



Photo: CDC/ Antibiotic Resistance Coordination and Strategy Unit (2019)

**User Manual: Public Health Laboratory
Impact: *A tool to estimate public health
laboratory contribution to and impact of
Salmonella diagnostic testing***



AUTHORS (alphabetical order by organizational unit):

Leah S. Fischer¹, Seonghye Jeon¹, Emily B. Kahn¹, Gloria J. Kang¹, Martin I. Meltzer¹, Ian D. Plumb², Hilary K. Whitham², Eija Trees³

Centers for Disease Control and Prevention, U.S. Department of Health and Human Services, Atlanta, GA.

¹Health Economics and Modeling Unit (HEMU)/DPEI/NCEZID/CDC

²Division of Foodborne, Waterborne, and Environmental Diseases (DFWED)/NCEZID/CDC

³Association of Public Health Laboratories

SUGGESTED CITATION (alphabetical order):

Fischer LS, Jeon S, Kahn EB, Kang GJ, Meltzer MI, Plumb ID, Trees E, Whitham HK. Public Health Laboratory Impact (Beta test version). User manual: Public Health Laboratory Impact: A tool to estimate public health laboratory contribution to and impact on *Salmonella* diagnostic testing. Centers for Disease Control and Prevention, U.S. Department of Health and Human Services; 2020.

DATE WRITTEN: October 2020

LAST UPDATED:

Acknowledgements

Our sincere gratitude to the Association of Public Health Laboratories partners, Honorata Hanson, Kristy Kubota, Lorelei Kurimski, Kirsten Larson, Shari Shea, Bertina Su, Andrea Wright, and Adom Yusuf for their time, dedication, and consultation on this project.

We would like to thank individuals from the Association of Public Health Laboratories – Member Laboratories who beta-tested the tool and provided invaluable feedback: Christine Bean, David Boxrud, Ryan Jepson, Patty Lewandowski, Michael Pentella, Deborah Severson, and Victor Waddell.

Disclaimers

The estimates generated by the Public Health Laboratory (PHL) Impact tool are intended to illustrate public health labs' contribution to and impact of *Salmonella* diagnostic testing. Results from the tool include estimates of *Salmonella* cases averted, hospitalizations and medical costs averted, which are calculated from data inputs for nontyphoidal *Salmonella* burden, public health laboratory throughput, and costs associated with diagnostic testing. These estimates should not be considered forecasts of what will occur.

The findings and conclusions in this manual and the accompanying tool (PHL Impact Tool) are those of the authors and do not necessarily represent the views of the Centers for Disease Control and Prevention (CDC).

System Requirements

PHL Impact uses the Windows* operating system (Microsoft Windows 2010 or higher) and Excel (Microsoft Office 2013 or higher). Full functionality of PHL Impact only is supported in the desktop version of Microsoft Office for Windows PCs. Some functionality may not be available in Microsoft Office for Macs or in the browser version of Office 365.

NOTE: Upon opening the spreadsheet tool, users *must* click the button at the top of the document to enable macros.

Technical note: Readers are advised not to change the cell reference style from the standard, default A1 style to the R1C1 style as this will cause conflicts with the programming.

*Microsoft Windows and Office are copyrighted products produced by Microsoft Corporation, WA. Use of trade names and commercial sources is for identification only and does not imply endorsement by the U.S. Department of Health and Human Services.

Table of Contents

Acknowledgements.....	1
Disclaimers	1
System Requirements.....	2
Background.....	4
Overview of how to use PHL Impact tool	4
Load, start, and navigation instructions	4
Data input	5
Part 1. Epidemiology	6
Part 2. Medical Costs	7
Part 3. Lab Testing.....	8
Part 4. Lab Costs.....	9
Part 5. Response Activities	10
Part 6. Illustrations of Response Impact (Optional)	11
Epidemiology (Details)	12
Results.....	13
Results – Illustrations of Response Impact	14
References	14
Printing.....	15
Appendix.....	15
Health Outcomes.....	15

