

Surveillance Tools for Meningitis Sentinel Hospital Surveillance: Field Guide to Rapidly Estimate the Hospital Catchment Population (Denominator) and the Annual Rate of Hospitalisations



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for Meningitis Sentinel
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Polio



Tick



**The Department of Immunization, Vaccines and Biologicals
thanks Gavi, the Vaccine Alliance and the U.S. Centers
for Disease Control and Prevention
whose unspecified financial support has made the
production of this document possible.**

This document was produced by the
Expanded Programme on Immunization (EPI)
of the Department of Immunization, Vaccines and Biologicals

*Ordering code: WHO/IVB/15.02
Printed: February 2015*

This publication is available on the Internet at:

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Printed by the WHO Document Production Services, Geneva, Switzerland

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Acknowledgments:

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1. Why estimate a denominator for a meningitis (Tier 1) sentinel hospital site?

The WHO coordinated invasive bacterial vaccine preventable diseases (IB-VPD) sentinel surveillance network monitors the characteristics and disease etiologies of children <5 years of age admitted to sentinel hospitals with suspect meningitis. Using variable laboratory diagnostic practices, sentinel hospitals determine if these children have probable bacterial meningitis and seek to identify the causative organism. When considering a rate, the IB-VPD sentinel surveillance system thus collects 'numerator' information. There is no corresponding data available to determine the 'at risk' population of children (e.g. denominator) that gave rise to the numerator. Determining both the numerator and denominator is needed to calculate an estimated annual rate of hospitalizations for suspect meningitis in a given population of children. The estimated annual rate of hospitalizations among children <5 years of age at the sentinel hospital is a useful tool nationally and globally, as follows:

- Nationally: Tracking the rate over time can help assess changes in disease patterns following vaccine introduction, and help monitor potential changes in clinical practices that can impact surveillance quality and thus should be further investigated.
- Regionally/Globally: Once an estimated rate is known for several sentinel hospitals, it may be possible to determine a target rate, such as the target rate for non-polio acute flaccid paralysis (AFP) of 2 per 100,000 children aged <15 years.

2. What are the objectives of this exercise and how long will it take?

- To estimate the denominator population of children <5 years of age (the 'at risk' population) for a sentinel hospital participating in the WHO IB-VPD Tier 1 (meningitis) surveillance network.
- For the sentinel hospital, the combination of available numerator data with the denominator of children <5 years of age will be used to estimate the annual rate with 95% confidence interval of admissions to the sentinel hospital for suspect meningitis in children <5 years of age residing in the geographical catchment area of the sentinel hospital
- If records are well-kept and easily accessible at the sentinel hospital, and no other hospitals are involved, then the exercise can be completed within a day. However, if other hospitals are involved and need to be visited, allow one additional day per hospital.

3. Guiding principles

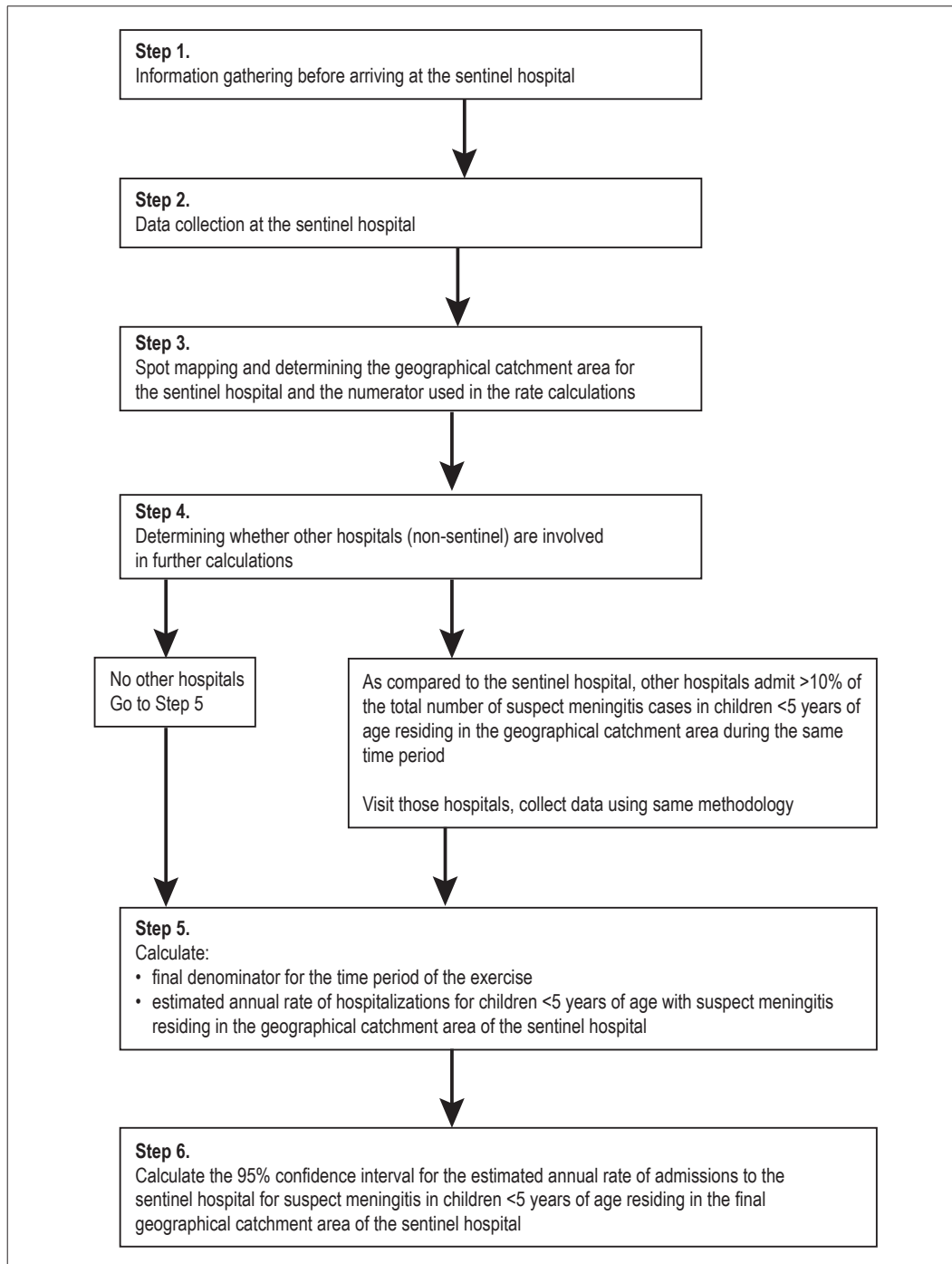
- Many approaches can be taken to determine a denominator, with different levels of complexity. This approach attempts to balance the amount of effort, time and resources required to obtain a reasonably accurate denominator and subsequently an estimated annual rate of hospitalizations for suspected meningitis in children <5 years of age at the sentinel hospital.
- Whenever there is a choice of approaches for this methodology, the option taken has been to underestimate, rather than overestimate, the rate. Thus, the generated rate would represent the ‘tip of the iceberg.’
- The catchment population estimation will, in general, be a one-time estimation completed during sentinel site evaluation visits. However, a ‘stock take’ is recommended every two years to determine whether any major changes to the denominator have occurred, such as the influx of a large number of refugees, opening of new hospitals, or other demographic shifts in population patterns. If so, this exercise should be repeated.
- To have confidence in the estimate’s stability, ≥ 100 suspect meningitis cases in children <5 years of age must have been admitted to the sentinel hospital within the years being assessed. It is encouraged to include at least the 2 most recent years (any 24 consecutive months) -- preferably 3 years -- of meningitis data. These data years do not need to be consecutive years but ideally should be.
- Overall, the methodology consists of:
 - Estimating the geographical sentinel hospital catchment area (i.e. sub-national levels comprising the catchment area for children <5 years of age with suspected meningitis)
 - Within that geographical hospital catchment area, estimating the population of children <5 years of age who would be taken to the sentinel hospital or other hospitals if signs and symptoms of meningitis develop (i.e.. the health care utilization component)
- IB-VPD surveillance methods will stay the same regardless of determination of the denominator catchment population.
- Using these methods, some hospitals meeting laboratory proficiency standards may also be able to calculate a rate of probable bacterial meningitis among children <5 years of age as well as rates of laboratory confirmed meningitis due to *Streptococcus pneumoniae*, *Haemophilus influenzae*, and *Neisseria meningitidis* among children <5 years of age. However, because there must be relatively large numbers of confirmed cases in order to generate a reliable rate, it is likely that most hospitals will be unable to calculate such rates.

