios for common binary outcomes because
51 logistic regression is more applicable to rare outcomes and because log-binomial regression
52 models may fail to converge. We conducted univariate analyses to estimate individual effects
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3 of mobility, demographics, socioeconomics, and health services knowledge (i.e. knowledge of
4 local hospital) on healthcare utilization. Missing data regarding main study outcome of acute
5 respiratory illness were handled through listwise deletion. Given large number of missing
6 vaccination cards, we analyzed vaccination in two ways: 1) using vaccination cards plus
7 maternal recall and 2) using vaccination cards alone. We conducted multivariable analyses
8 examining the association between mobility and healthcare utilization, adjusting for
9 demographics and socioeconomics known to influence health-seeking behavior.[9,16,30–32]
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11 Regression diagnostics included checks for influential observations with Cook's distance
12 calculations.
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25 **Ethics**

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28 The Ethical Review Committee of the International Centre for Diarrhoeal Disease
29 Research, Bangladesh (icddr,b) reviewed and approved the study protocol. Written informed
30 consent was obtained from all participants before taking part in the initial Hib impact study.
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36 **Patient and public involvement**

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38 No participants were directly involved in development of the research questions and
39 outcomes. No participants were involved in the design or conduct of the study. There are no
40 plans to disseminate the results of the research individually to study participants.
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47 **Results**

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49 We surveyed a total of 10,720 households with children less than 5 years old: 42% of
50 households had recently relocated within 12 months, 51% were residentially stable living in
51 their current residence over 24 months, and 7% were intermediately mobile (Figure 1). We
52 excluded from subsequent analyses 700 children living in their current residence 13-23
53 months and classified as intermediately mobile. For the healthcare utilization analysis, 1,458
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3 children had severe ARI symptoms within the 12 months prior to survey. For the vaccination
4 analysis, 8,508 children were age 9-59 months and thus should have completed all Expanded
5 Programme on Immunization-recommended vaccinations. Household demographics, parental
6 education, occupation, and hospital knowledge were available for all households. Missing
7 data included: income for 12 households, meningitis symptoms for 3 children, respiratory
8 illness symptoms for 1 child, and vaccination cards for 4,859 children age 9-59 months.
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16 Recently relocated families had smaller households, less education, less wealth, and
17 less knowledge of the local hospital compared to residentially stable families (Table 1).
18 Recently relocated families were poorer: 24% earned less than 5,000 Bangladeshi taka (US
19 \$73) per month compared to 18% of residentially stable families. For the wealth index
20 analysis, the first principal component accounted for 51% of overall variance, with largest
21 contributions from roof and floor materials, sanitation, and mobile phone ownership
22 (Supplemental Table 1). Among recently relocated families, 48% were in the two lowest
23 wealth quintiles compared to 37% of residentially stable families. Fewer recently relocated
24 caregivers had knowledge of the local hospital, 76%, compared to residentially stable
25 caregivers, 85% ($\chi^2=142.3$, $p<0.001$). Similar rates of illness in the 12 months prior to survey
26 were reported by all households: 14-15% of children with symptoms of severe ARI and 3-4%
27 with symptoms of meningitis/encephalitis.
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41 Full vaccination coverage measured by vaccination card plus maternal recall was
42 83% among all children age 9-59 months (Table 2). Full vaccination was 80% among recently
43 relocated children and 85% among residentially stable children (univariate PR 0.94, 95% CI
44 0.91-0.97, $p<0.001$). Vaccination was lower in households with more children and younger
45 children. Socioeconomic factors, especially mother's education, had the strongest association
46 with vaccination. In multivariable analyses, recently relocated children were 3% less likely
47 than residentially stable children to be fully vaccinated even after adjusting for demographic
48 and socioeconomic factors (multivariable PR 0.97, 95% CI 0.95-0.99, $p=0.016$).
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Vaccination was also analyzed using only vaccination cards (Table 3). At time of survey, only 43% of all children had vaccination cards available. Fewer recently relocated children had vaccination cards, 36%, compared to 48% of residentially stable children ($\chi^2=126.9$, $p<0.001$). Younger children were more likely to have cards than older children: 62% of children 9-23 months old had vaccination cards as compared to 38% of children 24-59 months old ($\chi^2=505.7$, $p<0.001$). Full vaccination per vaccination card was 83% among recently relocated children and 86% among residentially stable children (univariate PR 0.97, 95% CI 0.93-1.00, $p=0.083$). The 9-59 month age range for vaccination analysis allowed inclusion of a larger sample size of children vulnerable to vaccine-preventable disease. In contrast, routine vaccination schedules focus on children <2 years old and full vaccination coverage per Expanded Programme on Immunization in Bangladesh and many other countries is defined in children up to 23 months old.[18,33] Narrowing the age range of vaccination analysis to 9-23 months showed similar results although with smaller sample sizes limiting statistical power to detect mobility-vaccination associations (Supplementary Tables 2 and 3). In addition, using a 10-month age minimum to account for potential delay in measles vaccination recommended at 9 months old showed the same results as a 9-month age cutoff (data not shown). Checking for influential observations with Cook's distances identified no outliers in vaccination analyses (Supplemental Figure 1).[34]

Among all children under 5 years old with severe ARI in the past year, 75% visited a qualified medical provider (Table 4). Fewer recently relocated children with severe ARI saw a qualified provider, 69%, as compared to 82% of residentially stable children (univariate PR 0.84, 95% CI 0.79-0.90, $p<0.001$). Socioeconomic factors, especially household wealth, were strongly associated with qualified provider visits.

Health services knowledge was also strongly associated with acute healthcare visits: 80% of parents who knew about the local hospital sought ARI treatment from a qualified provider as compared to 51% of parents who did *not* have knowledge of the local hospital (univariate PR 1.57, 95% CI 1.34-1.85, $p<0.001$). After adjusting for demographic and

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3 socioeconomic factors, recently relocated households were 11% less likely than residentially
4 stable households to visit a qualified medical provider for children with severe ARI
5 (multivariable PR 0.88, 95% CI 0.84-0.93, $p < 0.001$). One outlier was identified by Cook's
6 distances in healthcare utilization analyses (Supplemental Figure 1). Excluding this outlier
7 and using robust error variance resulted in similar results to those presented (data not shown).
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16 Discussion

