CDC Division of Laboratory Systems

EXCELLENT LABORATORIES, OUTSTANDING HEALTH.

Semi-Quantitative Risk Characterization Tool for Biological Risk Assessments: User Guide

August 2026

Purpose

This document presents the key concepts and framework of the Semi-Quantitative Risk Characterization Tool for Biological Risk Assessments, a Microsoft Excel-based tool that uses a semi-quantitative scoring and weighting methodology to assess and visualize biological risk using a standardized risk matrix. The tool is designed to support clinical and public health laboratory professionals in systematically evaluating biological risks. This guide provides an overview of the tool's semi-quantitative scoring methodology, which automatically generates risk characterization results, including numerical risk scores and a risk matrix. It also includes detailed instructions to help users apply the tool consistently and effectively during biological risk assessments.

Scope

This document focuses on the risk characterization step of the biological risk assessment process. It details the variables that affect likelihood and consequence, explains the methodology for scoring and weighting these factors within the tool, and offers comprehensive instructions for data entry, result generation, and output interpretation using the risk matrix.

This document concentrates on the risk characterization step and is not intended to serve as a comprehensive guide to the entire biological risk assessment process. It illustrates how the tool can facilitate consistent, transparent, and informed risk-based decision-making and aims to support laboratory professionals in systematically evaluating biological risks and making well-founded decisions based on the resulting risk characterization.

For questions, please contact DLSBiosafety@cdc.gov.

Revision History:

- August 2026; Version 1; Initial posting.

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Definition of Terms

Term	Definition
Administrative Controls	Institutional policies, oversight mechanisms, and training programs governing safe work practices (e.g., standard operating procedures, incident reporting).
Biological Risk Assessment	A systematic process to identify, characterize, and evaluate risks associated with handling biological materials, to reduce risks to acceptable levels through appropriate control measures.
Consequence	The severity of harm that may result from an incident, influenced by factors such as agent virulence, availability of medical countermeasures, and host susceptibility.
Engineering Controls	Physical or mechanical systems designed to isolate or remove hazards, such as biosafety cabinets, ventilation systems, and facility containment features.
Hazard	Any biological agent, material, or condition that has the potential to cause harm to individuals, the community, or the environment.
Likelihood	The probability that an incident involving a biological hazard will occur, influenced by factors such as staff competency, engineering controls, and procedural safeguards.
Personal Protective Equipment (PPE)	Specialized clothing or equipment worn to minimize exposure to hazards.
Macros	Automated functions in Microsoft Excel that support calculations, data transfer, and tool functionality. Macros must be enabled for the Semi-Quantitative Risk Characterization Tool to operate correctly.
Mitigation	Actions or control measures implemented to reduce the likelihood or consequence of a risk. Mitigation may include administrative controls, engineering upgrades, procedural improvements, training, or enhancements to PPE.
Procedural Controls	Task-specific instructions or protocols that standardize laboratory activities and reduce opportunities for exposure (e.g., specimen handling, decontamination steps, waste disposal).
Risk	The combination of the likelihood that an incident will occur and the potential consequences if the incident occurs.
Risk Characterization	The process of evaluating factors that influence the likelihood and consequences of potential incidents to determine overall risk significance.
Risk Matrix	A two-dimensional tool that plots likelihood and consequence scores to visualize overall risk and support decision-making.
Semi-Quantitative Risk Characterization Tool	A Microsoft Excel-based tool that uses a semi-quantitative scoring and weighting methodology to assess and visualize biological risk using a standardized risk matrix.
Staff Competency	The training, expertise, and experience required for personnel to safely handle biological materials and effectively recognize hazards, assess risks, and implement safety measures.

Foundations of Biological Risk Characterization

What is Risk?

Laboratories handle various biological hazards, including infectious agents, clinical specimens, and specialized laboratory procedures, each of which may pose risks to laboratory personnel, the broader community, or the environment. However, hazards alone do not cause harm. Harm occurs when a hazard is present alongside conditions that permit exposure, ultimately resulting in an adverse outcome or incident.

Risk refers to the possibility that a hazard may cause harm, and is characterized by two interrelated components:

1. **Likelihood:** the probability that an incident involving a hazard will occur under specific conditions.

2. **Consequence:** the severity of harm that could result if the incident were to occur.

Together, these components provide a structured framework for evaluating the potential for laboratory hazards to result in adverse outcomes and form the basis of risk characterization.

What Is Risk Characterization?

Risk characterization is a critical step in the risk assessment process in which likelihood and consequence are evaluated together to determine the overall risk level. This step integrates the factors that influence the probability of an incident occurring with those that determine the severity of its potential consequences.

Factors influencing likelihood include hazard characteristics, personnel practices, the effectiveness of engineering and administrative controls, and the use of personal protective equipment (PPE). Factors influencing consequences include disease severity and the availability and effectiveness of medical countermeasures. A comprehensive assessment of these components provides a more complete understanding of the risk posed by a biological hazard.

Risk characterization may be conducted using qualitative, semi-quantitative, or quantitative methodologies, depending on the assessment framework and the information available. Regardless of the chosen approach, the procedure should be implemented consistently and thoroughly documented to support transparency and comparability in risk-based decision-making.

The Semi-Quantitative Risk Characterization Tool described in this guide uses a structured scoring and weighting methodology to evaluate likelihood and consequence and generate a standardized characterization of biological risk.

How Does Risk Characterization Fit into the Risk Assessment Process?

The biological risk assessment process generally includes several steps: identifying hazards, defining risks, evaluating those risks, and determining the need for mitigation. Risk characterization is within the evaluation step, where identified risks are assessed to determine their overall significance.

For comprehensive information on the broader risk assessment framework, refer to the CDC Biological Risk Assessment Process and Section II of the Biosafety in Microbiological and Biomedical Laboratories (BMBL), 6th Edition.

