Healthcare Utilization Survey in the Hybrid Model of the Surveillance for Enteric Fever in India (SEFI) Study: Processes, Monitoring, Results, and Challenges

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Background. Lack of reliable data in India drove the “Surveillance of Enteric Fever in India” (SEFI) concept. Hybrid surveillance, combining facility-based surveillance for the crude incidence, and a community-based healthcare utilization survey (HCUS) to calculate the factor needed to arrive at the adjusted incidence, was used in 6 sites. The HCUS aimed to determine the percentage of utilization of study facilities by the catchment population for hospitalizations due to febrile illness.

Methods. Population proportional to size sampling and systematic random sampling, in 2 stages, were used to survey 5000 households per site. Healthcare utilization was assessed.

Results. Febrile illness accounted for 20% of admissions among 137 990 individuals from 30 308 households. Only 9.6%–38.3% of those admitted with febrile illness sought care in the study hospitals. The rate of rural utilization of the private sector for hospitalization was 67.6%. The rate of hospitalization for febrile illness, per 1000 population, ranged from 2.6 in Manali to 9.6 in Anantapur; for 25.8% of the deaths associated with febrile illness, no facility was used before death.

Conclusions. One in 5 hospitalizations were associated with fever. Rural utilization of the private sector for hospitalization due to febrile illness was more than that of the public sector. Healthcare utilization patterns for hospital admissions due to febrile illness varied across sites. A meticulously performed HCUS is pivotal for accurate incidence estimation in a hybrid surveillance.

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Effective surveillance systems are a necessity for controlling communicable diseases. The World Health Organization propounds that “effective communicable disease control relies on effective response systems and effective response systems rely on effective disease surveillance” [1–3]. Surveillance systems require data from healthcare facilities and local communities to detect emerging trends of diseases and generate epidemiological data for national regulators. However, because reliable community-based data are scarce in low-middle-income countries, such as India [4, 5], policy makers are forced to rely on information collected by healthcare facilities [6].

Reliance on facility-based surveillance alone would underestimate the disease burden [3, 7] since not everyone who is ill seeks treatment, especially the underprivileged and the vulnerable, owing to numerous sociocultural and health literacy factors [8]. Of those who do seek treatment, a significant proportion may prefer to rely on private practitioners, traditional healers, or local pharmacies [9, 10], which are scarcely represented in India’s disease surveillance platforms and Health Management Information System, which also has numerous data quality issues [11].

Community-based cohort studies may yield more representative burden estimates but have their limitations too. With existing constraints of trained personnel and finances in low-middle-income countries, genuine efforts to monitor and measure health indicators on a large scale at the community level may be further challenged by language, social, and geographic barriers [6, 12, 13]. Even though community-based surveys, when implemented well, provide a high degree of sensitivity, they avowely lack the specificity of sophisticated laboratory tests to confirm the diagnoses [13].

A hybrid strategy may be used to bridge the gap between the 2 approaches. Such a model would use a sentinel healthcare facility–based surveillance to calculate a crude incidence rate, which would then be adjusted for cases that used other facilities for healthcare, obtained via annual or biannual healthcare utilization surveys (HCUSs) taking place in the catchment populations of the study facilities [14–19].
This strategy was used by tier 2 of the Surveillance for Enteric Fever in India (SEFI) network to generate data on the incidence and burden of severe enteric fever in India, which remains a significant public health concern in the country. Under this framework, 6 geographically distinct sites across India conducted surveillance for the disease between 2018 and 2020. This article describes the processes, monitoring, results, and challenges of the community-based HCUS at each of these sites as part of the SEFI project. The primary aim of HCUS was to estimate the proportion of the catchment populations at each selected site who had a febrile illness and sought inpatient care at hospitals associated with SEFI’s tier 2 over a period of 12 months, which was subsequently factored into the adjusted incidence estimates of enteric fever by the network.

METHODS

Study Setting

The study was designed as part of the SEFI network, a more extensive network of surveillance initiated to obtain the burden of enteric fever in India. SEFI was conceptualized as a multitiered surveillance system covering 18 sites, aimed at estimating the burden of enteric fever at different rural, urban, slum, hilly, and tribal settings across India, with varying designs of study at each of the tiers. Christian Medical College Vellore (CMC Vellore), was the central coordinating team for the network. The second tier followed the hybrid surveillance model, a relatively newly developed, cost-effective, and sustainable approach.

This hybrid surveillance was conducted in secondary hospital settings of 5 rural and 1 urban site and their catchment areas across India, namely, the Rural Development Trust Hospital, Bathalapalli (Anantapur district of Andhra Pradesh); Makunda Christian Leprosy and General Hospital, Bazarcherrra (Karimganj district of Assam); Duncan Hospital, Raxaul (East Champaran district of Bihar); Lady Willingdon Hospital, Manali (Kullu district of Himachal Pradesh); Chinchpada Christian Hospital (Nandurbar district of Maharashtra) and Civil Hospital, Sector 45, Chandigarh. All study hospitals were charitable hospitals except the one in Chandigarh, which is was a government facility. The catchment population for these hospitals ranged from 100 000 to 700 000. Site descriptions are summarized in Table 1.

Sampling Process

The tier 2 sites were selected, assuming that they were the dominant providers of inpatient medical care in their catchment areas. The catchment area of each of the study hospitals was defined as the geographically adjoining areas from where the most recent 1000 hospitalizations associated with febrile illness (“febrile hospitalizations”) occurred. Mapping of the catchment required reviewing inpatient hospital records of the previous 24 months in each site. Patient addresses were ordered by distance from the study facility, and the community development blocks that covered >80% of the recent 1000 hospital admissions for febrile illness formed the hospital’s catchment. It was anticipated that about 60% of febrile hospitalizations from the catchment area would occur in the study hospital. The annual incidence of hospitalization for febrile illness in these settings has been previously estimated at 6 per 1000 hospitalizations by the National Sample Survey Office [20].