-
- There may be more than one sentinel hospital in the same geographical area. In general, it may be possible to visit each sentinel hospital, collect data as outlined in this guide, and then use the pooled information from the sentinel hospitals to complete steps 3 onwards as outlined in this field guide. If a rate is to be determined in such a setting, it is advisable to obtain additional technical advice.
 - This methodology was developed specifically for suspect meningitis admissions among children <5 years of age. Because meningitis is a unique life-threatening illness, health care utilization patterns are likely to be unique for meningitis. **This methodology should not be used for other illnesses and the determined geographical catchment area of the sentinel hospital should only be used for meningitis, not other illnesses.**

4. Methodology Overview

The process for estimating a denominator is neither difficult nor complicated providing the following steps in this field guide are followed (Figure 1). A denominator is a useful tool for each country and collectively can help guide global efforts to determine trends. Therefore, use of the same methodology in all countries is important. Overall, this methodology uses information from suspect meningitis cases (e.g. the numerator) to define the geographical catchment area and subsequently the denominator.

Figure 1. Methodology Overview for Estimating a Denominator and Rate of Hospitalizations to the Sentinel Hospital for Suspected Meningitis among Children <5 Years of Age Residing in the Geographical Catchment Area of the Sentinel Hospital



5. Methods

Step 1: Information gathering before arriving at the sentinel hospital

This methodology uses the information obtained from suspect meningitis cases (e.g. the numerator) to determine the denominator.

For simplicity, in the remaining document the term 'district' is used to indicate sub-national areas. Other terms used by countries may be state, governate, province, ward, etc.

In many instances, the information below may not be available prior to arrival to the sentinel hospital, however, wherever possible collect and complete the following:

1. For the numerator:

- a) Determine if MoH/sentinel hospital/WHO office has an existing line list of suspect meningitis cases via IB-VPD surveillance that includes information on the district of residence of hospitalized children. Keep in mind that data collected via this exercise to estimate the denominator can be used to improve IB-VPD surveillance (Page 28).
- b) Determine if the sentinel hospital routinely collects and records information on the residence of hospitalized children.
- c) If so, determine where that information is recorded: admission logbook, ward logbook or discharge logbook, etc. It may be recorded in more than one place.
- d) Determine if the hospital records lumbar punctures (LP) taken. If so, determine where that information is recorded: LP logbook, laboratory logbook, etc.
- e) Confirm that data sources are complete and available for at least the 2 most recent years (any 24 consecutive months), preferably 3 years, at the sentinel hospital, and that ≥ 100 children < 5 years of age have been admitted with suspect meningitis during this timeframe.

Definition of Numerator for a Sentinel Hospital:

The number of suspect meningitis cases in children < 5 years of age admitted to sentinel hospital and residing in the determined geographical catchment area.

Why 2 years of data?

At least 2 complete years (any 24 consecutive months) of recent data is required for this method in order to mitigate anomalies such as unique seasonal changes or disease patterns.

If an admission/ward/discharge logbook does not contain information on suspect meningitis cases then search for cases in laboratory logbooks or LP logbooks. If necessary, cross-reference patient information from multiple sources such as admission/ward/discharge logbooks to collect information on age, district of residence and admission/discharge date.

2. For the denominator:

- a) Collect the most current estimates of the population of children <5 years of age for each district in the country. In a large country, such as India, you may wish to initially ask for those districts in the general proximity to the sentinel hospital(s). For a small country this may be all of the districts.

Definition of Denominator:

The affected population.

In this methodology the affected population is children <5 years of age within the determined geographical catchment area of the sentinel hospital, proportionally decreased by the impact of other major hospitals if applicable.

3. For mapping:

- a) Obtain a map of the country with the smallest sub-national areas (or 'administrative regions' such as districts) and the names of these areas. Identify the sentinel hospital(s) on the map.
- b) Collect the names and locations of hospitals in the general proximity to the sentinel hospital(s) that serve children, particularly children with suspect meningitis. In countries actively conducting polio acute flaccid paralysis (AFP) surveillance, these other hospitals are usually included as polio AFP zero reporting sites because children with AFP may be admitted. However, the hospitals may not exclusively be those sites.
- c) Spot map hospital(s) providing care for children <5 years in the country, or in large countries, those hospitals located in general proximity of the sentinel hospital(s).
- d) It is useful to seek expert advice from MoH/WHO/pediatricians, etc.

Collect whatever information is available before arrival at the sentinel hospital. Complete any missing information as soon as possible after arrival. If an external team is being used, a local guide may be needed by the team while in country. If so, arrangements should be made prior to the team's arrival.

When collecting data from hospital records, record all information available related to the residence (refer to hospital data collection template in Annex 3, page 24.) In particular, the hospital may only record the village of residence and additional investigation may be required to determine the district once data collection is completed at the sentinel hospital.

Step 1: Summary of Key Points:

Gather as much relevant information as possible before arriving at the sentinel hospital.

Types of relevant information include:

- 1) Numerator information
 - Sentinel hospital
 - Location
 - Data sources (admission logbooks, electronic databases, LP logbooks, etc)
 - Data availability (where data is kept and how to gain access)
 - Line list of meningitis cases reported through sentinel surveillance via MoH/Sentinel hospital/WHO
- 2) Denominator information
 - Population data by district for children <5 years of age, sources include government census or other programmes (i.e. Global Polio Eradication Initiative)
- 3) Mapping information
 - Maps containing the names of administrative areas/districts onto which sentinel and surrounding hospitals can be added
- 4) Location of hospitals that would admit children <5 years of age with suspected meningitis

Step 2. Data collection at the sentinel hospital

It is important to make clear at the sentinel hospital that this denominator exercise is not an evaluation of the hospital staff nor the functioning of the hospital.

By using **only** the sentinel hospital records, identify children <5 years of age admitted with suspect meningitis to determine the districts that will comprise the geographical hospital catchment area for suspect meningitis cases <5 years of age:

- 1) Take the IB-VPD line list of suspect meningitis cases in children <5 years of age and a map of the administrative areas to the sentinel hospital during this exercise.
- 2) Visit the sentinel hospital(s):
 - a) Review the hospital admission records / log books / electronic records for the past 2 years (any 24 consecutive months), preferably 3 years if available. If admission records are unavailable or incomplete, review discharge or pediatric ward logbooks.

Hospital records may be hard to locate or may be incomplete. It is critical that data sources are consistent throughout this entire process and are complete for at least two years (any 24 consecutive months).

There may be multiple data sources of varying usefulness. It is important to find all relevant data sources; then use best judgment to determine the best consistent data sources to use.

- b) Identify which hospital sources of information contain all the required information. Consider collecting data from multiple sources such as the emergency log book, ward log book, laboratory log book, etc. Collect the information only on suspect meningitis cases. **Note:** Suspect meningitis cases may not be entered as such in the hospital log books. In addition to suspect meningitis cases, include other entries that are clinically similar such as: “rule out meningitis” or “suspect cerebral tuberculosis”, etc.

The suspect meningitis case definition for surveillance is different from the information in the hospital log books.

For IB-VPD surveillance, the case definition for suspect meningitis is:

Any child aged 0-59 months (<5 years) admitted to the sentinel hospital with sudden onset of fever (>38.5oC rectal or >38.oC axillary) plus a history of one of the following:

- neck stiffness, altered consciousness with no alternative diagnosis, or other meningeal sign OR

Physician diagnosis of suspect meningitis.

For the purposes of this exercise, a more loose criteria is used to include any child <5 years of age that clinically might have meningitis of any etiology.

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- c) Review hospital lumbar puncture (LP) records. Determine the total number of LPs performed on children <5 years of age for the years being reviewed. If the total number of LPs recorded is within 10% of the total number of suspect meningitis cases collected in step 2b then continue. If not then cross reference the two data sets to find missing suspect meningitis cases in children <5 years of age.
 - d) Enter all available relevant data into the hospital data entry template (Annex 3, page 34). Only enter cases that have a record of age, district of residence and admission during the period of the exercise/data collection.
 - e) Cross reference the IB-VPD line list with the completed information in the data entry template to ensure no cases of suspect meningitis in children <5 years of age have been missed. Be sure not to duplicate entries from different data sources into the final database.