Background

Public health laboratories (PHLs) have a role in protecting public health and the environment by performing a range of critical services that include reference testing, diagnostic testing, disease surveillance, and emergency response support. This tool was developed to evaluate PHL system contributions to and impact on nontyphoidal *Salmonella* diagnostic testing at local jurisdiction levels, given the relatively large disease burden associated with outbreaks, cases, and hospitalizations from *Salmonella* infections in the United States. Nontyphoidal *Salmonella* are estimated to cause 1.35 million infections, 26,600 hospitalizations, and 421 deaths each year in the United States, resulting in an estimated \$400 million in direct medical costs when accounting for under-reported and under-diagnosed cases [1]. The tool allows public health decision-makers and funders to estimate the resources needed for *Salmonella* diagnostic testing by PHLs and its impact on outcomes associated with nontyphoidal *Salmonella* such as ER visits, hospitalizations, and deaths.

Overview of how to use PHL Impact tool

The PHL Impact tool's purpose is to help public health laboratory directors and staff estimate public health laboratories' contribution to and impact of *Salmonella* diagnostic testing. To use the tool, the user needs to provide estimates for five categories of data: epidemiology; medical costs; lab testing; lab costs; and outbreak response activities. An optional section of the tool requires users to provide information about one or two selected *Salmonella* outbreaks and associated response activities within the jurisdiction of interest. Specific data requirements are described in detail below under the heading "Data Input."

When all data inputs are entered using jurisdiction-specific data or the tool's default values, the results presented will include a summary of the health and economic impact of laboratory-based surveillance and testing for *Salmonella*, in addition to estimates of *Salmonella* cases averted, hospitalizations and medical costs averted.

NOTE: Users can copy and paste into a report or presentation any of the tables on the Results page.

Load, start, and navigation instructions

Open the PHL Impact spreadsheet and click the box at the top of the document that says, "Enable Macros," or "Enable Content" (depending on version of Excel being used). After enabling macros, click the "Start" button on the cover page to start navigating the tool. If you encounter any issues, contact HEMU@cdc.gov with a subject line [PHL Impact tool inquiry].



Users will click the “Prev” or “Next” buttons located in the upper right corner of each screen to navigate through the tool. Another way to navigate through the tool is by using the tabs at the bottom of the screen.



The call-out icon contains general information about tables for user input data and is located only on the Introduction and Epidemiology pages of the tool.



The question mark icon located throughout the tool contains page-specific definitions and explanations.

Data input

PHL Impact contains six work sheets in which users may enter data: 1. Epidemiology; 2. Medical Costs; 3. Lab Testing; 4. Lab Costs; 5. Response Activities; and 6. Response Illustrations. Data entry cells are marked yellow in each worksheet; these user entry cells are pre-populated with illustrative numbers or suggested default values based on national data. Grey cells contain calculated values and other values that should not be modified.

Note: All user-entered data are saved automatically when exiting the tool. To change any value, simply type over the existing text.

Part 1. Epidemiology

The “Epidemiology” page (screen shot below) contains information related to the burden of *Salmonella* in terms of total number of lab-confirmed, reported cases; hospitalizations; and deaths. On this page, users will specify a jurisdiction, year(s) for the analysis, and value(s) for lab confirmed, reported *Salmonella* cases during the year(s) the user specified for the analysis.

Users can choose to input up to three example years of data to represent low, medium, and high numbers of reported case counts (i.e., to represent year-to-year variability). Users will specify in the yellow cells the years to be included in the analysis.

Alternately, users have the option to enter the reported case count for only one year to reflect an “average” year. If it is not important for users to associate specific years with case counts, users may choose alternative labels (e.g., low, medium/average, and high).

NOTE: The year(s) or label(s) users enter on this page automatically populates on subsequent pages in the tool.