We calculated that 150 febrile hospitalizations in the catchment population were required to estimate the proportion hospitalized at the study facility with a 10% absolute precision and assuming a design effect of 1.5 for intrafamilial and village level clustering. Thus, we surveyed 25 000 individuals from about 5000 randomly selected households (assuming 5 persons per household) to identify 150 febrile hospitalizations in each site.

The HCUS described here was conducted in the catchment areas between June and October 2019. A 2-stage sampling process was used. In the first stage, a random sample of 100 primary sampling units (wards in urban and villages in rural areas) was selected by probability proportional to size sampling technique at each site. Subsequently, systematic random sampling was used to select households within the clusters. From a random start, 50 households were selected from each of the 100 clusters to obtain 5000 household interviews each from 6 sites.

Data Collection

After obtaining informed consent, data were collected on socioeconomic and demographic variables, mortality and morbidity profile, and health-seeking behavior based on 2-week and 12-month recall. Data were gathered electronically using Survey Solutions, a survey data capture software developed by the World Bank. The questionnaire was translated into 5 regional languages and then back-translated to check for accuracy. Training modules were developed to train 84 field workers and 12 supervisors (14 field workers and 2 supervisors per site) responsible for data collection. The monitoring and evaluation team were trained separately.

Monitoring Process

The National Institute of Epidemiology (ICMR-NIE), Chennai, was responsible for the on-site field monitoring and validation of the survey. The intrinsic hierarchical workflow of the software allowed quality checks at different points during data collection: fieldworkers formed the lowest tier (interviewers), and the data they collected were checked by the supervisors (second tier); the headquarters consisted of the ICMR-NIE team who performed a final check on the data collected for any quality issues (Supplementary Figure 1). If any were found at either the supervisor or headquarters level, the forms were rejected until query resolution.
| Characteristic                                      | Anantapur | Chandigarh | Chinchpada | Makunda | Manali | Raxaul | Overall |
|-----------------------------------------------------|-----------|------------|------------|---------|--------|--------|---------|
| Setting                                             | Rural     | Rural      | Rural tribal | Rural hilly | Rural hilly | Rural | ...     |
| Administrative units covered, no. of blocks or sectors | 8         | 1          | 1          | 2       | 1      | 3      | 16      |
| Approximate study area covered, km²                  | 2478      | 5          | 1030       | 540     | 102    | 450    | 4605    |
| Households, no.                                      | 5066      | 5302       | 5095       | 5052    | 5099   | 5168   | 30 782  |
| Total approached                                     | 5048      | 5084       | 5034       | 5042    | 5011   | 5089   | 30 308  |
| Participating                                       | 8         | 122        | 28         | 0       | 32     | 16     | 206     |
| With locked doors                                    | 10        | 96         | 33         | 10      | 56     | 63     | 268     |
| Refusing to participate                              |           |            |            |         |        |        |         |
| People surveyed, no.                                 | 19 162    | 21 725     | 23 234     | 24 408  | 21 697 | 27 764 | 137 990 |
| Households, no. (%)                                  |           |            |            |         |        |        |         |
| Type of family                                       |           |            |            |         |        |        |         |
| Nuclear                                             | 4210 (83.4) | 4263 (83.9) | 2988 (59.4) | 3974 (78.8) | 3387 (67.6) | 3661 (71.9) | 22483 (74.2) |
| Joint/extended                                      | 838 (16.6)  | 819 (16.1)  | 2046 (40.6) | 1068 (21.2) | 1624 (32.4) | 1428 (28.1) | 7819 (25.8)  |
| SES                                                 |           |            |            |         |        |        |         |
| Low                                                 | 3655 (72.4) | 3327 (65.4) | 2953 (58.7) | 3855 (76.5) | 1188 (23.7) | 3203 (62.9) | 18181 (60)   |
| Middle                                              | 1384 (27.4) | 1691 (33.3) | 2046 (40.6) | 1160 (23)  | 3025 (60.4) | 1724 (33.9) | 11030 (36.4) |
| High                                                | 9 (0.2)   | 66 (1.3)   | 35 (0.7)   | 27 (0.5)  | 798 (15.9)  | 162 (3.2)  | 1097 (3.6)   |
| Water source                                         |           |            |            |         |        |        |         |
| R/O or purified commercial                           | 3621 (71.7) | 1066 (21)  | 124 (2.5)  | 5 (0.1)  | 93 (1.9)  | 18 (0.4)  | 4927 (16.2)  |
| Municipal tap (inside dwelling)                     | 199 (3.9)  | 3560 (70)  | 251 (5)    | 175 (3.5) | 3059 (61)  | 95 (1.9)  | 7339 (24.2)  |
| Municipal tap (common to street)                    | 1180 (23.4) | 438 (8.6)   | 1510 (30)  | 325 (6.4) | 1205 (24)  | 146 (2.9) | 4804 (15.9)  |
| Bore well/tube well                                 | 43 (0.9)   | 12 (0.2)   | 2957 (58.7) | 1358 (26.9) | 6 (0.1)  | 4809 (45.4) | 9185 (30.2)  |
| Well (covered or uncovered)                         | 2 (0.1)   | 4 (0.1)   | 143 (2.8)  | 214 (42.5) | 6 (0.1)  | 17 (0.3)  | 2313 (7.6)   |
| Natural source (spring/lake/river)                  | 3 (0.1)   | 4 (0.1)   | 49 (1)    | 1038 (20.6) | 642 (12.8) | 4 (0.1)  | 1740 (5.7)   |
| Individual characteristics, no. (%)b                |           |            |            |         |        |        |         |
| Female sex                                          | 9411 (49.1) | 10555 (48.6) | 11618 (50) | 11931 (48.9) | 10693 (49.3) | 13129 (47.3) | 67337 (48.8) |
| Age ≥15 y                                           | 15265 (79.7) | 15865 (73)  | 18324 (78.9) | 16219 (66.4) | 17079 (78.7) | 17377 (62.6) | 100129 (72.6) |
| Marital status                                      |           |            |            |         |        |        |         |
| Married                                             | 10715 (55.9) | 10775 (49.6) | 12786 (55) | 10498 (43)  | 11761 (54.2) | 12628 (45.5) | 69163 (50.1)  |
| Divorced/separated                                  | 63 (0.3)  | 127 (0.6)  | 132 (0.6)  | 166 (0.7)  | 89 (0.4)  | 64 (0.2)  | 641 (0.5)   |
| Never married                                       | 7367 (38.4) | 10182 (46.9) | 9139 (39.3) | 12571 (51.5) | 8794 (40.5) | 14344 (51.7) | 62397 (45.2)  |
| Widowed                                             | 1017 (5.3) | 641 (3)    | 1177 (5.1) | 1173 (4.8) | 1053 (4.9) | 728 (2.6) | 5789 (4.2)   |
| Individuals with health insurance                   | 9129 (47.6) | 1149 (5.3) | 3609 (15.5) | 4936 (20.3) | 4187 (19.3) | 1981 (71) | 24991 (18.1) |