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18 Recently relocated households were less likely to use both acute and preventive child
19 healthcare services in our study in Dhaka, Bangladesh, and these findings support prior
20 literature exploring the effects of mobility on healthcare utilization.[6,10–13,16] Household
21 relocation had a strong association with decreased use of qualified medical services for severe
22 acute respiratory illness. Similarly, household relocation was associated with decreased
23 vaccination rates although this relationship was less robust. Another key finding was that
24 recently relocated parents were less knowledgeable about the local hospital compared to
25 residentially stable parents, and knowledge of the local hospital had as strong an association
26 with acute healthcare visits as some economic factors. Overall, recently relocated children in
27 our study had slightly lower vaccination rates and markedly lower use of acute healthcare
28 services for ARI than residentially stable children.
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41 Study strengths include data focused on urban Bangladesh and exploring vaccination
42 status using different measurements as well as adjusting for socioeconomic factors when
43 examining mobility and health service utilization. Our study used the Hib impact study's
44 rigorous community surveillance data of households living close to tertiary care pediatric
45 hospitals in Dhaka. Dhaka residents have high mobility and many options for healthcare.
46 Unlike in rural areas, physical access to health services is usually *not* a barrier to healthcare
47 use in urban areas. One study found almost all residents in Dhaka lived within 1 kilometer of
48 primary health services.[35] Routine immunizations are provided free by the government of
49 Bangladesh, but acute care services require out of pocket expenditures which can be a barrier
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3 to access. Our findings on mobility and child health services use in Dhaka could inform
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5 health services work in other urban low- and middle-income country contexts.[3,5]
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7 We analyzed vaccination using vaccination card data augmented with maternal recall,
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9 vaccination card data only, and several different age ranges. Accurately measuring
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11 vaccinations in children is a known difficulty in public health programs and research studies,
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13 especially in low- and middle-income countries where vaccination cards are frequently *not*
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15 available. Some studies have found poor agreement between parental recall, vaccination
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17 cards, and even official health records.[36–38] By contrast, other studies have found good
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19 correlation between maternal report and vaccination cards, and maternal recall is routinely
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21 used in Demographic and Health Surveys and Multiple Indicator Cluster Surveys.[39,40]
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23 Maternal recall can overestimate or underestimate vaccination history based on education,
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25 social desirability bias, and vaccine-specific knowledge. Vaccination card retention itself can
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27 be affected by parental education, household wealth, age of child, and even household
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29 relocation. Our data showed more missing cards among recently relocated households and in
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31 older children, thus those groups are subject to more maternal recall bias. Using only
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33 vaccination cards or narrower age ranges in our vaccination analyses resulted in smaller
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35 sample sizes which limited statistical power, but all analyses showed similar effect estimates
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37 of increased mobility associated with decreased vaccination. Moreover, the association
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39 between increased household relocation and decreased health services use was still seen even
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41 after adjusting for socioeconomic factors known to impact healthcare use.
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45 Study limitations include lack of data on mobility patterns and health services costs.
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47 Information on households' prior residences, distances moved, or frequency of moving was
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49 not available in our dataset. Households moving from rural Bangladesh to urban Dhaka,
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51 moving long distances, or relocating frequently probably have less knowledge and therefore
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53 use of locally available health services.[12] Several studies show that recent rural to urban
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55 migration is associated with lower vaccination coverage in children.[6,10,16] Lack of data on
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57 mobility patterns in our study precludes evaluation of how magnitude of relocation affected
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3 healthcare use. Our findings likely underestimate the negative association between mobility
4 and healthcare utilization for households with large migration such as rural to urban migrants
5 as compared to households with intra-Dhaka relocation where one would expect minimal
6 change in health-seeking behavior. We were also unable to examine household relocation
7 timing in relation to healthcare use. Recently relocated households were not asked if
8 healthcare visits occurred before or after moving. Healthcare visits before moving would not
9 be relevant to how mobility affects use of health services after moving. Our findings may
10 underestimate the negative association between mobility and health-seeking behavior because
11 our data included healthcare visits before moving which were unrelated to knowledge of the
12 new geographic area. Timing of healthcare visits in relation to acquiring knowledge of
13 hospital services was also not available, thus there may be reverse causality of recently
14 relocated households gaining knowledge of local providers after seeking care. Ultimately, our
15 results show a modest overall association between mobility and healthcare use which could be
16 elucidated by asking about migration patterns including timing of use of health services.
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32 Our study results may not be as generalizable to populations in urban areas without
33 tertiary care hospitals. Our sampling scheme focused on community catchment areas
34 surrounding tertiary care pediatric hospitals. Advantages of this study design were that it
35 allowed examination of healthcare utilization for severe disease since advanced services were
36 available within a small physical distance. In addition, it was a low-cost way to examine
37 population-level mobility instead of more resource-intensive active surveillance of migrant
38 populations. However, use of health services generally increases with geographic proximity,
39 and studies show this relationship is influenced by many factors including income and slum
40 versus non-slum locations.[35,41] Recently relocated populations may be even more
41 influenced by proximity than residentially stable populations because of fewer socioeconomic
42 resources and lack of knowledge of health services. This would bias our results towards
43 higher rates of health-seeking behavior among recently relocated households. Recently
44 relocated households in areas without tertiary care services may use health services less
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3 because of transport costs and lack of knowledge of health facilities physically distant. In
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5 addition, our study included participants who relocated into the study area, but not people
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7 who left the study area. In-migrants and out-migrants may be different in their healthcare
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9 utilization patterns, which could also affect generalizability.
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11 Our dataset did not contain cost of services, which is a well-known barrier to
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13 healthcare use.[20,21,31] Although vaccinations are provided for free, some non-
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15 governmental and private organizations charge fees for patient registration. Even small fees
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17 could have lowered vaccination rates. Cost of services, willingness to pay, and underlying
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19 finances are strongly linked, thus adjusting for socioeconomic factors of parental education
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21 and wealth in our models should have incorporated some cost effects on healthcare use.
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23 However, costs could affect recently relocated households disproportionately more than
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25 residentially stable households of the same socioeconomic status. One could hypothesize that
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27 immediately after relocating, families would first spend money on household goods before
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29 preventive medicine fees. Without cost data, we can still conclude from our analysis that
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31 increased mobility is associated with decreased healthcare use, but we have limited
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33 understanding of mechanisms through which mobility affects healthcare use.
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37 Barriers and delays to using appropriate healthcare services increase mortality.[31,42]
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39 One study in India of 290 children hospitalized for pneumonia in a tertiary care center found
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41 that delayed hospital referral, defined as three or more days between symptom onset and
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43 hospitalization, was associated with increased mortality (OR 52.1, 95% CI 6.7-402.4,
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45 $p < 0.001$) after adjusting for age, residence in slum, and illness severity.[42] In this study,
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47 incomplete immunization was also associated with increased mortality (OR 12.3, 95% CI 2.2-
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49 69.9, $p = 0.005$).[42] Reasons for delayed care-seeking can include access and cost. While cost
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51 does influence healthcare use, parents of sick children usually do seek some treatment. In the
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53 2014 Bangladesh Demographic and Health Survey, 52% of urban parents with children with
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55 ARI symptoms in the 2 weeks prior to survey sought treatment from a health facility, 23%
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57 went to pharmacies, and 12% went to traditional practitioners.[43] Only 12% of parents with
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3 sick children sought no health care treatment at all.[43] While cost does not seem a large
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5 barrier to seeking any treatment at all, cost likely influences choice of health provider.
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7 Household relocation disrupts prior relationships with healthcare providers and
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9 results in lack of familiarity with local services. Studies show that continuity of care is
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11 associated with increased vaccination, fewer emergency department visits, and decreased
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13 hospitalization among children.[12,44–46] People usually move to new areas because of pre-
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15 existing social connections through family, friends, or work.[7,47] These social contacts can
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17 act as pathways of important local knowledge, including health services, but recently
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19 relocated households have fewer social contacts and access fewer information sources. Other
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21 studies have also found that parental attitudes and knowledge are critical factors contributing
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23 to use of health services.[6,48–51] One literature review found that *practical* knowledge
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25 about vaccination schedule, timing, and logistics had a stronger association with vaccination
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27 uptake than scientific knowledge of vaccine names or biologic actions.[50] One study in India
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29 of 210 residents in slums and 100 migrant families of construction workers found 28% of
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31 slum residents and 64% of migrants identified lack of knowledge of place or time of services
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33 as a reason for decreased immunization.[51] Our study did not ask specifically about
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35 knowledge of vaccination services, but future research on knowledge of services could help
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37 elucidate how to connect new migrants to care.
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41 Our finding that recently relocated children in Dhaka use fewer qualified health
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43 services compared to residentially stable children sheds light on health barriers faced by a
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45 growing population of children living in urban centers of low- and middle-income countries.
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47 Rigorous community surveillance in hospital catchment areas allows for increased
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49 understanding of factors affecting access to and use of healthcare services. Policymakers
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51 working to improve urban child health could invest in accurate counting of children living in
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53 communities with high household turnover in order to connect recently relocated households
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55 to already existing local health services. Further studies by researchers on patterns and
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57 mechanisms through which mobility affects healthcare use could inform critical intervention
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3 points. Ultimately, cost-effective and targeted interventions to increase appropriate healthcare
4 use among recently relocated children could improve health of future urban populations.
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9 **Contributors**