	Low year	Average year	High year
Year(s):	2020	2000	2010
For:	U.S. State		

Reported Cases and Outcomes

last modified: Yesterday at 12:05 PM **Estimated reported *Salmonella* cases** Low (2020) Med (2000) High (2010)

National (for comparison)	21,268	39,385	70,893
U.S. State	400	800	1,200

[Click here to see the national estimates of *Salmonella* cases](#)

Note: Calculated based on the % of health outcomes (Batz et al. 2010). Users may enter in values if data are available.

Total hospitalized in U.S. State	8	15	23
Died	0	0	0

Total non-hospitalized in U.S. State	392	785	1,177
Received medical care	29	58	86

[Click here to edit epidemiologic parameters \(e.g., % hospitalization, % death\)](#)

Default values used to calculate hospitalizations, deaths, receiving medical care are based on USDA Economic Research Service [2] and Batz et al. [3]. If users would like to change the default values for these parameters, click the blue button to navigate to the 'epi parameters' page to enter alternate values. See page 11 for more information about modifying epidemiologic parameters.

This page also contains a table showing estimated *Salmonella* cases, total hospitalizations, deaths, and received medical care adjusted for under-reporting and under-diagnosis. These calculated values are based on user inputs; default values are set to be an under-reporting factor of 1.0 and under-diagnosis factor of 29.1 [1].

Estimated Cases and Outcomes modified for under-reporting and under-diagnosis			
	Low (2020)	Med (2000)	High (2010)
Number of estimated <i>Salmonella</i> cases	11,640	23,280	34,920
Total hospitalized in U.S. State	219	438	656
Died	4	9	13
Total non-hospitalized in U.S. State	11,421	22,842	34,264
Received medical care	838	1,676	2,514

Note: Modified for under-reporting factor of 1.0 and under-diagnosis factor of 29.1

[Click here to edit under-reporting or under-diagnosis factors](#)

If the user would like to alter the default values for under-reporting or under-diagnosis, clicking the text in the blue box (shown in the screen shot) will lead to a page where these values can be edited. After making the desired edits, the tool automatically updates all cells and calculations that contain under-reporting and under-diagnosis factors.

Click on the “Next” button on the worksheet’s upper-right side to move to the next section, Part 2. Medical Costs.

Part 2. Medical Costs

The “Medical Costs” page (screen shot below) contains cost estimates (mean cost per visit or per hospitalization) for four types of medical encounters: physician office visit, emergency room visit; hospital-based outpatient clinic visit; and hospitalization. The table on this page is pre-populated with default values based on U.S. national average costs (2019 USD) and do not include costs associated with productivity loss or premature death [2]. Users can change the default values to reflect a higher or lower mean cost per visit for any or all types of medical encounters.

Health outcome costs (2019 USD)	
	Mean cost per visit
Physician office visit	\$136
Emergency room visit	\$573
Hospital-based outpatient clinic visit	\$659
	Mean cost per hospitalization
Hospitalization (inpatient overnight stays)	\$13,938

NOTE: The values that you or previous users entered will automatically appear. To change these previously entered values, simply type over them. All data entered in the spreadsheet are saved automatically when exiting the tool.

Click the “Next” button on the worksheet’s upper-right side to move to the next section, Part 3. Lab Testing.

Part 3. Lab Testing

The “Lab Testing” worksheet contains three tables for user inputs to quantify throughput, and the volume of specimens and isolates tested broken down by test type. The tables on this page automatically populate the year(s) identified in Part 1. Epidemiology, allowing the user to enter a range of values or an average value for specimen or isolate throughput and testing volume for each lab test listed in the tables. If users would like to include more lab tests for specimens or isolates, each table contains two rows where the user may enter “other” tests.

NOTE: The values users enter in the tables need not be precise; general ballpark estimates of throughput and testing volume are sufficient for generating estimates.