Abbreviations: RO, reverse osmosis; SES, socioeconomic status.

*aDenominators for household characteristics are the number of participating households for the site.

*bDenominators for individual characteristics are the number of individuals surveyed at the site.
Real-time remote data monitoring was executed for each site by the central team in CMC Vellore based on set performance monitoring metrics (Supplementary Figure 2). The components of the performance monitoring matrix were response rate, time taken for each interview, completeness of data collected, validation by an independent monitor, and comparison with external validator indicators from the National Sample Survey and the 2011 Census of India [20, 21]. The central monitoring team quantitatively measured the performance at each site based on performance scores given to the field workers and clusters separately.

Scores for the fieldworkers, which could range from 0 to 1 with 0 the worst performance score and 1 the best, were based on the proportion of completeness of documentation of selected parameters and on the percentage of adequately timed interviews. Similarly, scores for the clusters, which also could range from 0 to 1, were created based on weights given for the documentation of the number of admissions, deaths, births from the 12-month recall period, any reported illness from the 2-week recall period, and their comparison with external national validators, such as the 2011 Census of India and the National Sample Survey 2014 data. Corrective actions were taken if any cluster or fieldworker had a score <0.5 (Supplementary Figure 3).

Statistical Analysis

Frequencies and percentages were calculated for the sociodemographic variables. Rates of all-cause and febrile illnesses and hospitalizations were calculated per 1000 population. The percentage of the patients admitted for febrile illness who sought care in the study hospitals was calculated for the pediatric age group, for adults, and overall. Socioeconomic status was calculated using a modified form of scale [21]. Logistic regression analysis and χ² tests were conducted to check for associations. Stata software (version 15) was used for analysis.

RESULTS

This study surveyed 137,990 individuals from 30,308 households across all 6 sites (Table 1). The demographic characteristic of the surveyed population is described in Table 2. On average, 60% of the families surveyed were of low socioeconomic status. The survey reported a high proportion of households practicing open-air defecation at 3 sites, with 13.9% in Anantapur, 26.8% in Chinchpada, and 41.1% in Raxaul.

From a 2-week recall, the rate of any-cause illness ranged from 83.9 to 243.2 per 1000 persons across the sites. The populations in Manali (49.2%), Makunda (42.4%), and Raxaul (49.7%) often relied on pharmacies for the treatment of illnesses that occurred in the 2-week recall period, while private clinics or hospitals were most often used in Anantapur (54%), Chandigarh (39%), and Chinchpada (63.9%). Within the same recall period, the rate of febrile illnesses ranged from 29.1 to 170.8 per 1000 persons and constituted 53.3% of all illnesses reported across the sites. The healthcare-seeking patterns for this group were similar to those in persons who reported any illnesses, with only 11.4% seeking care in the government facilities, 38.9% in pharmacies, 31.7% in private facilities, and 3.1% in the study hospitals (Table 2). Self-reported use of antibiotics in febrile illnesses in the 2-week recall period varied across sites, ranging from 13.8% in Manali to 46.7% in Makunda. However, it must be noted that 42% of the population did not know whether they had taken an antibiotic.

This study captured 4184 hospitalization episodes that occurred within a 12-month recall period across all sites, with 864 (20.6%) being for febrile illness (Table 3). The type of facility used for any hospitalization was classified into government and private facilities, and it was observed that most such events occurred at private hospitals in Anantapur (67.8%) and Raxaul (86.3%). In comparison, government hospitals were used more often in Chandigarh (90%), Chinchpada (53.3%), Makunda (50.3%), and Manali (51.5%). In the rural sites, 61.7% used the private sector for any inpatient care. Among all admissions, only 0.65% used health insurance, although 928 (22.2%) reported having some form of health insurance. The most common reasons listed for choosing a particular healthcare facility were the distance from home (48.6%), low cost of treatment (21.6%), quality of care (14.5%), and short waiting times before treatment (11.5%).

Across all 6 sites, 864 febrile hospitalization episodes that occurred within a 12-month recall period were captured. The febrile hospitalization rate per 1000 persons reported from hilly areas such as Manali and Makunda was low, with rates of 2.6 and 3.9 respectively, and in the plains, the rates were 5.5 in Raxaul, 8 in Chinchpada, 8.7 in Chandigarh, and 9.6 in Anantapur. Utilization of study hospitals for these events were 9.6% in Chinchpada, 17.4% in Anantapur, 25.5% in Raxaul, 35.7% in Manali, 37.5% in Makunda, and 38.3% in Chandigarh. At the rural sites, 67.6% of febrile hospitalizations occurred in private facilities.