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11 SL was the Principal Investigator and involved in every aspect of the study from
12 conceptualization to data analysis to manuscript writing and submission. NS, JA, and LH
13 were involved in data analysis, and LH drafted the written work. All authors collaborated on
14 and approved the final manuscript.
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20 **Competing interests**

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22 None declared.
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28 **Provenance and peer review**

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35 **Ethical considerations**

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37 The Ethical Review Committee of the International Centre for Diarrhoeal Disease
38 Research, Bangladesh (icddr,b) reviewed and approved the study protocol.
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43 **Participant consent**

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45 Written informed consent was obtained from all participants before taking part in the
46 initial Hib impact study.
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Data sharing

Data are available by emailing the corresponding author LH at lhong@stanford.edu.

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References

- 1 Troeger C, Blacker B, Khalil IA, *et al.* Estimates of the global, regional, and national morbidity, mortality, and aetiologies of lower respiratory infections in 195 countries, 1990–2016: a systematic analysis for the Global Burden of Disease Study 2016. *Lancet Infect Dis* 2018;**18**:1191–210. doi:10.1016/S1473-3099(18)30310-4
- 2 UN-Habitat. *World Cities Report 2016: Urbanization and Development – Emerging Futures*. New York: UN-Habitat 2016. <https://unhabitat.org/books/world-cities-report/> (accessed 12 Jan 2019).
- 3 United Nations, Department of Economic and Social Affairs, Population Division. *World Urbanization Prospects: The 2014 Revision [Highlights]*. New York: United Nations 2015. <http://esa.un.org/unpd/wup/Publications/Files/WUP2014-Highlights.pdf> (accessed 3 Feb 2016).
- 4 UN-Habitat. *The challenge of slums: global report on human settlements 2003*. New York: UN-Habitat 2003.
- 5 Ezeh A, Oyebo O, Satterthwaite D, *et al.* The history, geography, and sociology of slums and the health problems of people who live in slums. *The Lancet* 2017;**389**:547–58. doi:10.1016/S0140-6736(16)31650-6
- 6 Crocker-Buque T, Mindra G, Duncan R, *et al.* Immunization, urbanization and slums – a systematic review of factors and interventions. *BMC Public Health* 2017;**17**:556. doi:10.1186/s12889-017-4473-7
- 7 Rashid SF. Strategies to reduce exclusion among populations living in urban slum settlements in Bangladesh. *J Health Popul Nutr* 2009;**27**:574–86.
- 8 UN-Habitat. *State of the World's Cities 2006/7*. New York: : UN-Habitat 2006.
- 9 Unger A. Children's health in slum settings. *Arch Dis Child* 2013;**98**:799–805. doi:10.1136/archdischild-2011-301621
- 10 Antai D. Migration and child immunization in Nigeria: individual-and community-level contexts. *BMC Public Health* 2010;**10**:116.
- 11 Jelleyman T, Spencer N. Residential mobility in childhood and health outcomes: a systematic review. *J Epidemiol Community Health* 2008;**62**:584–92.
- 12 Fowler MG, Simpson GA, Schoendorf KC. Families on the move and children's health care. *Pediatrics* 1993;**91**:934–40.
- 13 Wood D, Halfon N, Scarlata D, *et al.* Impact of family relocation on children's growth, development, school function, and behavior. *JAMA* 1993;**270**:1334–8.
- 14 World Health Organization. *A conceptual framework for action on the social determinants of health*. Geneva: WHO 2010. http://apps.who.int/iris/bitstream/10665/44489/1/9789241500852_eng.pdf (accessed 27 Feb 2017).
- 15 Awoh AB, Plugge E. Immunisation coverage in rural–urban migrant children in low and middle-income countries (LMICs): a systematic review and meta-analysis. *J Epidemiol Community Health* 2016;**70**:305–11.