STOP:

Do not continue unless there is a minimum of 2 recent years (any 24 consecutive months) of information with at least 100 suspected meningitis cases in children of <5 years of age during the time frame of data collection

Step 2: Summary of Key Points:

- 1) Visit the sentinel hospital.
- 2) Find all relevant sentinel hospital data sources such as hospital admissions log books and laboratory log books which include age, district of residence, and admission during the period of the exercise/data collection. Evaluate which are the best data sources to use.
- 3) Review hospital data sources to find suspect meningitis cases in children <5 years of age.
- 4) If necessary, cross-reference admission/ward logbooks with LP records.
- 5) Record information for all suspect meningitis cases for children <5 years of age with relevant data as per the data entry template.
- 6) Cross reference the IB-VPD line list obtained (Annex 3, page 34) from the MoH/WHO with the database developed via the data entry template. Compare the two data sources to identify any missing suspect meningitis cases in children <5 years of age, whilst being careful not to enter the same case of suspect meningitis into the database twice.

The minimum data fields required are age, district of residence, and admission during the period of the exercise/data collection. Do not enter any case into the database that does not have all three of the required minimum data points.

Step 3: Spot mapping and determining the geographical catchment area for the sentinel hospital and the numerator used in the rate calculations

- 1) With the data collected via Steps 1 and 2, spot map the cases by year and district of residence. Use different color spots for each year (note: the cases do not need to be mapped to their exact location of residence, only to the district)
- 2) From the database created in step 2, create a table that lists the total number of suspect meningitis cases for each district (Table 1). For each district, also include the under 5 year old population and calculate the district-specific hospitalization rate for suspect meningitis (the number of cases in the district divided by the under 5 year old population multiplied by 100,000).
- 3) Sort/organize the table so that the districts are listed in order from those with the largest number of suspect cases to those with the smallest number of suspect cases.
- 4) Identify districts that comprise the geographical catchment area. The geographical catchment area is made up of the districts where the closest to 80% of suspect cases reside. Use judgment. It is more than likely that the cumulative percentage will not be exactly 80%, and cases may be spread across several districts. These districts form the provisional geographical catchment area where the 'at risk' denominator population of children <5 years of age reside. In Table 1, the example shows these are districts A, B, and C.

Table 1 displays the data collected at the sentinel hospital in the fictitious country of the Federal Republic of Ficticia. The districts in the table have been arranged in descending order by the total number of suspect meningitis cases for each district. The red box indicates the initial provisional geographical catchment area, which has been determined to include *approximately 80%* of the total number of suspect meningitis cases in children <5 years of age.

Table 1 : Example of the relevant data regarding suspect meningitis cases among children age <5 years admitted to the sentinel hospital by district of residence, Federal Republic of Ficticia, 2010-2011.

Name of district of residence	Total number (%) of suspect meningitis cases	Cumulative % of suspect meningitis cases	<5 years of age population	Hospitalization rate for suspect meningitis in children <5 years of age from within the district / 100,000
District A	42 (39.6)	39.6	70,000	60.0
District B	31 (29.3)	68.9	45,000	68.9
District C	14 (13.2)	82.1	15,000	93.3
District D	14 (13.2)	95.3	55,000	25.5
District E	3 (2.8)	98.1	35,000	8.6
District F	2 (1.9)	100.0	43,000	4.7
Total	106 (100.0)	100.0	263,000	

Districts A, B and C comprise the provisional geographical catchment area for this sentinel hospital

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- 5) On the map, outline the boundaries of the districts that comprise the provisional geographical catchment area where the ‘at risk’ denominator population of children <5 years of age reside and critically examine that area, as shown in Figure 2. In some countries, certain remote districts may be included with a high number of admitted suspect meningitis cases due to ease of access to the sentinel hospital (e.g. existence of a direct train connection combined with a good reputation of the sentinel hospital).
 - 6) Critically assess the defined provisional geographical catchment area and determine if there are other mitigating factors that would logically require a slight modification of the provisional geographical catchment area to include or exclude districts. Such mitigating factors can include the district-specific hospitalization rate for suspect meningitis, expert views, and trends on the spot map. For example, in Table 1, a mitigating factor to not include District D, although it contains the same number of suspect meningitis cases as District C, is the much smaller district-specific hospitalization rate for suspect meningitis in children <5 years of age in District D as compared to District C.

In deciding which districts to include in the final geographical catchment area for the sentinel hospital consider factors such as the hospitalization rate/100,000 for each district, expert opinion and trends on the spot map. It is unlikely that the final geographical catchment area will contain exactly 80% of suspect meningitis cases.

Figure 2 is a spot map showing all districts where suspect meningitis cases in children <5 years of age reside and who have been admitted to the sentinel hospital. Figure 2 shows the final geographical catchment area outlined in red, having completed the actions in Figure 3.

Figure 2. Example spot map showing the district of residence for each suspect meningitis case admitted to the sentinel hospital in Federal Republic of Ficticia, 2010-2011 and showing the determined geographical catchment area

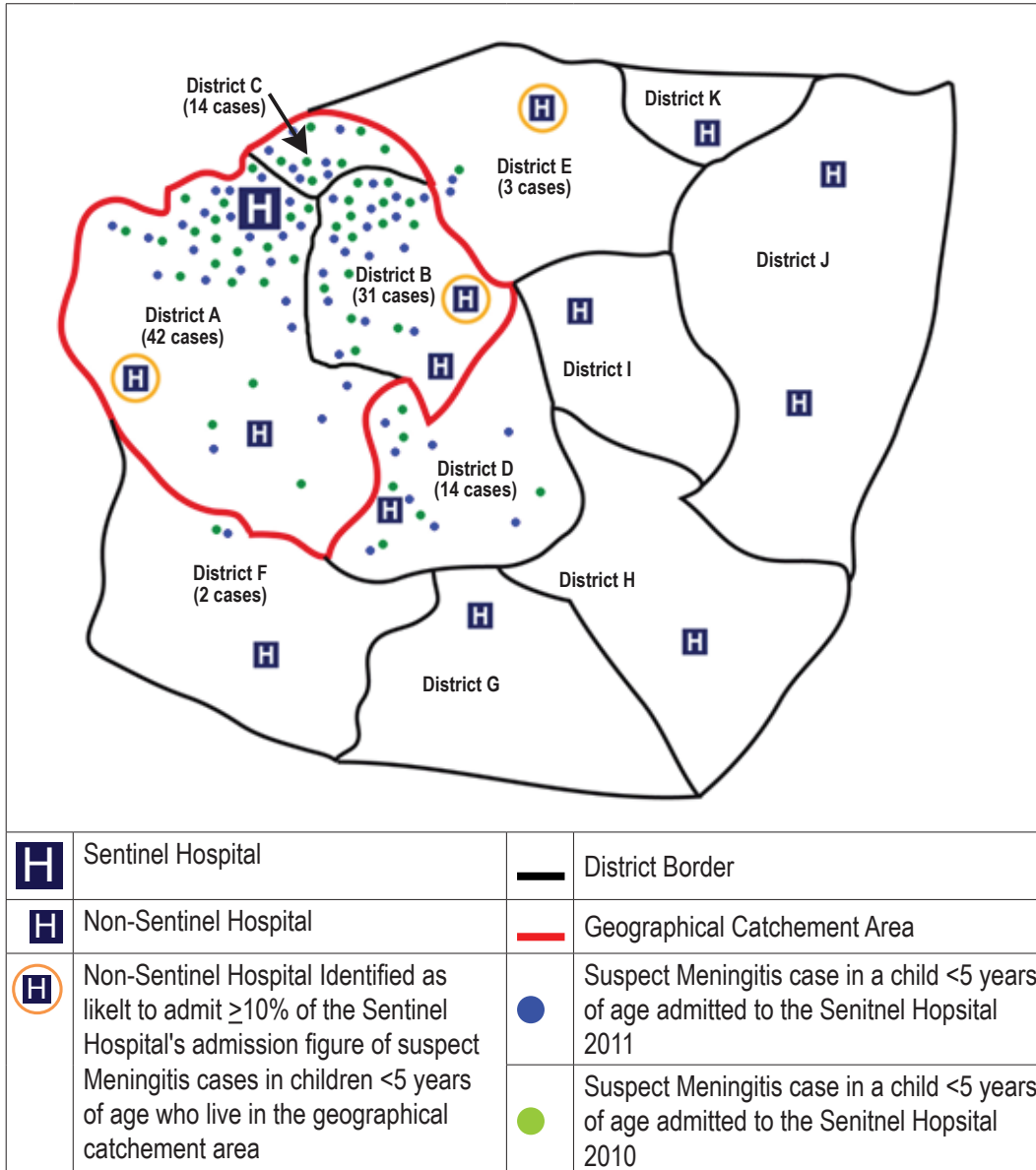


Figure 3. The key actions involved in determining the numerator and geographical catchment area

Action 1.