A total of 699 deaths were recorded in the 12-month recall across all sites. They were most often due to a chronic medical condition (35.5%), and a majority occurred in the ≥60-year age group (57.8%). Healthcare-seeking behavior before death varied across sites, with public facilities preferred in Anantapur (44.8%), Chandigarh (83.1%), and Chinchpada (37.3%); no treatment sought or treated at home in Makunda (49%) and Manali (44%); and Raxaul’s population most often choosing to receive treatment at a private facility (47.6%), before death due to any cause. Among the deaths recorded, 13.9% occurred with an associated febrile condition; of persons dying with a febrile illness, 25.8% died without seeking treatment in any facility (Table 4).

Risk factors associated with febrile hospitalization were analyzed using multivariate logistic regression (Table 5). Age <15 years, belonging to a household of low socioeconomic
### Table 2. Profile of Illnesses Reported for a 2-Week Recall Period

| Characteristics of Reported Illness | Anantapur (n = 1744) | Chandigarh (n = 2349) | Chinchpada (n = 1949) | Makunda (n = 4758) | Manali (n = 2435) | Raxaul (n = 6752) | Overall (n = 19987) |
|-------------------------------------|----------------------|-----------------------|----------------------|---------------------|------------------|------------------|-------------------|
| **Illnesses per 1000 persons, no.** |                      |                       |                      |                     |                  |                  |                   |
| Any illness                        | 91 (53.6)            | 108.1                 | 83.9                 | 194.9               | 112.2            | 243.2            | 144.8             |
| Febrile illness                    | 31.2                 | 69.9                  | 42.2                 | 89.7                | 29.1             | 170.8            | 72                |
| **Any-cause illness**              |                      |                       |                      |                     |                  |                  |                   |
| Patient aged ≥15 y                 | 1540 (88.3%)         | 1648 (70.2%)          | 1522 (78.1%)         | 3284 (69.0%)        | 2001 (82.2%)     | 4402 (65.2%)     | 14397 (72%)       |
| Female patient                     | 925 (53)             | 1282 (54.6%)          | 1057 (54.2%)         | 2458 (51.7%)        | 1376 (56.5%)     | 3441 (51)        | 10539 (52.7%)     |
| Antibiotics used                   | 219 (12.6)           | 444 (18.9%)           | 205 (10.5)           | 1325 (27.8%)        | 162 (6.7)        | 909 (13.5)       | 3264 (16.3%)      |
| **Type of illness**                |                      |                       |                      |                     |                  |                  |                   |
| Febrile illness                    | 597 (34.2)           | 1518 (64.6%)          | 981 (50.3)           | 2190 (46.0%)        | 632 (26)         | 4741 (70.2%)     | 10659 (53.3%)     |
| Other medical illness              | 1091 (62.6)          | 794 (33.8)            | 921 (47.3)           | 2414 (50.7)         | 1737 (71.3)      | 1778 (26.3)      | 8735 (43.7)       |
| Pregnancy related                  | 13 (0.7)             | 11 (0.5)              | 11 (0.6)             | 15 (0.3)            | 13 (0.5)         | 25 (0.4)         | 88 (0.4)          |
| **Treatment facility**             |                      |                       |                      |                     |                  |                  |                   |
| Government facility                | 281 (16.1)           | 634 (27)              | 486 (24.9)           | 597 (12.6)          | 249 (10.2)       | 149 (2.2)        | 2396 (12)         |
| Home remedies/no treatment         | 24 (1.4)             | 116 (4.9)             | 145 (7.4)            | 245 (5.2)           | 404 (16.6)       | 364 (5.4)        | 1298 (6.5)        |
| Pharmacy                            | 78 (4.5)             | 209 (8.9)             | 47 (2.4)             | 2016 (42.4)         | 1199 (49.2)      | 3356 (49.7)      | 6905 (34.6)       |
| Private facility                    | 941 (54)             | 915 (39)              | 1245 (63.9)          | 1292 (27.2)         | 400 (16.4)       | 1806 (26.8)      | 6599 (33)         |
| Study hospital                      | 103 (5.9)            | 254 (10.8)            | 18 (0.9)             | 239 (5)             | 86 (3.5)         | 96 (1.4)         | 796 (4)           |
| Traditional healers/registered medical practitioners | 317 (18.2) | 221 (9.4) | 8 (0.4) | 369 (7.8) | 97 (4) | 981 (14.5) | 1993 (10) |
| **Febrile illness**                |                      |                       |                      |                     |                  |                  |                   |
| Patient aged ≥15 y                 | 448 (75)             | 955 (62.9)            | 699 (71.3)           | 1192 (54.4)         | 414 (65.5)       | 2669 (56.3)      | 6377 (59.8)       |
| Female patient                     | 306 (51.3)           | 799 (52)              | 523 (53.3)           | 1144 (52.2)         | 364 (57.6)       | 2346 (49.5)      | 5472 (51.3)       |
| Antibiotics used                   | 131 (21.9)           | 269 (17.7)            | 140 (14.3)           | 1022 (46.7)         | 87 (13.8)        | 798 (16.8)       | 2447 (23)         |
| **Treatment facility**             |                      |                       |                      |                     |                  |                  |                   |
| Government facility                | 110 (18.4)           | 377 (24.8)            | 281 (28.6)           | 309 (14.1)          | 71 (11.2)        | 68 (1.4)         | 1216 (11.4)       |
| Home remedies/no treatment         | 8 (13)               | 53 (3.5)              | 50 (5.1)             | 56 (2.6)            | 91 (14.4)        | 151 (3.2)        | 409 (3.8)         |
| Pharmacy                            | 21 (3.5)             | 119 (7.8)             | 9 (0.9)              | 1108 (50.6)         | 303 (47.9)       | 2583 (54.5)      | 4143 (38.9)       |
| Private facility                    | 306 (51.3)           | 705 (46.4)            | 627 (63.9)           | 556 (25.4)          | 105 (16.6)       | 1084 (22.9)      | 3383 (31.7)       |
| Study hospital                      | 37 (6.2)             | 131 (8.6)             | 8 (0.8)              | 72 (3.3)            | 30 (4.7)         | 51 (1.1)         | 329 (3.1)         |
| Traditional healers/registered medical practitioners | 115 (19.3) | 133 (8.8) | 6 (0.6) | 89 (4.1) | 32 (5.1) | 804 (17) | 1179 (11.1) |

aData represent no. (%) of illnesses unless otherwise specified.