- 1
2
3 16 Kusuma YS, Kumari R, Pandav CS, *et al.* Migration and immunization: determinants of
4 childhood immunization uptake among socioeconomically disadvantaged migrants in
5 Delhi, India. *Trop Med Int Health* 2010;**15**:1326–32.
6
7 17 NIPORT, icddr,b, MEASURE Evaluation. Bangladesh Urban Health Survey 2013 Final
8 Report. 2015. <http://www.cpc.unc.edu/measure/resources/publications/tr-15-117>
9 (accessed 3 Feb 2016).
10
11 18 Government of Bangladesh. Bangladesh EPI coverage evaluation survey 2011, Expanded
12 Programme on Immunization. 2011.
13 [http://www.dghs.gov.bd/images/docs/EPI/CES%20Reports/EPI%20Coverage%20Evalua](http://www.dghs.gov.bd/images/docs/EPI/CES%20Reports/EPI%20Coverage%20Evaluation%20Survey%202011.pdf)
14 [tion%20Survey%202011.pdf](http://www.dghs.gov.bd/images/docs/EPI/CES%20Reports/EPI%20Coverage%20Evaluation%20Survey%202011.pdf)
15
16 19 Hayford K, Uddin MJ, Koehlmoos TP, *et al.* Cost and sustainability of a successful
17 package of interventions to improve vaccination coverage for children in urban slums of
18 Bangladesh. *Vaccine* 2014;**32**:2294–9. doi:10.1016/j.vaccine.2014.02.075
19
20 20 Uddin MJ, Larson CP, Oliveras E, *et al.* Child immunization coverage in urban slums of
21 Bangladesh: impact of an intervention package. *Health Policy Plan* 2010;**25**.
22 doi:10.1093/heapol/czp041
23
24 21 Perry H, Weierbach R, Hossain I, *et al.* Childhood immunization coverage in zone 3 of
25 Dhaka City: the challenge of reaching impoverished households in urban Bangladesh.
26 *Bull World Health Organ* 1998;**76**:565–73.
27
28 22 Luby SP, Halder AK, Saha SK, *et al.* A low-cost approach to measure the burden of
29 vaccine preventable diseases in urban areas. *Vaccine* 2010;**28**:4903–12.
30 doi:10.1016/j.vaccine.2010.05.040
31
32 23 Uddin MJ, Shamsuzzaman M, Horng L, *et al.* Use of mobile phones for improving
33 vaccination coverage among children living in rural hard-to-reach areas and urban streets
34 of Bangladesh. *Vaccine* 2016;**34**:276–83. doi:10.1016/j.vaccine.2015.11.024
35
36 24 Sultana NK, Saha SK, Al-Emran HM, *et al.* Impact of introduction of the Haemophilus
37 influenzae type b conjugate vaccine into childhood immunization on meningitis in
38 Bangladeshi infants. *J Pediatr* 2013;**163**:S73–8.
39
40 25 Vyas S, Kumaranayake L. Constructing socio-economic status indices: how to use
41 principal components analysis. *Health Policy Plan* 2006;**21**:459–68.
42 doi:10.1093/heapol/czl029
43
44 26 Luby SP, Halder AK. Associations among handwashing indicators, wealth, and
45 symptoms of childhood respiratory illness in urban Bangladesh. *Trop Med Int Health*
46 2008;**13**:835–44. doi:10.1111/j.1365-3156.2008.02074.x
47
48 27 Sharker MY, Nasser M, Abedin J, *et al.* The risk of misclassifying subjects within
49 principal component based asset index. *Emerg Themes Epidemiol* 2014;**11**:6.
50
51 28 Zou G. A modified poisson regression approach to prospective studies with binary data.
52 *Am J Epidemiol* 2004;**159**:702–6.
53
54 29 Chen W, Shi J, Qian L, *et al.* Comparison of robustness to outliers between robust
55 poisson models and log-binomial models when estimating relative risks for common
56
57
58
59
60

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2
3 binary outcomes: a simulation study. *BMC Med Res Methodol* 2014;**14**:82.
4 doi:10.1186/1471-2288-14-82
5
- 6 30 Quaiyum MA, Gazi R, Khan AI, *et al*. Programmatic aspects of dropouts in child
7 vaccination in Bangladesh: findings from a prospective study. *Asia Pac J Public Health*
8 2011;**23**:141–50. doi:10.1177/1010539509342119
9
- 10 31 Hussain A, Ali SM, Kvåle G. Determinants of mortality among children in the urban
11 slums of Dhaka city, Bangladesh. *Trop Med Int Health* 1999;**4**:758–64.
12
- 13 32 Hidalgo B, Goodman M. Multivariate or Multivariable Regression? *Am J Public Health*
14 2012;**103**:39–40. doi:10.2105/AJPH.2012.300897
15
- 16 33 Restrepo-Méndez MC, Barros AJ, Wong KL, *et al*. Inequalities in full immunization
17 coverage: trends in low- and middle-income countries. *Bull World Health Organ*
18 2016;**94**:794–805B. doi:http://dx.doi.org/10.2471/BLT.15.162172
19
- 20 34 Fox J, Weisberg S. *An R Companion to Applied Regression. Chapter 6: Diagnosing*
21 *Problems in Linear and Generalized Linear Models*. SAGE Publications 2011.
22 https://us.sagepub.com/sites/default/files/upm-binaries/38503_Chapter6.pdf
23
24
- 25 35 Heller LR. Do slums matter? Location and early childhood preventive care choices
26 among urban residents of Bangladesh. *Soc Sci Med* 2013;**94**.
27 doi:10.1016/j.socscimed.2013.06.011
28
- 29 36 Miles M, Ryman TK, Dietz V, *et al*. Validity of vaccination cards and parental recall to
30 estimate vaccination coverage: a systematic review of the literature. *Vaccine*
31 2013;**31**:1560–8. doi:10.1016/j.vaccine.2012.10.089
32
- 33 37 Murray CJ, Shengelia B, Gupta N, *et al*. Validity of reported vaccination coverage in 45
34 countries. *Lancet* 2003;**362**:1022–7.
35
- 36 38 Luman ET, Ryman TK, Sablan M. Estimating vaccination coverage: validity of
37 household-retained vaccination cards and parental recall. *Vaccine* 2009;**27**:2534–9.
38 doi:10.1016/j.vaccine.2008.10.002
39
- 40 39 Brown J, Monasch R, Bicego G, *et al*. *An assessment of the quality of national child*
41 *immunization coverage estimates in population-based surveys*. MEASURE Evaluation,
42 Carolina Population Center, University of North Carolina at Chapel Hill 2002.
43
44
- 45 40 Khan A, Khan A. Validating measures of immunization coverage: lessons from
46 international experience. USAID 2012.
47 [http://www.resdev.org/files/policy_brief/10/Policy%20brief%2010%20-](http://www.resdev.org/files/policy_brief/10/Policy%20brief%2010%20-%20Validation%20of%20Immunization%20Literature.pdf)
48 [%20Validation%20of%20Immunization%20Literature.pdf](http://www.resdev.org/files/policy_brief/10/Policy%20brief%2010%20-%20Validation%20of%20Immunization%20Literature.pdf) (accessed 2 Oct 2015).
49
- 50 41 Fujita M, Sato Y, Nagashima K, *et al*. Impact of geographic accessibility on utilization of
51 the annual health check-ups by income level in Japan: A multilevel analysis. *PLoS One*
52 2017;**12**:e0177091. doi:10.1371/journal.pone.0177091
53
- 54 42 Bokade CM, Madhura AD, Bagul AS, *et al*. Predictors of mortality in children due to
55 severe and very severe pneumonia. *Niger Med J* 2015;**56**:287.
56
- 57 43 National Institute of Population Research and Training - NIPORT/Bangladesh, Mitra and
58 Associates, ICF International. *Bangladesh Demographic and Health Survey 2014*. Dhaka,
59
60

Bangladesh: NIPORT, Mitra and Associates, and ICF International 2016.
<http://dhsprogram.com/pubs/pdf/FR311/FR311.pdf>