Develop a table by using the collected data. The table should list districts in descending order by the frequency of the number of suspect meningitis cases residing in the district. Calculate the percentage (%) of suspect meningitis cases residing in each district. Data from Figure 2 (page 14) and Table 1 (page 12).

District of residence	Total number of suspect meningitis cases in children of age <5 years (%)
District A	42 (39.6)
District B	31 (29.3)
District C	14 (13.2)
District D	14 (13.2)
District E	3 (2.8)
District F	2 (1.9)
Total	106 (100.0)

Action 2.

Add a column and include the under 5 years of age population for each district. Add another column and calculate the district-specific rate of hospitalizations (the number of suspect cases in the district divided by the under 5 year old population multiplied by 100,000).

District of residence	Total number of suspect meningitis cases in children of age <5 years (%)	< 5 years of age population	Annual hospitalisation rate for meningitis in children <5 years of age from within the geographical catchment area /100,00
District A	42 (39.6)	70,000	60
District B	31 (29.3)	45,000	68.9
District C	14 (13.2)	15,000	93.3
District D	14 (13.2)	55,000	25.5
District E	3 (2.8)	35,000	8.6
District F	2 (1.9)	43,000	4.7
Total	106 (100.0)	263,000	

Action 3.

Add a column and include the **cumulative percentage** of suspect meningitis cases by district. Identify the top districts where approximately 80% of cases reside in order to determine the provisional geographical catchment area.

District of residence	Total number of suspect meningitis cases in children of age <5 years (%)	Cumulative % of suspect meningitis cases	< 5 years of age population	Annual hospitalisation rate for meningitis in children <5 years of age from within the geographical catchment area /100,00
District A	42 (39.6)	39.6	70,000	60
District B	31 (29.3)	68.9	45,000	68.9
District C	14 (13.2)	82.1	15,000	93.3
District D	14 (13.2)	95.2	55,000	25.5
District E	3 (2.8)	98.1	35,000	8.6
District F	2 (1.9)	100.0	43,000	4.7
Total	106 (100.0)	100.0	263,000	

Action 4.

Determine the final geographical catchment area by considering other factors such as:

- District rate of suspect meningitis hospitalization per 100,000
- Expert/MoH opinion
- Trends on the spot map
- Anomalies in the data

In this exercise, **the final geographical catchment area = District A, District B and District C.** District D is excluded due to the much lower district specific rate of suspect meningitis admissions.

The **numerator** for the rate calculation is the total number of suspect meningitis cases in children <5 years of age admitted to the sentinel hospital from the districts comprising the final geographical catchment area (42+31+14=**87**).

Step 3: Summary of Key Points:

- 1) Spot map the cases.
- 2) Using the data of suspect meningitis cases in children <5 years of age admitted to the sentinel hospital that has been created, categorize cases by district of residence and then sort by the number of cases in each district in descending order.
- 3) Identify the districts where the closest to approximately *80% of cases are residents* to determine the *provisional geographical catchment area*.
- 4) Re-evaluate the provisional geographical catchment area using other considerations such as the district-specific rate of suspect meningitis hospitalization in children <5 years of age per 100,000, trends on the spot map, and expert/MoH opinion.
- 5) Outline those districts that comprise the *final geographical catchment area of the sentinel hospital* on the spot map.
- 6) The **numerator** is the number of suspect meningitis cases <5 years of age admitted to the sentinel hospital residing within the final geographical catchment area during the data collection period. In the example from this exercise, this totals 87.

Provisional geographical catchment area of the sentinel hospital:

The administrative area(s) where approximately 80% of suspect meningitis cases admitted to the sentinel hospital reside.

Final geographical catchment area of the sentinel hospital:

Revision to the provisional geographical catchment area by inclusion or exclusion of administrative areas based on expert advice, if needed. This ultimately determines the numerator for the rate calculation.

Numerator:

The number of suspect meningitis cases <5 years of age at the sentinel hospital residing within the final geographical catchment area. In the example from this exercise, this totals 87.

Step 4: Determining whether other hospitals (non-sentinel) are involved in further calculations and, if so, collecting data from those non-sentinel hospitals

- 1) For all the hospitals considered, both sentinel and non-sentinel, the critical data will be information on admissions for suspect meningitis among children <5 years of age who reside in the geographical catchment area of the sentinel hospital. **For the further calculations, only children who reside in the final geographical catchment area will be included.** In the exercise described in this field guide, this is Districts A, B, and C.
- 2) The next step is to consider the health care utilization practices of children <5 years of age who reside in the final geographical catchment area. It should be determined to which hospitals, other than the sentinel hospital, children residing in the geographical catchment area will be taken if they develop signs and symptoms of meningitis. Such a hospital may lie outside the geographical catchment area, but children may be taken to that hospital if it is, for example, well known in the community as a hospital providing high quality care.
- 3) Using the list of the districts that comprise the final geographical catchment area and the spot map, identify these relevant non-sentinel hospitals by seeking the advice of experts such as MoH/WHO, sentinel hospital administrators, and pediatricians. Ask which other hospitals are likely to admit $\geq 10\%$ of the sentinel hospital's admission figure of suspect meningitis cases during the same time period as the data abstraction in children <5 years of age who live in the geographical catchment area. In some cases, these non-sentinel hospitals that serve children in the geographical catchment area could be located outside the final geographical catchment area. If so, they should be identified. These hospitals will not change the geographical catchment area nor the numerator but will have an effect on the denominator calculations, as later explained in Step 5, section b, page 19.
 - a) **If there are no (zero) non-sentinel hospitals identified, Go to Step 5 and use only the data from the sentinel hospital and the already available data on the number of children <5 years of age who reside in the geographical catchment area.**
 - b) **If any non-sentinel hospitals are identified as likely to admit $\geq 10\%$ of the sentinel hospital's admission figure of suspect meningitis cases in children <5 years of age who live in the geographical catchment area during the same time period (as determined in Step 2, page 10), then continue completing this step. This will entail repeating the same data collection process as for the sentinel hospital in each of the other identified non-sentinel hospitals. However, only collect information on children <5 years of age admitted with suspected meningitis who live in the final geographical catchment area. Refer to Table 2 for more details.**

The final geographical catchment area is where the affected population of children ('at risk' denominator population) lives. Some of these children may travel outside of this area to receive medical attention.

Non-sentinel hospitals should be identified that are likely to admit > 10% of the sentinel hospital's admission figure of suspect meningitis cases in children <5 years of age who live in the geographical catchment area during the time period of this data collection (as determined in Step 2, page 10). These hospitals may be located within the geographical catchment area or just outside that area.

Table 2. Data collection process for non-sentinel hospital(s) that are likely to admit $\geq 10\%$ of the sentinel hospital's admission figure of suspect meningitis cases in children <5 years of age who live in the geographical catchment area during the same time period.

Involved Hospitals	Actions to Take
If there are non-sentinel hospitals identified	Continue to Step 5, section a, page 19
Non-sentinel hospitals identified	<p>Visit the hospitals, and collect the same information for the same time period as for the sentinel hospital on the number of admissions for suspect meningitis cases. Information is needed only for the cases that reside in the final geographical catchment area.</p> <ul style="list-style-type: none"> • Cross-reference the line list from the non-sentinel hospital with the line list of the sentinel hospital to ensure that there has not been double counting of children who are referred. • Delete any duplicates from the records obtained at the non-sentinel hospital, only counting these children at the sentinel hospital. • End result: Information on the number of suspect meningitis cases <5 years of age admitted to non-sentinel hospitals and residing in the final geographical catchment area of the sentinel hospital

Step 4: Summary of Key Points:

- 1) Consult with MoH/WHO, sentinel hospital staff and pediatricians to identify other health care facilities that are likely to admit $\geq 10\%$ of the sentinel hospital's admission figure of suspect meningitis cases in children <5 years of age who live in the geographical catchment area during the same time period. These other health care facilities may be located both within and outside the geographical catchment area.
 - a) If there are no such hospitals, continue to Step 5, section a, page 19
 - b) If there are any such hospitals identified, complete Step 4. Visit these hospitals and repeat the data collection process completed at the sentinel hospital.