bDenominators in the febrile illness section are the number of febrile illnesses reported for the site for the 2-week recall period.
### Table 3. Profile of Hospitalizations Captured for a 12-Month Recall Period

| Characteristics of Reported Hospitalizations | Anantapur (n = 904) | Chandigarh (n = 693) | Chinchpada (n = 643) | Makunda (n = 740) | Manali (n = 437) | Raxaul (n = 767) | Overall (n = 4184) |
|---------------------------------------------|---------------------|----------------------|----------------------|-------------------|-----------------|-----------------|-------------------|
| Hospitalizations per 1000 persons, no.       |                     |                      |                      |                   |                 |                 |                   |
| Any cause                                   | 47.2 (91.0)         | 31.9 (91.2)          | 27.7 (91.4)          | 30.3 (92.0)       | 20.1 (95.0)     | 27.6 (90.0)     | 30.3 (91.5)       |
| Febrile Illness                             | 9.6 (56.0)          | 8.7 (69.8)           | 8.0 (64.5)           | 7.9 (74.9)        | 2.6 (71.8)      | 5.5 (61.2)       | 6.3 (65.5)        |
| Any-cause hospitalizations                   |                     |                      |                      |                   |                 |                 |                   |
| Patient aged ≥15 y                          | 823 (91.0)          | 632 (91.2)           | 588 (91.4)           | 681 (92.0)        | 415 (95.0)      | 690 (90.0)      | 3829 (91.5)       |
| Female patient                              | 506 (56.0)          | 484 (66.8)           | 415 (64.5)           | 554 (71.9)        | 314 (71.8)      | 469 (61.2)       | 2712 (65.5)       |
| Government facility                         | 291 (32.2)          | 463 (66.8)           | 343 (53.3)           | 372 (50.3)        | 225 (51.5)      | 105 (13.7)       | 1799 (43.0)       |
| Private facility                            | 466 (51.6)          | 69 (10.0)            | 256 (40.1)           | 105 (14.2)        | 112 (25.6)      | 513 (66.9)       | 1523 (36.4)       |
| Study hospital                              | 147 (16.3)          | 161 (23.2)           | 42 (6.5)             | 263 (35.5)        | 100 (22.3)      | 149 (19.4)       | 862 (20.6)        |
| Type of illness                             |                     |                      |                      |                   |                 |                 |                   |
| Febrile Illness                             | 184 (20.4)          | 188 (27.1)           | 187 (29.1)           | 96 (13.0)         | 56 (12.2)       | 153 (20.0)       | 864 (20.6)        |
| Other medical condition                     | 355 (39.3)          | 142 (20.5)           | 145 (22.6)           | 133 (18.0)        | 84 (19.2)       | 228 (29.7)       | 1087 (26.0)       |
| Surgical and trauma                         | 178 (19.7)          | 94 (13.6)            | 83 (12.9)            | 101 (13.6)        | 79 (18.1)       | 201 (26.2)       | 736 (17.6)        |
| Childbirth related                          | 187 (20.7)          | 269 (38.8)           | 228 (35.5)           | 410 (55.4)        | 218 (49.9)      | 185 (24.1)       | 1497 (35.8)       |
| Febrile Illness hospitalizationsb            |                     |                      |                      |                   |                 |                 |                   |
| Patient aged ≥15 y                          | 131 (71.2)          | 152 (80.9)           | 152 (81.3)           | 74 (77.1)         | 45 (80.4)       | 110 (71.9)       | 664 (76.9)        |
| Female patient                              | 88 (47.8)           | 86 (45.7)            | 83 (44.4)            | 39 (40.6)         | 26 (46.4)       | 63 (41.2)        | 385 (44.8)        |
| Government facility                         | 57 (31.0)           | 103 (54.8)           | 88 (47.1)            | 41 (42.7)         | 25 (44.6)       | 8 (5.2)          | 322 (37.3)        |
| Private facility                            | 95 (47.6)           | 75 (39.6)            | 81 (43.3)            | 19 (19.3)         | 11 (19.6)       | 109 (71.2)       | 328 (38.0)        |
| Study hospital                              | 32 (17.4)           | 72 (38.3)            | 18 (9.6)             | 36 (37.5)         | 20 (35.7)       | 36 (23.5)        | 214 (24.8)        |
| Duration of hospitalization for AFI, median, d | 4                   | 4                    | 4                    | 4                 | 4               | 4               | 4                 |

aData represent no. (%) of hospitalizations unless otherwise specified.

bDenominators for AFI hospitalizations are the number of AFI hospitalizations reported for the site for the 12-month recall period.
status, having a child <5 years of age in the family, and having a family size <4 members were associated with febrile hospitalizations.

**Monitoring**

Table 6 summarizes the cluster and fieldworker scores at each of the sites. A cluster score <0.5 was considered to be poor performing. Of the 600 clusters, 131 clusters had scores indicating poor performance and had to be resurveyed under supervision. Cluster scores improved after the resurvey. Mean cluster scores improved from 0.51 to 0.75 in Anantapur, from 0.64 to 0.80 in Makunda, from 0.73 to 0.80 in Chandigarh, from 0.67 to 0.72 in Chinchpada, from 0.58 to 0.62 in Manali, and from 0.71 to 0.75 in Raxaul, after the resurvey. This improvement in scores is statistically significant in all sites except Manali. The mean score for the field workers ranged from 0.64 in Manali to 0.92 in Chinchpada. The field workers who were not performing well were either retrained or replaced. Supplementary Figure 3 represents a sample scoring sheet depicting the performance of each cluster in a site.