- 44 Christakis DA, Mell L, Wright JA, *et al.* The association between greater continuity of care and timely measles-mumps-rubella vaccination. *Am J Public Health* 2000;**90**:962.
- 45 Christakis DA, Mell L, Koepsell TD, *et al.* Association of lower continuity of care with greater risk of emergency department use and hospitalization in children. *Pediatrics* 2001;**107**:524–9.
- 46 Van Walraven C, Oake N, Jennings A, *et al.* The association between continuity of care and outcomes: a systematic and critical review. *J Eval Clin Pract* 2010;**16**:947–56.
- 47 Kuhn R. Identities in motion: Social exchange networks and rural-urban migration in Bangladesh. *Contributions to Indian Sociology* 2003;**37**:311–37.
doi:10.1177/006996670303700113
- 48 Mills E, Jadad AR, Ross C, *et al.* Systematic review of qualitative studies exploring parental beliefs and attitudes toward childhood vaccination identifies common barriers to vaccination. *J Clin Epidemiol* 11;**58**:1081–8. doi:10.1016/j.jclinepi.2005.09.002
- 49 Rainey JJ, Watkins M, Ryman TK, *et al.* Reasons related to non-vaccination and under-vaccination of children in low and middle income countries: findings from a systematic review of the published literature, 1999–2009. *Vaccine* 2011;**29**:8215–21.
- 50 Favin M, Steinglass R, Fields R, *et al.* Why children are not vaccinated: a review of the grey literature. *International Health* 2012;**4**:229–38. doi:10.1016/j.inhe.2012.07.004
- 51 Sharma V, Singh A, Sharma V. Provider’s and User’s Perspective about Immunization Coverage among Migratory and Non-migratory Population in Slums and Construction Sites of Chandigarh. *J Urban Health* 2015;**92**:304–12. doi:10.1007/s11524-015-9939-2

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Figures and Tables

Table 1: Mobility status of study households with children age 0-59 months and association with demographic, socioeconomic, and health characteristics using t- and χ^2 -tests

	Residentially stable, ≥ 24 months n=5513		Recently relocated, ≤ 12 months n=4507		p-value
<u>Demographics</u>	<u>mean</u>	<u>SE</u>	<u>mean</u>	<u>SE</u>	
Number of household members	5.40	0.09	4.60	0.10	<0.001
Number of children <5yrs in household	1.28	0.01	1.25	0.01	0.194
Age of index child in months	30.0	0.23	28.7	0.25	<0.001
	<u>n</u>	<u>%</u>	<u>n</u>	<u>%</u>	
Sex of index child: Male	2478	45	2048	45	0.622
<u>Socioeconomics</u>					
Mother's education					<0.001
No education	1133	21	1162	26	
Some schooling	1142	21	1176	26	
Finished secondary	1849	34	1483	33	
> Secondary	1389	25	686	15	
Father's education					<0.001
No education	1261	23	1139	25	
Some schooling	913	17	911	20	
Finished secondary	1525	28	1372	30	
> Secondary	1814	33	1085	24	
Occupation of household head					<0.001
Unemployed or other	482	9	232	5	
Daily labor	916	17	1218	27	
Shopkeeper or merchant	1787	32	1058	23	
Salaried service	2328	42	1999	44	
Monthly household income ^a					<0.001
$\leq 5,000$ taka (US \$73)	971	18	1080	24	

5,001 – 10,000 taka	1634	30	1925	43	
> 10,000 taka (US \$145)	2900	53	1498	33	
Household wealth index ^b					<0.001
Lowest	1092	20	1110	25	
Second	922	17	1021	23	
Third	966 ^f	18	911	20	
Fourth	1455	26	1155	26	
Highest	1078	20	310	7	
<u>Health services knowledge</u>					
Knowledge of local hospital	4709	85	3428	76	<0.001
<u>Health outcomes</u>					
Severe acute respiratory illness suffered by index child within 12 months ^e	763	14	695	15	0.026
Meningitis/encephalitis suffered by index child within 12 months ^d	185	3	164	4	0.443

^a12 respondents (8 residentially stable and 4 recently relocated) did not know or did not disclose household income.

^bPolychoric Principal Components Analysis was used to create a household wealth index including structural housing characteristics, cooking fuel, drinking water, and sanitation.

^cOne residentially stable respondent did not know if child recently had a severe acute respiratory illness.

^dThree respondents did not know if child recently had a serious illness with mental status changes (2 residentially stable and 1 recently relocated).

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Table 2: Using vaccination card plus maternal recall, vaccination coverage among children age 9-59 months and association with mobility status using univariate and multivariable models with modified Poisson regression

	Partial vaccination n=1465 (17%)		Full vaccination ^a n=7043 (83%)		PR ^b	95% CI	p-value
<u>Univariate analyses</u>							
Mobility status	<u>n</u>	<u>%</u>	<u>n</u>	<u>%</u>			
Residentially stable ≥24 months	706	15	4007	85	Reference		
Recently relocated ≤12 months	759	20	3036	80	0.94	0.91-0.97	<0.001
Demographics	<u>mean</u>	<u>SE</u>	<u>mean</u>	<u>SE</u>			
Number of children <5yrs in household	1.31	0.02	1.25	0.01	0.96	0.93-0.98	0.002
Age of index child in months	32.0	0.44	34.2	0.16	1.002	1.001-1.003	<0.001
Socioeconomics							
Mother's education	<u>n</u>	<u>%</u>	<u>n</u>	<u>%</u>			
No education	629	31	1377	69	Reference		
Some schooling	401	21	1540	79	1.16	1.10-1.21	<0.001
Finished secondary	323	11	2513	89	1.29	1.23-1.36	<0.001
> Higher secondary	112	6	1613	94	1.36	1.30-1.43	<0.001
Occupation of household head							
Unemployed or other	106	17	505	83	Reference		
Daily labor	524	29	1283	71	0.86	0.82-0.90	<0.001
Shopkeeper or merchant	348	14	2084	86	1.04	0.99-1.08	0.112
Salaried service	487	13	3171	87	1.05	1.01-1.09	0.029
Household wealth status (PCA ^c)							
Lowest	596	32	1290	68	Reference		
Second	334	20	1298	80	1.16	1.09-1.24	<0.001
Third	242	15	1348	85	1.24	1.16-1.32	<0.001
Fourth	193	9	2043	91	1.34	1.25-1.42	<0.001
Highest	100	9	1064	91	1.34	1.25-1.43	<0.001
Health services knowledge							
Does <i>not</i> have knowledge of local hospital	354	23	1218	77	Reference		
Has knowledge of local hospital	1111	16	5825	84	1.08	1.05-1.12	<0.001

<u>Multivariable analyses with different models</u>			
Mobility, adjusting for demographics (# of children and age of index child)	0.94	0.92-0.97	<0.001
Mobility, adjusting for socioeconomics (education, occupation, and wealth)	0.97	0.95-0.99	0.009
Mobility, adjusting for demographics and socioeconomics	0.97	0.95-0.99	0.016

^aFull vaccination coverage per Expanded Programme on Immunization includes 1 dose of BCG, 3 doses of polio, 3 doses of DPT, and 1 dose of measles vaccines.

^bPR, Prevalence Ratio.

^cPolychoric Principal Components Analysis was used to create a household wealth index including structural housing characteristics, cooking fuel, drinking water, and sanitation.