Throughput				
<i>Salmonella</i> testing breakdown		Low (2020)	Med (2000)	High (2010)
Total number of <i>Salmonella</i> specimens received		100	200	500
Specimens tested by the PHL		100	200	500
Specimens sent elsewhere by PHL		0	0	0
Total number of <i>Salmonella</i> isolates received		400	800	1,200
Isolates tested by the PHL		400	800	1,200
Isolates sent elsewhere by PHL		0	0	0
Specimens				
<i>Salmonella</i> specimens tested by the PHL		Low (2020)	Med (2000)	High (2010)
Number of <i>Salmonella</i> specimens tested by PHL		100	200	500
Perform Culture		100	200	500
CIDT		100	200	500
Other: _____				
Other: _____				
Isolates				
<i>Salmonella</i> isolates tested by the PHL		Low (2020)	Med (2000)	High (2010)
Number of <i>Salmonella</i> isolates tested by PHL		400	800	1,200
Conventional Serotyping		0	0	0
Molecular Serotyping		400	800	1,200
Antimicrobial Susceptibility		400	800	1,200
PFGE		400	800	1,200
WGS Lab		400	800	1,200
WGS Data Analysis		400	800	1,200
Other: _____				
Other: _____				

Part 4. Lab Costs

The Lab Costs worksheet contains information about mean costs per specimen and isolate tested using a variety of lab tests. The page is prepopulated with upper and lower cost estimates for each type of lab test included in the tool (grey calls); sources for default cost estimates include peer-reviewed literature, grey literature, and expert opinion [6-11]. The values contained in the yellow cells are the lower estimates for mean lab test and shipping costs. Using these values will result in conservative estimates of lab testing costs (per specimen/isolate) associated with *Salmonella* outbreak(s). If users wish to change the default estimates, users should enter new values in the yellow cells.

Click the “Next” button on the upper-right side of the worksheet to move to the next section, Part 5. Response Activities.

<i>Salmonella</i> Specimen costs			
Mean Cost per Specimen Tested		Lower Estimate	Upper Estimate
Culture	\$68	\$68	\$102
CIDT	\$252	\$252	\$377
Other: _____			
Other: _____			
<i>Salmonella</i> Isolate costs			
Mean Cost per Isolate Tested		Lower Estimate	Upper Estimate
Conventional Serotyping	\$93	\$93	\$140
Molecular Serotyping	\$31	\$31	\$88
Antimicrobial Susceptibility	\$30	\$30	\$45
PFGE	\$94	\$94	\$141
WGS Lab	\$212	\$212	\$318
WGS Data Analysis	\$13	\$13	\$40
Other: _____			
Other: _____			
Shipping costs for specimens and isolates sent elsewhere			
Mean shipping cost per			
Specimens sent elsewhere	\$60		
Isolates sent elsewhere	\$60		

Part 5. Response Activities

The Response Activities worksheet contains a table for user inputs for quantifying outbreak investigations and community outreach activities such as public messaging and product recalls associated with *Salmonella* outbreaks. As in previous worksheets, users are encouraged to enter data for three example years that represent a range of low, average, and high values.

NOTE: We recommend working with the State Epidemiologist to obtain estimates for the number of outbreak investigations and community outreach activities.

Ballpark low, average, and high estimates of the number of response activities in a given year are adequate. It is not necessary to enter precise values in the tool.

<i>Salmonella</i> Outbreak Response Activities in U.S. State			
	Low (2020)	Med (2000)	High (2010)
Number of outbreak investigations	0	0	0
Number of community outreach activities (messaging, recalls, etc)	0	0	0

Part 6. Illustrations of Response Impact (Optional)

The optional Response Impact worksheet allows users to generate up to two illustrations of the impact of *Salmonella* outbreak response activities in the jurisdiction of interest [10]. To generate an illustration, the user will populate four cells that will yield an estimate of the number of ***Salmonella* cases averted** due to product recall. **NOTE:** We recommend working with the state or local health department epidemiologists to identify *Salmonella* outbreaks on which to base the illustration(s) and obtain estimates of the amount of outbreak-related product distributed and discarded in the jurisdiction of interest.