**DISCUSSION**

The utilization of study facilities for febrile hospitalizations at the 6 sites under the SEFI tier 2 study ranged from 9.6% to 38.3%. The SEFI network used these estimates to calculate the adjusted incidence rate for typhoid and paratyphoid fevers in India. The observed utilization rate is lower than the presumed 60% while selecting the facilities for hybrid surveillance. Low and variable utilization of the study facility underscores the importance of serially assessing community-based healthcare utilization to generate adjusted, more accurate estimates of the occurrence of *Salmonella* infections and other diseases associated with fever [4, 7, 18, 19].

High population density, availability of traditional/different systems of medicine in India, the plurality of private health sector providers, which has an almost equal number of qualified doctors and unqualified practitioners, and lack of facilities in the public health sectors could be some of the reasons for low utilization of any single health facility in a particular site [22]. In areas with multiple preferred healthcare facilities, selecting a single sentinel facility for facility-based surveillance in hybrid models may underestimate the incidence rates. Sentinel facilities should be carefully selected because, as the percentage of sentinel facility utilization by the population increases, the uncertainty around the adjustment factor for incidence estimation in hybrid surveillance decreases.

In hilly and rugged terrains, the population’s healthcare-seeking behavior might be different from that of the population.
in the plains owing to poor accessibility. The febrile hospitalization rates reported from hilly areas such as Manali and Makunda were 2.6 and 3.9 per 1000 persons, respectively, and in the plains, these rates were 5.5 in Raxaul, 8 in Chinchpada, 8.7 in Chandigarh, and 9.6 in Anantapur. In the hybrid model in the Surveillance for Enteric Fever in Asia Project study conducted in Bangladesh, Pakistan, and Nepal, the percentages of all individuals who were reported to have been hospitalized for fever within the past 12 months were 1.3% in Bangladesh, 0.6% in Nepal, and 0.4% in Pakistan [12], comparable to findings in the current study.

Further analysis of healthcare utilization patterns showed that illnesses captured using a 2-week recall period were primarily treated using pharmacies or private sector clinics across all sites. Self-reported antibiotic use in the 2-week recall varied across sites. The proportion of the population who were not aware of whether they consumed an antibiotic during the 2-week recall was alarmingly high. Frequent use of pharmacies as the first point of healthcare in rural areas and unawareness of the medicines consumed is particularly concerning owing to inappropriate antibiotic dispensation by pharmacists, which might worsen the already existing antimicrobial resistance in the community [24, 25]. While tighter regulations might help, they should be accompanied by improved awareness among the pharmacists regarding antibiotic misuse and mass awareness campaigns within communities regarding the risks of unwarranted antibiotic consumption.

In the rural sites, 61.73% of all admissions occurred in a private facility, rising to 67.60% in those with a febrile illness. Overreliance on the private sector for treatment was observed for the illnesses recorded in the 2-week recall period also. This will result in significant out-of-pocket expenditures, ultimately resulting in catastrophic health expenditures and impoverishment of households, continuing the vicious cycle of poverty and

### Table 5. Logistic Regression Analysis of Factors Associated With Admissions for Febrile Conditions Among Catchment Populations, Based on a 12-Month Recall Period

| Factor                               | Admissions for Febrile Condition, No. | OR (95% CI) | P Value |
|--------------------------------------|---------------------------------------|-------------|---------|
|                                      | Yes                                   | No          |         |
| **Univariate analysis**              |                                       |             |         |
| Age, y                               |                                       |             |         |
| <15                                  | 195                                   | 37 666      | 0.81 (.69–.95) | .01 |
| ≥15                                  | 635                                   | 99 494      | Reference          |
| Sex                                  |                                       |             |         |
| Female                               | 379                                   | 66 958      | Reference          |
| Male                                 | 451                                   | 70 202      | 1.13 (.99–1.30)  |
| SES                                  |                                       |             |         |
| Low                                  | 510                                   | 77 762      | 1.22 (1.06–1.40)  |
| Middle or high                       | 320                                   | 59 398      | Reference          |
| Child aged <5 y in family            |                                       |             |         |
| Yes                                  | 288                                   | 542         | 1.03 (.89–1.19)  |
| No                                   | 46 698                                | 90 462      | Reference          |
| **Multivariate analysis**            |                                       |             |         |
| Age, y                               |                                       |             |         |
| <15                                  | 195                                   | 37 666      | 0.80 (.68–.95)  |
| ≥15                                  | 635                                   | 99 494      | Reference          |
| Sex                                  |                                       |             |         |
| Female                               | 379                                   | 66 958      | Reference          |
| Male                                 | 451                                   | 70 202      | 1.13 (.99–1.30)  |
| SES                                  |                                       |             |         |
| Low                                  | 510                                   | 77 762      | 1.20 (1.04–1.38)  |
| Middle or high                       | 320                                   | 59 398      | Reference          |
| Child aged <5 y in family            |                                       |             |         |
| Yes                                  | 288                                   | 542         | 1.17 (1.003–1.36) |
| No                                   | 46 698                                | 90 462      | Reference          |
| **Family size**                      |                                       |             |         |
| <4 members                           | 383                                   | 52 851      | 1.37 (1.19–1.57)  |
| ≥4 members                           | 447                                   | 84 309      | Reference          |
| Abbreviations: CI, confidence interval; OR, odds ratio; SES, socioeconomic status.
ill health, especially in the vulnerable groups [26]. Studies have shown that out-of-pocket expenditures are 4 times higher in the private sector than in public facilities for an episode of hospitalization [27]. Inadequate health insurance coverage (22.18%) and even lower insurance usage (0.65%) during a hospitalization episode further exacerbate this problem. A study done among the urban poor in Delhi reports that only 9.7% were enrolled for the Rashtriya Swasthya Bima Yojana plan [28]. Lack of awareness of health insurance plans that can be availed, poor access, and the limitations of these plans in (eg. in illnesses covered and private hospitals included) may be reasons for underutilization of such plans, as reported in other studies [28].