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Table 3: Using vaccination card only, vaccination coverage among children age 9-59 months who have vaccination cards and association with mobility status using univariate and multivariable models with modified Poisson regression

	Partial vaccination n=564 (15%)		Full vaccination ^a n=3085 (85%)		PR ^b	95% CI	p-value
<u>Univariate analyses</u>							
Mobility status	<u>n</u>	<u>%</u>	<u>n</u>	<u>%</u>			
Residentially stable ≥24 months	329	14	1948	86	Reference		
Recently relocated ≤12 months	235	17	1137	83	0.97	0.93-1.00	0.083
Demographics	<u>mean</u>	<u>SE</u>	<u>mean</u>	<u>SE</u>			
Number of children <5yrs in household	1.26	0.02	1.24	0.01	0.99	0.96-1.02	0.486
Age of index child in months	27.1	0.64	29.6	0.25	1.002	1.001-1.003	0.001
Socioeconomics							
Mother's education	<u>n</u>	<u>%</u>	<u>n</u>	<u>%</u>			
No education	165	28	430	72	Reference		
Some schooling	123	16	654	84	1.16	1.09-1.24	<0.001
Finished secondary	186	14	1158	86	1.19	1.11-1.28	<0.001
> Higher secondary	90	10	843	90	1.25	1.17-1.33	<0.001
Occupation of household head							
Unemployed or other	35	13	238	87	Reference		
Daily labor	148	26	413	74	0.84	0.78-0.91	<0.001
Shopkeeper or merchant	143	13	921	87	0.99	0.94-1.04	0.778
Salaried service	238	14	1513	86	0.99	0.95-1.04	0.704
Household wealth status (PCA ^c)							
Lowest	148	27	401	73	Reference		
Second	131	21	503	79	1.09	1.02-1.16	0.009
Third	97	15	572	86	1.17	1.09-1.26	<0.001
Fourth	110	10	1005	90	1.23	1.15-1.32	<0.001
Highest	78	11	604	89	1.21	1.13-1.30	<0.001
Health services knowledge							
Does <i>not</i> have knowledge of local hospital	101	19	434	81	Reference		
Has knowledge of local hospital	463	15	2651	85	1.05	1.01-1.09	0.025

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3 Multivariable analyses with different models

4 Mobility, adjusting for demographics (# of children and age of index child)	0.97	0.94-1.01	0.126
5 Mobility, adjusting for socioeconomics (education, occupation, and wealth)	0.98	0.95-1.02	0.308
6 Mobility, adjusting for demographics and socioeconomics	0.98	0.95-1.02	0.396

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8 ^aFull vaccination coverage per Expanded Programme on Immunization includes 1 dose of BCG, 3 doses of polio, 3 doses of DPT, and 1 dose of measles vaccines.

9 ^bPR, Prevalence Ratio.

10 ^cPolychoric Principal Components Analysis was used to create a household wealth index including structural housing characteristics, cooking fuel, drinking water, and sanitation.

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Table 4: Qualified provider visits for severe acute respiratory illness within prior year among children < 5 years old and association with mobility using univariate and multivariable models with modified Poisson regression

	No qualified provider for severe ARI ^a n=358 (25%)		Qualified provider for severe ARI ^a n=1100 (75%)		PR ^b	95% CI	p-value
<u>Univariate analyses</u>							
Mobility status	<u>n</u>	<u>%</u>	<u>n</u>	<u>%</u>			
Residentially stable ≥24 months	141	18	622	82	Reference		
Recently relocated ≤12 months	217	31	478	69	0.84	0.79-0.90	<0.001
Demographics	<u>mean</u>	<u>SE</u>	<u>mean</u>	<u>SE</u>			
Number of children <5yrs in household	1.23	0.03	1.25	0.02	1.02	0.97-1.08	0.437
Age of index child in months	29.1	0.83	23.7	0.44	0.994	0.992-0.996	<0.001
Socioeconomics							
Mother's education	<u>n</u>	<u>%</u>	<u>n</u>	<u>%</u>			
No education	134	38	220	62	Reference		
Some schooling	127	32	267	68	1.09	0.96-1.23	0.170
Finished secondary	79	16	425	84	1.36	1.20-1.54	<0.001
> Higher secondary	18	9	188	91	1.47	1.30-1.66	<0.001
Occupation of household head							
Unemployed or other	24	23	82	77	Reference		
Daily labor	139	36	244	64	0.82	0.72-0.94	0.005
Shopkeeper or merchant	89	22	320	78	1.01	0.90-1.14	0.848
Salaried service	106	19	454	81	1.05	0.93-1.18	0.435
Household wealth status (PCA ^c)							
Lowest	154	40	228	60	Reference		
Second	93	30	220	70	1.18	1.02-1.37	0.031
Third	59	21	220	79	1.32	1.16-1.51	<0.001
Fourth	37	12	277	88	1.48	1.31-1.67	<0.001
Highest	15	9	155	91	1.53	1.35-1.73	<0.001
Health services knowledge							
Does <i>not</i> have knowledge of local hospital	114	49	118	51	Reference		

Has knowledge of local hospital	244	20	982	80	1.57	1.34-1.85	<0.001
<u>Multivariable analyses with different models</u>							
Mobility, adjusting for demographics (# of children and age of index child)					0.84	0.79-0.89	<0.001
Mobility, adjusting for socioeconomic (education, occupation, and wealth)					0.89	0.84-0.94	<0.001
Mobility, adjusting for demographics and socioeconomic					0.88	0.84-0.93	<0.001

^aARI, Acute Respiratory Illness.

^bPR, Prevalence Ratio.

^cPolychoric Principal Components Analysis was used to create a household wealth index including structural housing characteristics, cooking fuel, drinking water, and sanitation.

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Figure 1: Children sampled by mobility status for healthcare utilization and vaccination coverage analysis

Note: *ARI = Acute Respiratory Illness

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Supplemental Figure 1: Cook's distance calculations to examine influential observations

Cook's distance plots of multivariable models examining mobility, demographics, and socioeconomic factors for: vaccination using card plus maternal recall among children 9-59 months (A), vaccination using card only among children 9-59 months (B), qualified provider visits for respiratory infections among children <5 years old (C), vaccination using card plus maternal recall among children 9-23 months (D), and vaccination using card only among children 9-23 months (E). The red lines indicate threshold value of $4/n$ where n =number of observations.