Once the user has identified an outbreak (or two) for the illustration(s), select from the drop-down box the relevant product unit (e.g., case, kg, lbs, pack, unit). Next, populate the yellow cells with values for the amount of outbreak-related product distributed and discarded by retailers. Then, enter the number of *Salmonella* cases attributable to the product. Then the page estimates the number of *Salmonella* cases in a specific foodborne outbreak that is prevented due to response activities.

The derived illustrations of response impact will be based on data from the jurisdiction of interest. Although they will be anecdotal, the illustrations are intended to serve as examples of potential public health impact in terms of cases, hospitalizations, and medical costs that might occur without support from public health laboratories. Please note that the estimated cases averted for a specific outbreak does not take into account other potential outbreak-related impacts such as preventing future outbreaks from the same strain, informing consumers, or supporting initiatives to prevent the majority of infections that are not associated with outbreaks.

<i>Salmonella</i> Outbreak Response Activities in U.S. State		
	Illustration 1	Illustration 2
Unit of the product	<input type="text" value="kg"/>	<input type="text" value="case"/>
Amount of outbreak-related products distributed	<input type="text" value="25,000"/> kg	<input type="text" value="5,000"/> case
Amount of products discarded by retailers due to response activities	<input type="text" value="10,000"/> kg	<input type="text" value="2,000"/> case
Amount of products consumed	<input type="text" value="15,000"/> kg	<input type="text" value="3,000"/> case
Number of <i>Salmonella</i> cases attributable to the product	<input type="text" value="200"/>	<input type="text" value="100"/>

<i>Salmonella</i> Outbreak Response Impact		
	Illustration 1	Illustration 2
Number of <i>Salmonella</i> cases prevented due to response activities	<input type="text" value="133"/>	<input type="text" value="67"/>

[Click here to see How the cases are calculated](#)

Epidemiology (Details)

This page contains the default values used in PHL Impact (screen shot below) [3, 11]. To change any of parameters, enter the new value in the yellow cell, and the appropriate calculated cells (grey cells) in Part 1. Epidemiology and Results pages will reflect the edit.

For users who are interested in delving deeper, the Epidemiology (Details) page provides additional information about calculations, specifically for the total number of reported cases, number of non-hospitalized and hospitalized cases (not shown).

EPIDEMIOLOGY (Details)

Proportion of health outcomes	
<i>% hospitalized</i>	1.9%
<i>% dead among hospitalized cases</i>	2.0%
<i>% received outpatient medical care</i>	7.2%

[Click here to see the health outcomes decision tree](#)

Medical encounters per case (hospitalized)	
<i>Physician office visit</i>	0.7
<i>Emergency room visit</i>	0.3
<i>Hospital-based outpatient clinic visit</i>	0.2

Medical encounters per case (non-hospitalized)	
<i>Physician office visit</i>	1.4
<i>Emergency room visit</i>	0.1
<i>Hospital-based outpatient clinic visit</i>	0.3

Correction for under-reporting and under-diagnosis	
<i>under-reporting factor</i>	1.0
<i>under-diagnosis factor</i>	29.1

Results

The Results page contains summary information for the users' jurisdiction during a given year(s) related to:

- burden of nontyphoidal *Salmonella*;
- outbreak response activities;
- volume of specimens and isolates tested by the public health lab;
- total and average (per case) direct medical costs associated with *Salmonella* outbreak(s); and
- total and average (per specimen/isolate) lab testing costs associated with *Salmonella* outbreak(s).

Please note that the estimates assume that all jurisdiction-specific data and parameters entered in the tool are accurate. National estimates are provided as default values and may be used for comparison if these national estimates are used in place of jurisdiction-specific estimates, it is important to be aware of how the jurisdiction might compare to the national average. As with any model, it is also important to be aware of these assumptions when drawing conclusions from the outputs. The tool is intended to help laboratories summarize laboratory costs and response activities associated with addressing the burden of *Salmonella* infections.

The information on this page is formatted in tables that users may copy and paste into a report or presentation.