The study found several risk factors associated with the occurrence of a febrile hospitalization among the catchment populations. Having a child of <5 years of age in the household was one factor, which indicates that this age group may be a driver of infectious diseases in households, as has been previously noted [29–31]. We also found that children <15 years of age had a lower chance of hospitalization due to febrile illness than adults. Other studies have reported delays in treatment seeking among adults, which may be due to inadequate access to healthcare facilities, negligence, and the fear of losing daily wages in rural settings, which leads to more severe disease presentation and hence more hospitalizations [32].

Low socioeconomic status was also associated with febrile hospitalizations, which could be because of financial concerns that delay treatment [33] and the receipt of healthcare from unqualified personnel [34, 35]. Finally, being part of a smaller family (<4 members) increased an individual's odds (odds ratio, 1.36) of experiencing a febrile hospitalization; this finding, however, was not consistent with those from other studies [36]. Another study reports that crowding was associated with a 60% reduction in the incidence of asthma but had a 2.5-fold increase in the incidence of lower respiratory tract infections [37]. The Surveillance for Enteric Fever in Asia Project reports age, household wealth, and disease severity as important determinants of healthcare seeking for acute febrile illness in Bangladesh, Pakistan, and Nepal [12].

Among the deaths associated with fever, 25.8% occurred at the deceased individual's home or without treatment. When deaths due to any cause were considered, this percentage rose to 39.2%. Such cases are often unrecorded in the country's registers, leading to a poor understanding of mortality rates and causes of death in India. Thus, verbal autopsy-based studies, such as the Million Deaths Study [38], remain necessary and should receive continued support in the future.

The current study faced several challenges, such as inclement weather, rugged terrain, language and dialect variations, and differences in sociocultural norms. We also had difficulty finding adequately trained field research assistants who could converse in the local languages in 6 diverse study locations. The survey also had to be halted in Manali for multiple weeks owing to flooding in the area. An observed limitation was recall bias, that is, fewer admission episodes reported beyond 6 months of recall. The investigators also found it extremely challenging to obtain accurate self-reported answers for questions related to the diagnoses, severity of illness, and antibiotic use because of lack of awareness and low literacy rates among respondents from the rural communities of India. Some participants found it difficult to understand what an “antibiotic” was and it was hence difficult to elicit the correct response even after multiple attempts. Lack of knowledge regarding diseases and treatment among the participants make such health surveys difficult in rural India, unlike in developed countries. It was also challenging for the central team to monitor the survey simultaneously in 6 remote locations. This challenge was overcome partly by facilitating on-site monitoring visits by ICMR-NIE, Chennai, and systematic remote monitoring of the performance at each site by CMC Vellore through scoring systems developed for the current study.

In conclusion, the study estimates that 1 in every 5 hospitalizations is for febrile illness. Private facilities are relied on...
more in rural sites for treatment. The HCUS, in the hybrid surveillance of the tier 2 SEFI study, provided the needed factor to calculate the adjusted incidence of enteric fever in India. HCUSs are an essential component of any hybrid surveillance system to provide accurate estimates of the incidence of illnesses. Rigorously designed HCUSs can help generate reliable epidemiological data for various other febrile illnesses and help track health improvements across a wide variety of settings.

Supplementary Data
Supplementary materials are available at The Journal of Infectious Diseases online. Consisting of data provided by the authors to benefit the reader, the posted materials are not copyedited and are the sole responsibility of the authors, so questions or comments should be addressed to the corresponding author.

Notes
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Author contributions. P. S., J. J., and G. K. conceived and designed the study; R. R., A. S. K., K. R., and P. S., and developed the study protocol and analysis plan; R. R. coordinated the project; R. R., M. M., and A. E. coordinated data collection at the sites; R. R., J. K. A., D. K., R. K. R., and N. S. analyzed the data; R. R., N. S., and J. J. drafted the manuscript. All authors have reviewed the manuscript and approved it, had complete access to data, and guaranteed the manuscript.