Step 5: Calculate the final denominator for the time period of the exercise and the estimated annual rate of hospitalizations for children <5 years of age with suspected meningitis residing in the final geographical catchment area of the sentinel hospital

At this point, the following have been determined:

- The final geographical catchment area of the sentinel hospital for suspect meningitis admissions among children < 5 years of age
- The numerator for the rate calculations. This is the number of children admitted to the sentinel hospital with suspect meningitis who reside in the geographical catchment area
- The number of other non-sentinel hospitals, if any, that admit $\geq 10\%$ of the sentinel hospital's admission figure of suspect meningitis cases in children <5 years of age who live in the geographical catchment area during the same time period of this data collection.

The method of calculating the rate of hospitalizations for suspect meningitis will differ based on:

- a) If only the sentinel hospital is involved. In this case, follow the instructions in 'A' below.
- b) If non-sentinel hospitals are identified. In this case, follow the instructions in 'B' below.

Situation A: If only the sentinel hospital is involved (i.e. there are no other hospitals that admit $\geq 10\%$ of the sentinel hospital's admission figure of suspect meningitis cases in children <5 years of age who live in the geographical catchment area during the same time period of this data collection) then use only the data from the sentinel hospital.

Numerator: number of children <5 years of age admitted to sentinel hospital with suspect meningitis residing in final geographical catchment area of the sentinel hospital

Denominator:

- If only the sentinel hospital is involved, then there is no need to adjust the denominator to take into account the impact of other hospitals. Thus, in this case, the denominator is the number of children <5 years of age residing in the final geographical catchment area as determined in Step 3, page 12.
- **Time period:** The time period used for the numerator and denominator calculations should be the same. Multiply the catchment population (denominator) by the number of years of meningitis data that have been used. For example, if suspect meningitis case data is used for 2 years from 2010-2011, then the catchment population number should be multiplied by 2. This is the **final denominator**.
 - In the example provided, this is $130,000 \times 2 = 260,000$. (See Table 3.)

Rate:

- Divide the total number of cases of suspect meningitis admitted to the sentinel hospital among children residing in the geographical catchment area by the final denominator obtained above.
 - In the example provided, this is $87 / 260,000 = 0.0003346$
- Multiple by 100,000 to **estimated annual sentinel hospital rate of suspect meningitis hospitalizations per 100,000 children <5 years of age within the final geographical catchment area.**
 - In the example provided, this is: $0.0003346 \times 100,000 = 33.46$

Now go to Step 6, page 24 to calculate the 95% confidence interval for this rate.

Situation B: If non-sentinel hospitals are identified: In this situation, children <5 years of age residing in the geographical catchment area may be admitted to either the sentinel hospital or non-sentinel hospitals if developing signs and symptoms of meningitis. To determine the rate of hospitalizations for suspect meningitis among children <5 years of age for the sentinel hospital, it must be estimated how many children residing in the geographical catchment area would be taken to the sentinel hospital (and not one of the other hospitals) if developing meningitis. This is done by decreasing the administrative numbers of children <5 years of age (from census data or other sources) residing in the geographical catchment area based on meningitis admissions to the other non-sentinel hospitals.

Denominator:

Impact of admissions to other hospitals: There are other hospitals either inside or outside of the geographical catchment area that receive significant numbers of admissions of children <5 years of age with suspect meningitis residing in the geographical catchment area. Thus, the denominator must be proportionally decreased by adjusting downwards the number of children <5 years of age from the government/census figures in the final geographical catchment area. Table 3 shows an example of the calculations.

Table 3: Example of the relevant data regarding suspect meningitis cases among children age <5 years admitted to the sentinel hospital and non-sentinel hospitals by district of residence, Federal Republic of Ficticia, 2010-2011

District Name	Sentinel Hospital	Total Population of Children Aged < 5 Years in District	Other hospitals that admit $\geq 10\%$ of the sentinel hospital's admission figure of suspect meningitis cases in children <5 years of age who live in the geographical catchment area during the same time period of this data collection		
	Total Number (%) of Admitted Suspect Meningitis Cases in Children <5 Years of Age		Hospital 1 Total Number (%) of Admitted Suspect Meningitis Cases in Children <5 Years of Age	Hospital 2 Total Number (%) of Admitted Suspect Meningitis Cases in Children <5 Years of Age	Hospital 3 Total Number (%) of Admitted Suspect Meningitis Cases in Children <5 Years of Age
District A	42 (39.6%)	70,000	15	4	0
District B	31 (29.3%)	45,000	3	22	5
District C	14 (13.2%)	15,000	2	0	22
Geographical Catchment Area Total	87	130,000	20	26	27
Districts A, B, and C comprise the geographical catchment area	X = Total number of children < 5 years admitted to the sentinel hospital with suspect meningitis and residing in final geographical catchment area: 87	Y = Total population of children < 5 years in final geographical catchment area: 130,000	Z = The sum of hospitalized suspect meningitis cases in non-sentinel hospitals (20 + 26 + 27 = 73 as shown above)		

$\frac{X}{X + Z}$ Calculation of the denominator population of children <5 years of age multiplied by **Y** = adjusted catchment population

In these calculations:

- **X** : the number of children <5 years of age who reside in the final geographical catchment area and are admitted to the sentinel hospital with suspected meningitis during the data collection time period (in this example X=87.)
- **Y** : the total population of children <5 years of age residing in the final geographical catchment area (in this example Y = 130,000 children under the age of 5 years residing in District A, B and C).

-
- If there are other hospitals either inside or outside the final geographical catchment area likely to admit $\geq 10\%$ of the sentinel hospital's admission figure of suspect meningitis cases in children <5 years of age who live in the geographical catchment area during the same time period of this data collection, then **Z** is the number of children admitted during the data collection time period in these hospitals. (In this exercise, Z = the 73 children admitted to Hospitals 1, 2, and 3 who reside in districts A, B, and C)

An example is provided in Table 3, this is: $87 / (87+20+26+27) \times 130,000 = 70,688$

Thus, the adjusted denominator catchment population of children residing in the final geographical area is 70,688.

When calculating the estimated annual sentinel hospital rate of suspect meningitis hospitalizations for children residing in the final geographical catchment area, remember to use only the suspect meningitis cases that reside within the final geographical catchment area. Do not use all the meningitis cases admitted to the sentinel hospital.

- **Time period:** The time period used for the numerator and denominator calculations must be the same. Multiply the adjusted catchment population (denominator) by the number of years of meningitis data that have been used. For example, if suspect meningitis case data is used for 2 years from 2010-2011, then the adjusted catchment population number should be multiplied by 2. This is the *final denominator for the rate calculation*.
 - Therefore, in this example: $70,688 \times 2 = 141,376$.

Numerator: number of children <5 years of age admitted to sentinel hospital with suspect meningitis residing in final geographical catchment area of the sentinel hospital

Rate:

Divide the total number of suspect meningitis cases in children <5 years of age admitted to the sentinel hospital and residing in the final geographical catchment area by the denominator obtained above.

In this example: $87 / 141,376 = 0.00061538$

- Multiply by 100,000 to obtain **estimated annual sentinel hospital rate of suspect meningitis hospitalizations per 100,000 children <5 years of age within the final geographical catchment area..**
 - In this example: $0.00061538 \times 100,000 = 61.538$

Go to Step 6, page 24 to calculate the 95% confidence interval for this rate.