Results – Illustrations of Response Impact

This page summarizes the illustrative impact of *Salmonella* outbreak response activities, in terms of the number of cases and hospitalizations averted, and the total direct medical costs averted.

Illustration of <i>Salmonella</i> Outbreak Response Impact		
	Illustration 1	Illustration 2
Number of cases averted	133	67
Number of hospitalizations averted	2.51	1.25
Total direct medical costs averted	\$47,487	\$23,744

References

1. CDC. Antibiotic Resistance Threats in the United States 2019. Available from: <https://www.cdc.gov/drugresistance/pdf/threats-report/2019-ar-threats-report-508.pdf>.
2. CDC. National Outbreak Reporting System (NORS). Available from: <https://wwwn.cdc.gov/norsdashboard/>.
3. Batz MB, Hoffmann S, Morris JG. Disease-outcome trees, EQ-5D scores, and estimated annual losses of quality-adjusted life years (QALYs) for 14 foodborne pathogens in the United States. *Foodborne Pathogens Disease*. 2014;11(5):395-402. doi: 10.1089/fpd.2013.1658.
4. Scallan E, Hoekstra RM, Angulo FJ, Tauxe RV, Widdowson M-A, Roy SL, et al. Foodborne Illness Acquired in the United States—Major Pathogens. *Emerging Infectious Diseases*. 2011;17(1):7-15. doi: 10.3201/eid1701.P11101.
5. USDA Cost Estimates of Foodborne Illnesses. Available from: <https://www.ers.usda.gov/data-products/cost-estimates-of-foodborne-illnesses.aspx>.

6. Imdad A, Retzer F, Thomas LS, McMillian M, Garman K, Rebeiro PF, et al. Impact of Culture-Independent Diagnostic Testing on Recovery of Enteric Bacterial Infections. *Clinical Infectious Diseases*. 2017;66(12):1892–8. doi: 10.1093/cid/cix1128.
7. Trees E, Carias C, Adhikari B, Armstrong G. Economics of Next Genome Sequencing for Salmonella, CDC Office of Advanced Molecular Detection. 2018.
8. APHL. Salmonella Serotyping in US Public Health Laboratories. 2014.
9. Yoshida C, Gurnik S, Ahmad A, Blimkie T, Murphy SA, Kropinski AM, et al. Evaluation of Molecular Methods for Identification of Salmonella Serovars. *Journal of Clinical Microbiology*. 2016;54(8). doi: 10.1128/JCM.00262-16.
10. Musser K, editor Implementation and Impact of *Salmonella* serotype determination using pulsed-field gel electrophoresis in New York APHL Annual Meetings; 2017.
11. Kubota KA, Wolfgang WJ, Baker DJ, Boxrud D, Turner L, Trees E, et al. PulseNet and the Changing Paradigm of Laboratory-Based Surveillance for Foodborne Diseases. *Public Health Reports*. 2019;134:22S-8S. doi: 10.1177/0033354919881650.
12. Scharff RL, Besser J, Sharp DJ, Jones TF, Peter G-S, Hedberg CW. An Economic Evaluation of PulseNet: A Network for Foodborne Disease Surveillance. *American Journal of Preventive Medicine*. 2016;50:S66-S73. doi: 10.1016/j.amepre.2015.09.018.

Printing

To print your results on a single page, you must change the printing page setup to Landscape format. To do so,

- 1). Click File and then choose Page Setup.
- 2). In the Orientation section, change Portrait to Landscape.
- 3). Click OK.

CONTACT

For additional help or feedback, please email your comments or questions to or Martin I Meltzer M.S., Ph.D. (MMeltzer@cdc.gov) or contact the Health Economics and Modeling Unit at hemu@cdc.gov.

Appendix

Health Outcomes

This Health Outcomes page provides the percentage breakdown of health outcomes resulting from nontyphoidal *Salmonella* [3] that are the default epidemiologic parameters shown on the Epidemiology (Details) page and used for the calculated values on worksheet, 1. Epidemiology.

HEALTH OUTCOME