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References
1. World Health Organization. WHO recommended surveillance standards, 2nd ed. World Health Organization [Internet]. World Health Organization; [cited 2019 Dec 18], 1999. Available from: https://apps.who.int/iris/handle/10665/65517
2. Sharma R, Ratnesh L, Karad AB, Kandpal H, Dharwal AC, Ichhupujani RL. Communicable disease outbreak detection by using supplementary tools to conventional surveillance methods under Integrated Disease Surveillance Project (IDSP), India. J Commun Dis 2009; 41:419–59.
3. Oum S, Chandramohan D, Cairncross S. Community-based surveillance: a pilot study from rural Cambodia. Trop Med Int Health 2005; 10:689–97.
4. Bigogo G, Audi A, Aura B, Aol G, Breiman RF, Feikin DR. Health-seeking patterns among participants of population-based morbidity surveillance in rural western Kenya: implications for calculating disease rates. Int J Infect Dis 2010; 14:e967–73.
5. Sheikh S, Qureshi RN, Raza F, et al; CLIP Working Group. Self-reported maternal morbidity: Results from the community level interventions for pre-eclampsia (CLIP) baseline survey in Sindh, Pakistan. Pregnancy Hypertens 2019; 17:113–20.
6. Technical Contributors To The June WHO Meeting. A definition for community-based surveillance and a way forward: results of the WHO global technical meeting, France, 26 to 28 June 2018. Euro Surveill Bull Eur Sur Mal Transm Eur Commun Dis Bull. European Centre for Disease Prevention and Control (ECDC); 2019; 24:1800681.
7. Burton DC, Flannery B, Onyango B, et al. Healthcare-seeking behaviour for common infectious disease-related illnesses in rural Kenya: a community-based house-to-house survey. J Health Popul Nutr 2011; 29:61–70.
8. O’Donnell O. Access to health care in developing countries: breaking down demand side barriers. Cad Saude Publica 2007; 23:2820–2834.
9. Groce NE, Reeve ME. Traditional healers and global surveillance strategies for emerging diseases. Emerg Infect Dis 1996; 2:351–3.
10. Porter G, Grills N. Medication misuse in India: a major public health issue in India. J Public Health 2016; 38:e150–7.
11. Bodavala R. Evaluation of Health Management Information System in India: Need for Computerized Databases in HMIS. Boston: Harvard School of Public Health, [cited 2019 Dec 18], 1998. Available from: https://cdn1.sph.harvard.edu/wp-content/uploads/sites/114/2012/10/rp176.pdf
12. Andrews JR, Vaidya K, Saha S, et al. Healthcare utilization patterns for acute febrile illness in Bangladesh, Nepal, and Pakistan: results from the Surveillance for Enteric Fever in Asia Project. Clin Infect Dis 2020; 71:248–56.
13. Smolinski MS, Crawley AW, Olsen JM, Jayaraman T, Libel M. Participatory disease surveillance: engaging communities directly in reporting, monitoring, and responding to health threats. JMIIR Public Health Surveill 2017; 3:e62.
14. Andrews JR, Barkume C, Yu AT, et al. Integrating facility-based surveillance with healthcare utilization surveys to estimate enteric fever incidence: methods and challenges. J Infect Dis 2018; 218:268–76.
15. Luby SP, Saha S, Andrews JR. Towards sustainable public health surveillance for enteric fever. Vaccine 2015; 33(suppl 3):C3–7.
16. Crump JA, Youssef FG, Luby SP, et al. Estimating the incidence of typhoid fever and other febrile illnesses in developing countries. Emerg Infect Dis 2003; 9:539–44.
17. Nasrin D, Wu Y, Blackwelder WC, et al. Health care seeking for childhood diarrhea in developing countries: evidence from seven sites in Africa and Asia. Am J Trop Med Hyg 2013; 89(1 suppl):3–12.
18. Jordan HT, Prapasiri P, Areerat P, et al. A comparison of population-based pneumonia surveillance and health-seeking behavior in two provinces in rural Thailand. Int J Infect Dis 2009; 13:355–61.
19. Panzner U, Pak GD, Im J, et al. Typhoid fever surveillance in Africa program: Healthcare patterns in febrile study populations. Int J Infect Dis 2014; 21:246–7.
20. Census of India Website; Office of the Registrar General & Census Commissioner, India [Internet]. [cited 2021 Aug 1]. Available from: https://censusindia.gov.in/2011-common/ censusdata2011.html
21. National Sample Survey Office, Government of India. Health in India- NSS 71st Round (Jan to Jun 2014). Available from: http://mospi.nic.in/sites/default/files/publication_reports/nss_rep574.pdf
22. Kattula D. Measuring poverty in southern India: a comparison of socio-economic scales evaluated against childhood stunting. PLoS One 2016; 11:e0160706.
23. Duggal R. Health care utilisation in India. Health Millions 1994; 2:10–2.
24. Shet A, Sundaresan S, Forsberg BC. Pharmacy-based dispensing of antimicrobial agents without prescription in India: appropriateness and cost burden in the private sector. Antimicrob Resist Infect Control 2015; 4:55.
25. Barker AK, Brown K, Ahsan M, Sengupta S, Sadfar N. What drives inappropriate antibiotic dispensing? a mixed-methods study of pharmacy employee perspectives in Haryana, India. BMJ Open 2017; 7:e013190.
26. Sharma D, Prinja S, Aggarwal AK, Bahuguna P, Sharma A, Rana SK. Out-of-pocket expenditure for hospitalization in Haryana State of India: extent, determinants & financial risk protection. Indian J Med Res 2017; 146:759–67.
28. Jain N, Kumar A, Nandraj S, Furtado KM. Same data, multiple interpretations. 2015; 4.
28. Kusuma YS, Pal M, Babu BV. Health insurance: awareness, utilization, and its determinants among the urban poor in Delhi, India. J Epidemiol Glob Health 2018; 8:69–76.
29. Byington CL, Ampofo K, Stockmann C, et al. Community surveillance of respiratory viruses among families in the Utah Better Identification of Germs-Longitudinal Viral Epidemiology (BIG-LoVE) Study. Clin Infect Dis 2015; 61:1217–24.
30. Scott EM, Magaret A, Kuypers J, et al. Risk factors and patterns of household clusters of respiratory viruses in rural Nepal. Epidemiol Infect 2019; 147:e288.
31. Schlinkmann KM, Bakuli A, Karch A, et al. Transmission of respiratory and gastrointestinal infections in German households with children attending child care. Epidemiol Infect 2018; 146:627–32.
32. Chaturvedi HK, Bajpai RC, Tiwari P. Determination of cut-off and correlates of delay in treatment-seeking of febrile illness: a retrospective analysis. BMC Public Health 2020; 20:572.
33. Weissman JS, Stern R, Fielding SL, Epstein AM. Delayed access to health care: risk factors, reasons, and consequences. Ann Intern Med 1991; 114:325–31.
34. Das J, Mohpal A. Socioeconomic status and quality of care in rural India: new evidence from provider and household surveys. Health Aff 2016; 35:1764–73.
35. Kanungo S, Bhowmik K, Mahapatra T, Mahapatra S, Bhadra UK, Sarkar K. Perceived morbidity, healthcare-seeking behavior and their determinants in a poor-resource setting: observation from India. PLoS One 2015; 10:e0125865.
36. Islam M, Sultana ZZ, Iqbal A, Ali M, Hossain A. Effect of in-house crowding on childhood hospital admissions for acute respiratory infection: a matched case-control study in Bangladesh. Int J Infect Dis 2021; 105:639–45.
37. Cardoso MR, Cousens SN, de Géès Siqueira LF, Alves FM, D’Angelo LA. Crowding: risk factor or protective factor for lower respiratory disease in young children? BMC Public Health 2004; 4(1):19.
38. Jha P, Gajalakshmi V, Gupta PC, et al; RGI-CGHR Prospective Study Collaborators. Prospective study of one million deaths in India: rationale, design, and validation results. PLoS Med 2006; 3:e18.