Step 5: Summary of Key Points:

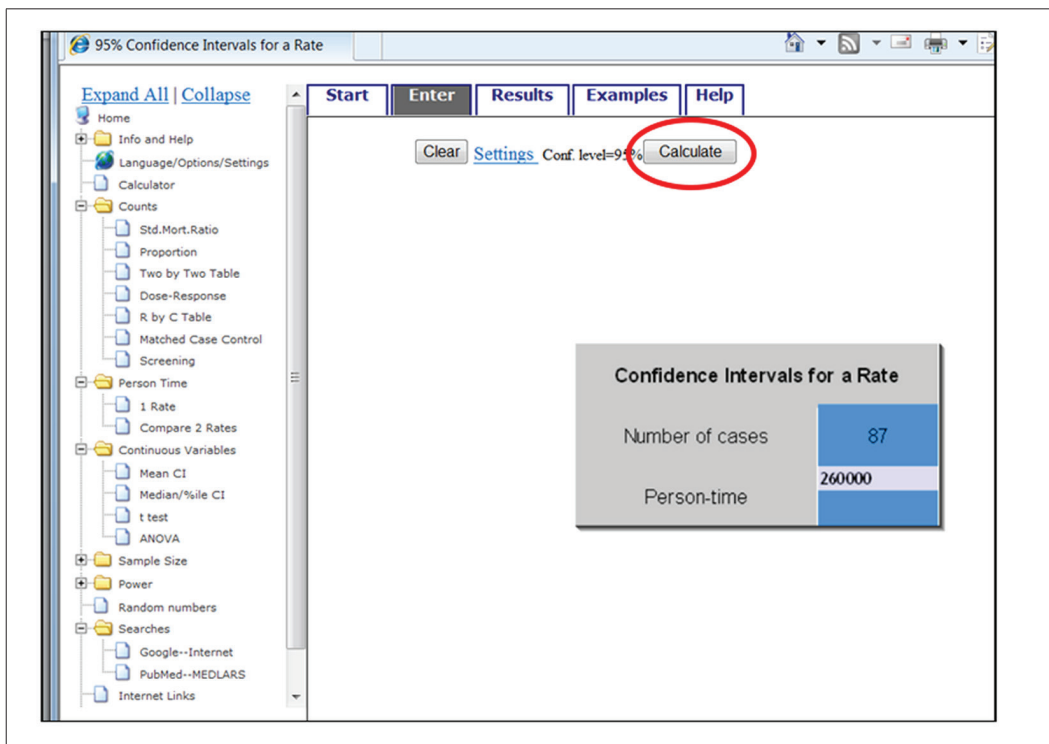
- 1) Calculate the denominator
 - Option 1: **Only the sentinel hospital** is likely to admit significant numbers of children <5 years of age who reside within the geographical catchment area and who develop signs and symptoms of meningitis.
 - The denominator is the number of children <5 years of age residing in the geographical catchment area.
 - Option 2: In the situation where **non-sentinel hospitals** are likely to admit \geq 10% of the sentinel hospital's admission figure of suspect meningitis cases in children <5 years of age who live in the geographical catchment area during the same time period of this data collection
- 2) Calculate the estimated annual sentinel hospital rate of suspect meningitis hospitalizations per 100,000 children <5 years of age within the final geographical catchment area

Step 6: Calculate the 95% confidence interval for the estimated annual rate of hospitalizations for children <5 years of age with suspect meningitis residing in the geographical catchment area of the sentinel hospital

The ‘true’ rate in the geographical catchment area population is likely to differ from what has been estimated via this exercise simply due to chance. However, an uncertainty range can be put around the calculated rate in which there is 95% confidence that the ‘true’ rate falls. This range is referred to as the 95% confidence interval. To calculate the 95% confidence interval, many open source websites can be used including <http://openepi.com/v37/PersonTime1/PersonTime1.htm>

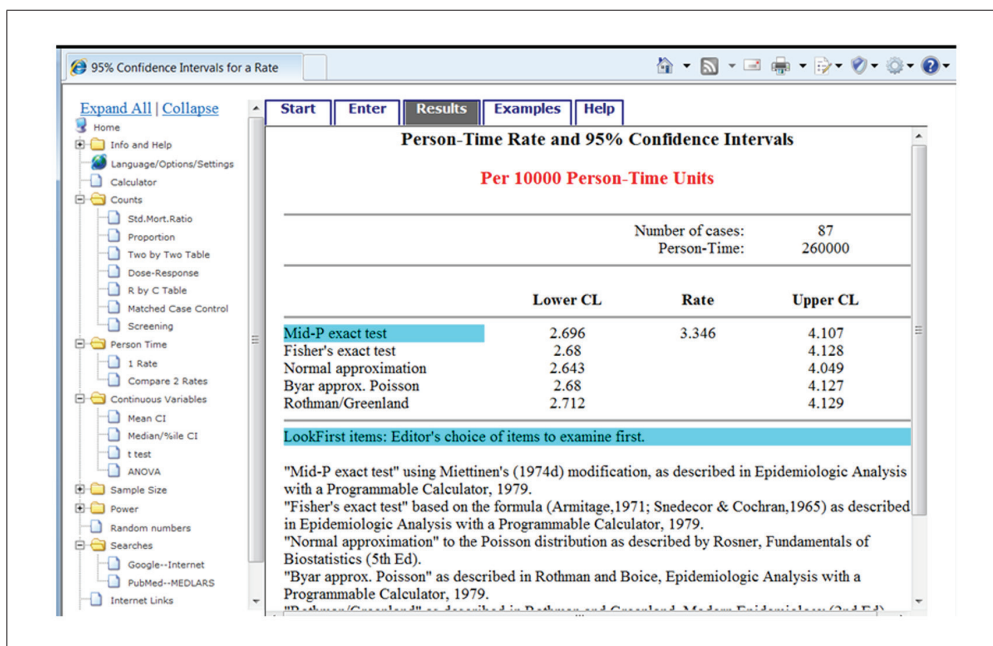
Below are examples using the website for the situations where

- 1) only the sentinel hospital is the only hospital involved
- 2) where there are other (non-sentinel) hospitals involved.
- 3) **If only the sentinel hospital is involved** (i.e. there are no other hospitals that receive significant numbers of meningitis admissions among children residing in the geographical catchment area)



In the above example, the data reflects:

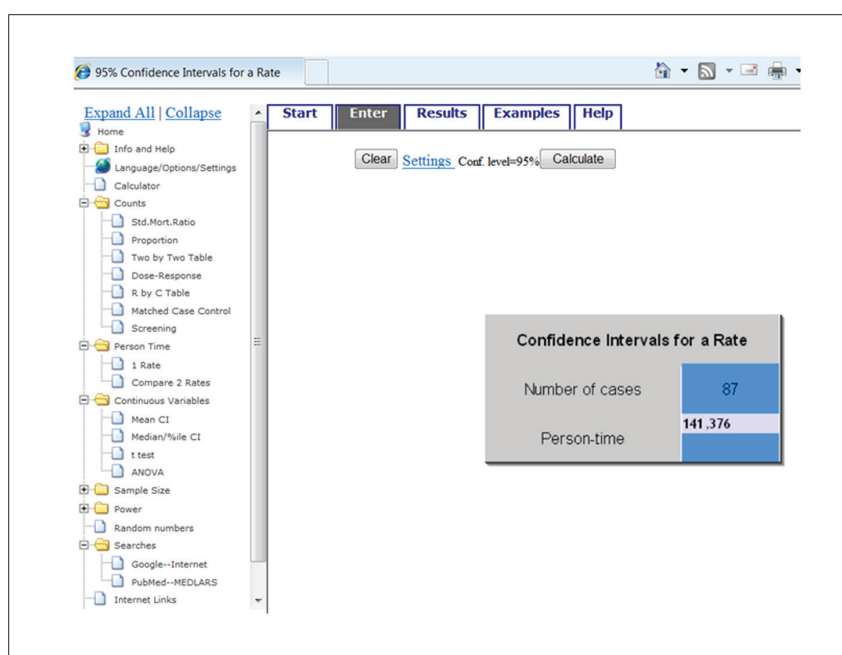
- **Number of cases:** There were 87 children <5 years of age admitted to the sentinel hospital with suspected meningitis who resided in the defined geographic catchment area.
- **Person-time:** This is the denominator, which in this example was determined to be 260,000 children <5 years of age.
- **Click “Calculate”**



The rate obtained is expressed per 10,000 persons. For the purpose of this exercise, multiply by 10 to obtain a rate per 100,000 persons.