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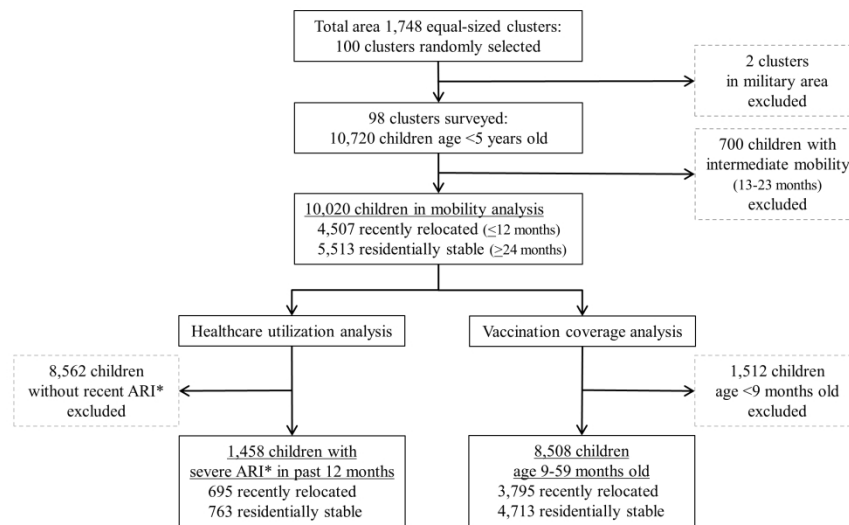


Figure 1: Children sampled by mobility status for healthcare utilization and vaccination coverage analysis
 Note: *ARI = Acute Respiratory Illness

Figure 1: Children sampled by mobility status for healthcare utilization and vaccination coverage analysis
 Note: *ARI = Acute Respiratory Illness

254x190mm (300 x 300 DPI)

**Effect of household relocation on child vaccination and health service utilization in Dhaka, Bangladesh:
a cross-sectional community survey**

SUPPLEMENTAL FIGURES AND TABLES

Supplemental Table 1: Household wealth principal components analysis coding and variable loading

Indicator	Coding	Loading
Number of rooms	Continuous	0.337
Housing arrangement	1 = Free 2 = Rental 3 = Owned	0.235
Roof	1 = Natural roof (bamboo/thatch) 2 = Rudimentary roof (tin) 3 = Finished roof (cement/concrete/tiled) 4 = Other	0.392
Walls	1 = Natural walls (jute/bamboo/mud) 2 = Rudimentary walls (wood) 3 = Finished walls (tin/brick/cement) 4 = Other	0.316
Floor	1 = Natural floor (earth/bamboo) 2 = Rudimentary floor (wood) 3 = Finished floor (cement/concrete) 4 = Other	0.377
Cooking fuel	1 = Natural (wood/grass/dung) 2 = Coal/charcoal 3 = Kerosene 4 = Electricity 5 = Gas (liquid/biogas) 6 = Other	0.350
Drinking water	1 = Unimproved (unprotected/surface/bottled) 2 = Improved but not piped 3 = Improved and piped into yard or private dwelling 4 = Other	0.170
Sanitation	1 = Unimproved (open defecation/hanging/open or broken pit) 2 = Improved but not piped	0.374

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	3 = Improved and piped sewer 4 = Other	
Mobile phone ownership	0 = No 1 = Yes	0.380

Note: 51% of overall variance was explained by the first component.

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Supplemental Table 2: Using vaccination card plus maternal recall, vaccination coverage among children age 9-23 months and association with mobility status using univariate and multivariable models with modified Poisson regression

	Partial vaccination n=518 (21%)		Full vaccination ^a n=1906 (79%)		PR ^b	95% CI	p-value
<u>Univariate analyses</u>							
Mobility status	<u>n</u>	<u>%</u>	<u>n</u>	<u>%</u>			
Residentially stable ≥ 24 months	243	19	1053	81	Reference		
Recently relocated ≤ 12 months	275	24	853	76	0.93	0.88-0.98	0.009
Demographics	<u>mean</u>	<u>SE</u>	<u>mean</u>	<u>SE</u>			
Number of children <5yrs in household	1.31	0.03	1.24	0.01	0.94	0.89-0.99	0.035
Age of index child in months	14.73	0.20	16.35	0.11	1.02	1.02-1.03	<0.001
Socioeconomics							
Mother's education	<u>n</u>	<u>%</u>	<u>n</u>	<u>%</u>			
No education	207	41	303	59	Reference		
Some schooling	121	22	433	78	1.32	1.18-1.47	<0.001
Finished secondary	141	16	719	84	1.41	1.27-1.56	<0.001
> Higher secondary	49	10	451	90	1.52	1.36-1.69	<0.001
Occupation of household head							
Unemployed or other	26	15	147	85	Reference		
Daily labor	195	38	318	62	0.73	0.66-0.81	<0.001
Shopkeeper or merchant	124	19	538	81	0.96	0.88-1.04	0.287
Salaried service	173	16	903	84	0.99	0.91-1.07	0.752
Household wealth status (PCA ^c)							
Lowest	212	40	321	60	Reference		
Second	114	25	348	75	1.25	1.11-1.40	<0.001
Third	84	18	382	82	1.36	1.20-1.54	<0.001
Fourth	59	10	560	90	1.50	1.34-1.69	<0.001
Highest	49	14	295	86	1.42	1.26-1.61	<0.001
Health services knowledge							
Does <i>not</i> have knowledge of local hospital	127	28	324	72	Reference		
Has knowledge of local hospital	391	20	1582	80	1.12	1.05-1.19	<0.001

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<u>Multivariable analyses with different models</u>			
Mobility, adjusting for demographics (# of children and age of index child)	0.93	0.88-0.98	0.007
Mobility, adjusting for socioeconomics (education, occupation, and wealth)	0.96	0.91-1.01	0.136
Mobility, adjusting for demographics and socioeconomics	0.96	0.92-1.01	0.138

^aFull vaccination coverage per Expanded Programme on Immunization includes 1 dose of BCG, 3 doses of polio, 3 doses of DPT, and 1 dose of measles vaccines.

^bPR, Prevalence Ratio.

^cPolychoric Principal Components Analysis was used to create a household wealth index including structural housing characteristics, cooking fuel, drinking water, and sanitation.

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Supplemental Table 3: Using vaccination card only, vaccination coverage among children age 9-23 months who have vaccination cards and association with mobility status using univariate and multivariable models with modified Poisson regression

	Partial vaccination n=281 (19%)		Full vaccination ^a n=1222 (81%)		PR ^b	95% CI	p-value
<u>Univariate analyses</u>							
Mobility status	<u>n</u>	<u>%</u>	<u>n</u>	<u>%</u>			
Residentially stable ≥ 24 months	156	18	715	82	Reference		
Recently relocated ≤ 12 months	125	20	507	80	0.97	0.92-1.04	0.469
Demographics	<u>mean</u>	<u>SE</u>	<u>mean</u>	<u>SE</u>			
Number of children <5yrs in household	1.23	0.03	1.21	0.01	0.98	0.93-1.04	0.543
Age of index child in months	14.4	0.27	15.9	0.15	1.02	1.01-1.03	<0.001
Socioeconomics							
Mother's education	<u>n</u>	<u>%</u>	<u>n</u>	<u>%</u>			
No education	94	35	176	65	Reference		
Some schooling	57	17	286	83	1.28	1.15-1.42	<0.001
Finished secondary	93	17	461	83	1.28	1.14-1.43	<0.001
> Higher secondary	37	11	299	89	1.37	1.22-1.52	<0.001
Occupation of household head							
Unemployed or other	14	12	100	88	Reference		
Daily labor	89	33	184	67	0.77	0.68-0.87	<0.001
Shopkeeper or merchant	66	16	352	84	0.96	0.88-1.04	0.327
Salaried service	112	16	586	84	0.96	0.88-1.04	0.297
Household wealth status (PCA ^c)							
Lowest	84	32	179	68	Reference		
Second	67	24	211	76	1.12	0.99-1.25	0.062
Third	52	17	248	83	1.21	1.08-1.37	0.002
Fourth	42	10	381	90	1.32	1.18-1.48	<0.001
Highest	36	15	203	85	1.25	1.10-1.41	<0.001
Health services knowledge							
Does <i>not</i> have knowledge of local hospital	55	22	194	78	Reference		
Has knowledge of local hospital	226	18	1028	82	1.05	0.98-1.13	0.141