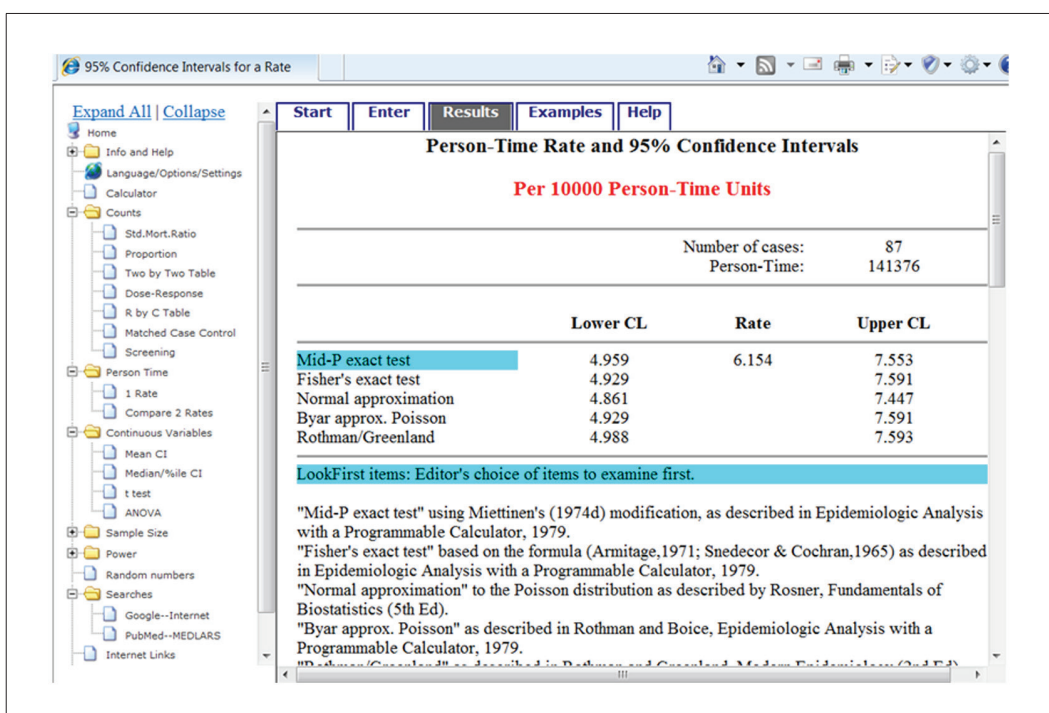
In this example, the estimated annual sentinel hospital rate with 95% confidence level of suspect meningitis hospitalizations per 100,000 children <5 years of age within the final geographical catchment area is 33.5 (27.0 – 41.1).

- a) **If other hospitals (non-sentinel)** admit significant numbers of meningitis cases that occur among children <5 years of age residing in the geographical catchment area



In the above example, the data reflects:

- **Number of cases:** There were 87 children <5 years of age admitted to the sentinel hospital with suspected meningitis who resided in the defined geographic catchment area.
- **Person-time:** This is the final denominator, which in this example was determined to be 141,376 children <5 years of age.
- Click “Calculate”

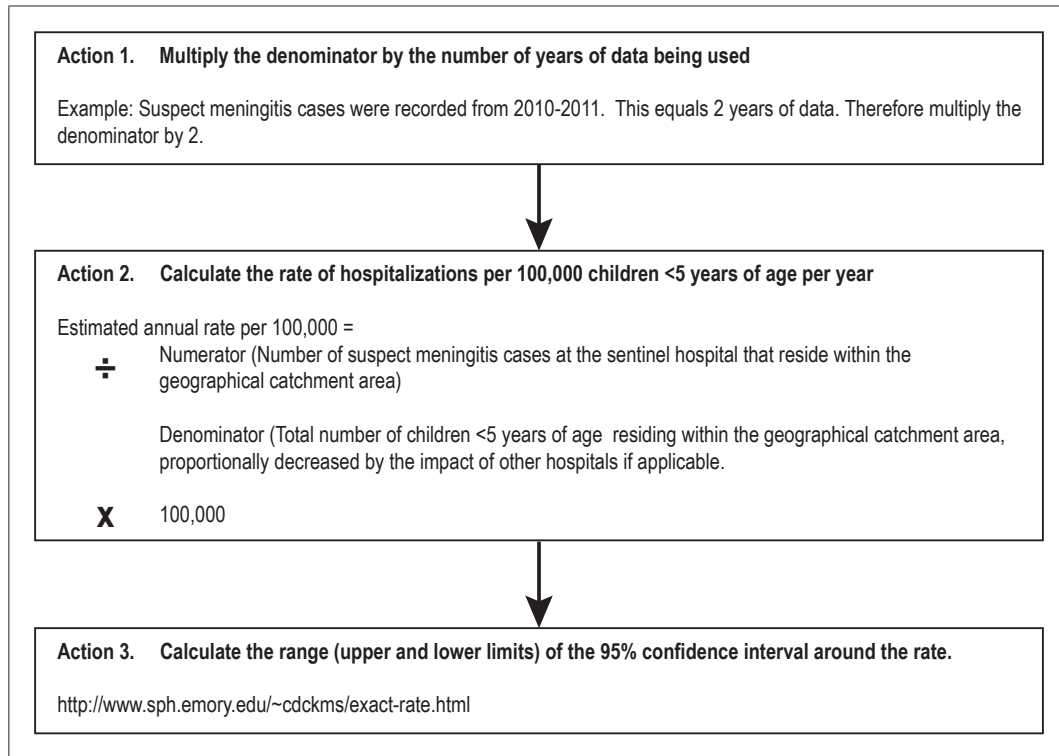


The rate obtained is expressed per 10,000 persons. For the purpose of this exercise, multiple by 10 to obtain a rate per 100,000 persons.

Thus, in this example, the estimated annual sentinel hospital rate with 95% confidence level of suspect meningitis hospitalizations per 100,000 children <5 years of age within the final geographical catchment area is 61.5 (49.6 – 75.5).

Figure 4. displays sequentially the calculations and process required to calculate the denominator for the sentinel hospital, and the estimated annual sentinel hospital rate with 95% confidence level of suspect meningitis hospitalizations per 100,000 children <5 years of age within the final geographical catchment area.

Figure 4: Calculation of the Estimated Annual Rate for the Sentinel Hospital of Admissions of Suspect Meningitis per 100,000 Children <5 Years of Age within the Final Geographical Catchment Area with a 95% Confidence Interval



Step 6: Summary of Key Points:

- 2) Calculate the 95% confidence interval around the estimated annual sentinel hospital rate of suspect meningitis hospitalizations per 100,000 children <5 years of age within the final geographical area. Many open source websites can be used including: <http://openepi.com/v37/PersonTime1/PersonTime1.htm>

Using this exercise to improve IB-VPD surveillance

This exercise is useful to improve IB-VPD surveillance at the sentinel hospital because:

- A better understanding is gained of surveillance practices at the hospital as well as the population of children served by the hospital; and
- The reported line list of cases is compared with the cases found through reviewing the hospital log books. It is likely that some missed cases may be identified as well as other gaps in the surveillance system. Discussions at the sentinel hospital can help to problem solve methodologies to rectify these gaps.

Interpreting the results

These results should be interpreted cautiously. Important factors to note when interpreting the results include:

- 1) Seek to identify any factors that might bias results and lead to a false conclusion. For example, there are sources of systematic error that are not due to chance that can cause a false estimated rate in the population. These types of errors include confounding, measurement errors, and selection bias. For example, parents of children admitted with suspect meningitis may give false addresses in the belief it will give them an advantage within the healthcare system. This is likely to lead to a false increase in the numerator in some districts and a false decrease in others. This type of error could not be accounted for by calculating 95% confidence intervals.

The 95% confidence interval accounts only for random sampling variation and does not account for misclassification errors and other biases. If these exist, the true uncertainty in the estimated rate is greater than what can be expressed in a standard 95% confidence interval.

- This rate is *not the incidence rate* of suspect meningitis in children <5 years of age residing in geographical catchment area. Rather, it is the *rate of hospitalizations* for suspect meningitis among children <5 years of age residing in the geographical catchment area of the sentinel hospital. An incidence rate would seek to include all children <5 years of age developing signs and symptoms of suspect meningitis, regardless of whether or not they were admitted to the sentinel hospital.
- Since most cases of meningitis are treated as inpatients, with admissions generally limited to a small number of health facilities with capacity to care for severe illness, this methodology may also estimate meningitis disease incidence. However, the hospitalization rate may under- or over-estimate true meningitis incidence rates because children with meningitis may die at home, may be misdiagnosed on admission or diagnosed differently at sentinel versus non-sentinel hospitals. Thus, rates derived using this method should be cautiously interpreted; in developing countries with poor population access to health care, children with meningitis may not reach a health care facility and thus the rate may underestimate disease. Alternatively, the clinical case definition that is used may result in including viral meningitis or encephalitis, in which case the rate may be an over-estimate. Additionally, epidemics of disease that occurred during this time period may also result in over-estimating the result. Thus, local clinical knowledge will be required to help interpret the rate.