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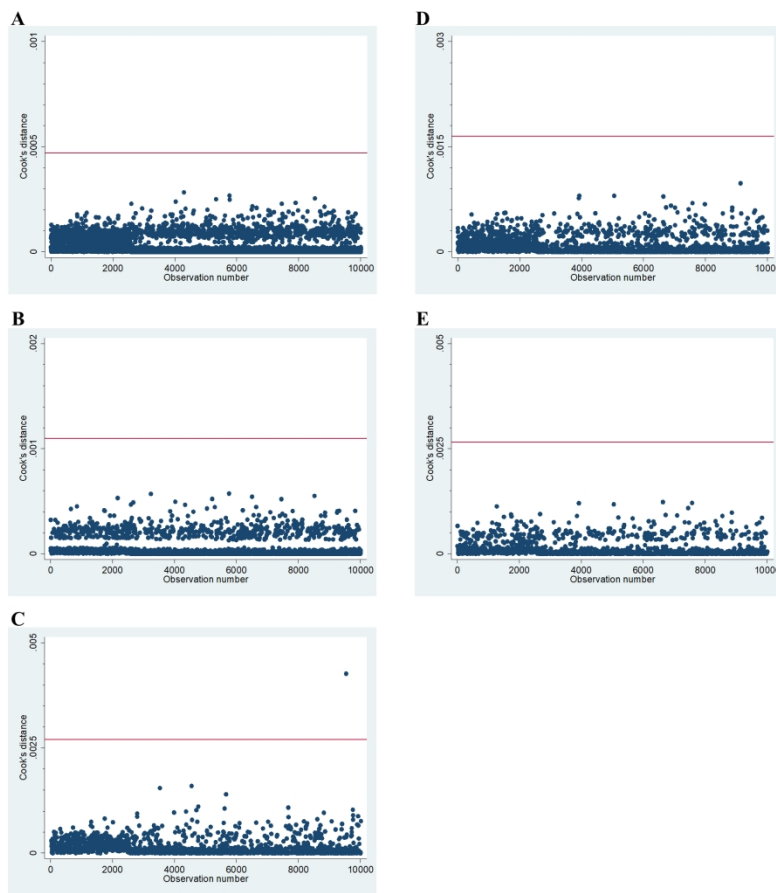
<u>Multivariable analyses with different models</u>			
Mobility, adjusting for demographics (# of children and age of index child)	0.98	0.93-1.04	0.582
Mobility, adjusting for socioeconomics (education, occupation, and wealth)	1.00	0.94-1.06	0.948
Mobility, adjusting for demographics and socioeconomics	1.00	0.95-1.07	0.888

^aFull vaccination coverage per Expanded Programme on Immunization includes 1 dose of BCG, 3 doses of polio, 3 doses of DPT, and 1 dose of measles vaccines.

^bPR, Prevalence Ratio.

^cPolychoric Principal Components Analysis was used to create a household wealth index including structural housing characteristics, cooking fuel, drinking water, and sanitation.

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Supplemental Figure 1: Cook's distance calculations to examine influential observations
 Cook's distance plots of multivariable models examining mobility, demographics, and socioeconomics for: vaccination using card plus maternal recall among children 9-59 months (A), vaccination using card only among children 9-59 months (B), qualified provider visits for respiratory infections among children <5 years old (C), vaccination using card plus maternal recall among children 9-23 months (D), and vaccination using card only among children 9-23 months (E). The red lines indicate threshold value of $4/n$ where n =number of observations.

190x254mm (300 x 300 DPI)

Effect of household relocation on child vaccination and health service utilization in Dhaka, Bangladesh: a cross-sectional community survey

STROBE 2007 (v4) Statement—Checklist of items that should be included in reports of *cross-sectional studies*

Section/Topic	Item #	Recommendation	Reported on page #
Title and abstract	1	(a) Indicate the study's design with a commonly used term in the title or the abstract	1
		(b) Provide in the abstract an informative and balanced summary of what was done and what was found	2
Introduction			
Background/rationale	2	Explain the scientific background and rationale for the investigation being reported	4
Objectives	3	State specific objectives, including any prespecified hypotheses	6
Methods			
Study design	4	Present key elements of study design early in the paper	6
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection	6
Participants	6	(a) Give the eligibility criteria, and the sources and methods of selection of participants	7
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable	7
Data sources/ measurement	8*	For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group	7
Bias	9	Describe any efforts to address potential sources of bias	8
Study size	10	Explain how the study size was arrived at	7
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why	8
Statistical methods	12	(a) Describe all statistical methods, including those used to control for confounding	8
		(b) Describe any methods used to examine subgroups and interactions	8
		(c) Explain how missing data were addressed	8
		(d) If applicable, describe analytical methods taking account of sampling strategy	8

		(e) Describe any sensitivity analyses	8
Results			
Participants	13*	(a) Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed	9
		(b) Give reasons for non-participation at each stage	9
		(c) Consider use of a flow diagram	Figure 1
Descriptive data	14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders	9
		(b) Indicate number of participants with missing data for each variable of interest	9
Outcome data	15*	Report numbers of outcome events or summary measures	9
Main results	16	(a) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included	10
		(b) Report category boundaries when continuous variables were categorized	9
		(c) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period	n/a
Other analyses	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses	10
Discussion			
Key results	18	Summarise key results with reference to study objectives	11
Limitations	19	Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias	13
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence	15
Generalisability	21	Discuss the generalisability (external validity) of the study results	14
Other information			
Funding	22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based	17

*Give information separately for cases and controls in case-control studies and, if applicable, for exposed and unexposed groups in cohort and cross-sectional studies.

Note: An Explanation and Elaboration article discusses each checklist item and gives methodological background and published examples of transparent reporting. The STROBE checklist is best used in conjunction with this article (freely available on the Web sites of PLoS Medicine at <http://www.plosmedicine.org/>, Annals of Internal Medicine at <http://www.annals.org/>, and Epidemiology at <http://www.epidem.com/>). Information on the STROBE Initiative is available at www.strobe-statement.org.