-
- In sentinel hospitals with reliable and consistent laboratory diagnostic practices, the estimated denominator can be used to determine rates for probable bacterial meningitis as well as laboratory-confirmed Hib or pneumococcal meningitis among children <5 years of age.
 - The calculated rate and 95% confidence interval is specific for the sentinel hospital, and it should not be assumed that other hospitals would have a similar rate.
 - Once the rate is calculated, it is important to conduct a ‘reality check’ by comparing this rate and 95% confidence interval to what might be expected based upon data provided from the literature. Country specific information on the numbers of expected cases of etiology-specific meningitis in children <5 years of age due to Spn and Hi can be found at http://www.who.int/immunization_monitoring/burden/Pneumo_hib_estimates/en/index2.html.
 - Sentinel hospitals need to maintain consistent practices including case-identification, specimen collection, and laboratory practices among a stable at-risk population of children in order to monitor trends over time.

**Now use the worksheet in Annex 1, page 30 to estimate the denominator
for your sentinel hospital**

Annex 1:

Worksheet for Calculations

Step 1: (See page 7): Information gathering before arriving to sentinel hospital

- Gather as much information as possible before arriving at the sentinel hospital
- If the information is unavailable prior to arrival, then collect all data while at the sentinel hospital

Step 2: (See page 10): Data collection at the sentinel hospital

What is the time period of the data collection? :

(Write the relevant years above)

How many suspect meningitis cases in children <5 years of age were admitted at the sentinel hospital during this time period?

(Write the number of cases admitted at sentinel hospital above)

Step 3: (See page 12): Spot mapping and determining the geographical catchment area for the sentinel hospital and the numerator used in the rate calculations

Determine the geographical catchment area of the sentinel hospital, and subsequently determine the numerator for the rate calculations

Which administrative areas (usually districts) comprise the final geographical catchment area?

The geographical catchment area is made up of the districts where the closest to 80% of suspect cases reside. These districts comprise the geographical catchment area.

Write the relevant district/s

Write the number of suspect meningitis cases in children aged < 5 years who reside in this district/s

Write the relevant district/s

Write the number of suspect meningitis cases in children aged < 5 years who reside in this district/s

Write the relevant district/s

Write the number of suspect meningitis cases in children aged < 5 years who reside in this district/s

What is the total number of suspect meningitis cases admitted to the sentinel hospital during the data collection period in Step 2 that reside in those districts? (This is the **numerator.)**

- a) -----
Write the **total** number of suspect meningitis cases admitted at the sentinel hospital who live in the geographical catchment area

What is the total population of children under 5 years of age that live in the geographical catchment area?

- b) -----
Write the total number of children <5 years of age who live in the districts comprising the geographical catchment area. This data is usually obtained from census information. However, if this data is not available from the census, seek other sources.

Step 4: (See page 17): Determine whether other (non-sentinel) hospitals are involved in further calculations

- Other hospitals (non-sentinel) that are involved in this exercise may or may not be located in the geographical catchment area, but are likely to admit $\geq 10\%$ of the sentinel hospital's admissions figure of suspect meningitis cases among children <5 years of age residing in the geographical catchment area

Are the following criteria met for any other (non-sentinel) hospitals:

- Likely to admit $\geq 10\%$ of the sentinel hospital's admission figure of suspect meningitis cases in children <5 years of age who live in the geographical catchment area during the same time period (as determined in Step 2)
- These non-sentinel hospitals may actually be located outside the geographical catchment area, but should be considered if they are likely to admit children residing in the geographical catchment area.

No, Go to Step 5

Yes, Complete Step 4 Visit the hospitals and collect data using the same methodology as at the sentinel hospital. Only use data of <5 year olds with suspect meningitis residing in the geographical catchment area to adjust the denominator downwards.

Write the total number of suspect meningitis cases in children ≤ 5 years of age admitted at the non-sentinel hospitals who live in the final geographical catchment area

Step 5: (See page 19): Calculate the denominator for the time period of the exercise and estimated annual rate of hospitalizations for children <5 years of age with suspect meningitis residing in the geographical catchment area of the sentinel hospital

If no other hospitals (non-sentinel) are involved:

- **Numerator** = the number of children < 5 years of age with suspect meningitis who reside in the geographical catchment area that were admitted to the sentinel hospital during the data collection period (obtained from step 3a above)

Write the number from Step 3a above

- **Denominator** = multiple the total number of children < 5 years of age who reside in the geographical catchment area (obtained from step 3b above) by the number of years of data collection (obtained from step 2 above)

Write the number from Step 3b multiplied by the number of years

- **Annual rate of admissions for suspect meningitis at the sentinel hospital** = numerator divided by the denominator multiplied by 100,000

Write the rate

If other hospitals (non-sentinel) are involved:

- **Numerator** = the number of children < 5 years of age with suspect meningitis who reside in the geographical catchment area that were **admitted to the sentinel hospital** during the data collection period (obtained from step 3a above)

Write the number from Step 3a above

- **Denominator =**
 - Begin with the numerator from above.

Write the number from Step 3a above (again)
 - Then, divide the numerator by the total number of children with suspect meningitis identified in all the hospitals, including the sentinel hospital

Numerator divided by the total number of suspect meningitis cases in children < 5 years of age who reside in the geographical catchment area **admitted to all hospitals in this exercise** (sentinel plus non-sentinel)
 - Next, write the total number of total children < 5 years of age who reside in the geographical catchment area (obtained from step 3b above)

Write the number from Step 3b above
 - Then, multiple the two above numbers

Write the result
 - Multiple the above number by the number of years of data collection (obtained from step 2 above)

Write the number multiplied by the number of years. **This is the denominator for the rate calculation.**
- **Annual rate of admissions for suspect meningitis at the sentinel hospital** = numerator divided by the denominator multiplied by 100,000

Write the result

Step 6: (See page 24): Calculate the 95% confidence interval for the annual rate of admissions to the sentinel hospital for suspect meningitis in children <5 years of age residing in the geographical catchment area of the sentinel hospital

Calculate the 95% confidence interval for this rate (many open source websites can be used including: <http://openepi.com/v37/PersonTime1/PersonTime1.htm>)

Write the lower and upper 95% confidence intervals

Annex 2: Data Dictionary

Data Field	Description	Example
Name ¹	The full name of the patient	<i>Abdul Aziz</i>
IdentifiedVia	The source of hospital information from where the case was identified	<i>Admission log book Lumbar puncture log book Laboratory log book</i>
Age	The date of birth or the age of the patient when admitted. It is crucial to check that the patient's age is less than 5 years or less than 59 months.	<i>9 months Or 21-July-2012</i>
Date	The date that the patient was first admitted to the hospital in which data is being collected. If the exact date is not available, then the month should be collected. If the month is unknown, the minimum required is the year of admission. If this is not given in the admission record then it may be possible to acquire this information through other means such as the shift date for the logbook	<i>3-Feb-09 Or 2009</i>
Address	The address of residence of the patient. Typically this is just the settlement name.	<i>Village A</i>
District of Residence	The district of residence of the patient.	<i>District B</i>
Provisional Diagnosis	Provisional/admission diagnosis given to the patient at the hospital in which data is being collected.	<i>Meningitis? Cerebral Malaria?</i>
Discharge Diagnosis	Discharge diagnosis given to the patient at the hospital in which data is being collected. Only collected if information is readily available in the reviewed hospital information sources	<i>Meningitis Febrile seizure</i>
Gender	The gender of the patient.	<i>Female</i>
Suspect Duplication	Is there a possibility that this patient record has been entered twice into the database? Has this patient been recorded from two logbooks from within the same hospital, i.e. the admissions book and the pediatric ward book?	<i>No</i>

¹ The name of patient admitted is used purely to identify duplicate entries into the database and this information is deleted after the database has been compiled.

Annex 3: Hospital Data Entry Template

Example

Name*	Identified via**	Age	Date of Admission	Address***	District of Residence	Provisional Diagnosis	Discharge Diagnosis	Gender*	Suspected Duplication?
Abdul Aziz	Admission log book	9 Months	3-Feb-09	Village A	District B	Meningitis? Cerebral Malaria?	Resolved Meningitis	F	No
Pedro Gonzalez	LP log book	23 Months	July-10	El Capo Village	District C	Seizure/suspect meningitis	Unknown	M	No

* Name and gender are included to aid in the cross-referencing of patients between differing data sources, such as the IB VPD line list and the various sentinel hospital data sources. Once this is completed, names should be removed.

** Begin first by reviewing the hospital admission log books, then review the lumbar puncture or other log books. Note from which data source the case was identified.

*** Collect all information related to the residence of the child that is found at the hospital. In some situations, only the name village will be available, additional work will be required following the data abstraction to determine the district where the village is located.

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