The Semi-Quantitative Risk Characterization Tool

The Semi-Quantitative Risk Characterization Tool helps users systematically evaluate biological risks with a semi-quantitative scoring method. The tool assesses specific likelihood and consequence factors within set categories, assigning numerical scores to reflect different levels of concern. These individual scores are combined through weighting and calculations to produce semi-quantitative risk characterization outputs, including total likelihood and consequence scores, as well as placement on a risk matrix. This process offers a standardized approach for comparing risks across procedures and supporting decisions about risk evaluation and whether additional mitigation actions may be needed.

Risk characterization methods may use numerical scoring in different ways depending on the assessment purpose, available data, and institutional context. This tool is one example of a semi-quantitative approach because it assigns numerical scores and weights to categorical criteria to support comparison and prioritization, rather than producing measured probabilities or statistically modeled risk estimates. The concepts underlying this tool, including the selection of risk factors and the scoring framework, are drawn from existing biosafety risk assessment resources and subject-matter expert input[1,2]. These approaches have been adapted and built into an automated Microsoft Excel-based format.

The subsequent sections present an overview of the risk factors, scoring framework, and calculation methodology that form the basis of the tool, detailing their application in assessing biological risks.

Factors That Influence Likelihood and Consequence

Risk characterization involves identifying and assessing conditions that affect both the likelihood of incidents involving biological hazards and the potential severity of their outcomes. These conditions inform the factor-level scoring methodology used in the tool.

Each factor represents a condition that may increase or decrease the likelihood of an incident or the seriousness of its consequences.

Consistent with the definition of risk, the factors used in this tool fall into two categories:

- **Likelihood factors:** conditions that influence the probability that an incident will occur.
- **Consequence factors:** conditions that influence the severity of harm if an incident occurs.

In clinical or diagnostic laboratory environments, personnel often work directly with potentially infectious materials to perform diagnostic or analytical activities. For this reason, the likelihood factors included in this tool consider both hazard exposure characteristics, such as agent stability, environmental persistence, transmissibility, and operational conditions that laboratories can implement, maintain, or improve, including staff competency, engineering controls, administrative controls, procedural controls, and PPE.

Likelihood Factors

1. **Hazard Exposure Characteristics**
   Describes a biological agent's stability, environmental persistence, and transmissibility. Agents with higher levels of these characteristics may be more likely to contribute to exposure during laboratory activities.

   In situations where the biological agent has not been identified or confirmed, evaluators are advised to rely on relevant contextual information, including specimen source, clinical presentation, outbreak circumstances, and travel history. When uncertainty is present, it is recommended to adopt a cautious approach to scoring.

2. **Staff Training and Competency**
   Reflects the skill, experience, and preparedness of personnel performing the task. Insufficient or inconsistent training increases the likelihood of procedural errors or exposure incidents.

3. **Engineering Controls**
   Includes biosafety cabinets, ventilation systems, and facility design elements used to provide physical containment. Deficiencies in functionality, certification, or availability increase the likelihood of exposure.

4. **Administrative Controls**
   Includes institutional policies, reporting mechanisms, and supervisory practices. When these measures are weak, outdated, or inconsistently implemented, the risk of deviation from established safe practices increases.

5. **Procedural Controls**
   Refers to task-specific safety practices embedded in laboratory workflows. When these procedures are outdated, unclear, or inconsistently applied, the likelihood of exposure increases.

6. **Personal Protective Equipment (PPE)**
   Represents specialized clothing and equipment used to reduce potential exposure. Improper selection, use, or maintenance of PPE increases the likelihood of exposure.

Consequence factors focus on the potential severity of outcomes if exposure occurs, including the severity characteristics of the biological hazard and the availability of vaccines or therapeutics.

Consequence Factors

1. **Hazard Severity Characteristics**
   Refers to the inherent severity of the biological agent, including its pathogenicity, morbidity, mortality potential, and capacity to cause severe disease. Agents with high pathogenicity or those that may induce severe disease are associated with more significant consequences.

   When the agent is not identified, evaluators are advised to assume a plausible worst-case severity and assign higher scores if a high-risk pathogen cannot be ruled out.

2. **Vaccines and Therapeutics**
   Represents the availability, accessibility, and effectiveness of medical countermeasures. Limited availability, diminished effectiveness, or restricted access to vaccines or treatments may increase the potential severity of adverse outcomes.

Scoring and Weighting Framework

Each likelihood and consequence factor outlined above is accompanied by criteria that define conditions corresponding to lower, moderate, or higher levels of concern. These criteria are intended to support consistent scoring across activities and assessors when

using the tool. Raw scores range from 1 to 4, with higher scores indicating conditions associated with a higher likelihood or more significant consequences.

The factor categories reflect common considerations used in biological risk assessment. The specific criteria, scores, and weights used in this tool were developed through discussions among subject-matter experts and practical application in laboratory settings. They are provided as an example semi-quantitative framework and are not intended to represent universal, prescriptive, or externally validated values.

When using the tool, evaluators should assign raw scores based on documented conditions at the time of the assessment. These raw scores are then weighted and combined to generate relative likelihood and consequence scores for comparison and prioritization.

The following criteria define the conditions associated with each likelihood and consequence factor, along with their corresponding raw scores.

Likelihood Factor Criteria

1. Hazard Exposure Characteristics

Criteria	Raw Score
The hazard is extremely fragile and has poor transmissibility	1
The hazard is moderately stable and/or has moderate transmissibility	2.5
The hazard is very stable with strong transmissibility, or its stability/transmissibility is unknown	4

Hazard Exposure Characteristics uses a modified three-point scale instead of the standard four-point scale used for other factors in this tool. This approach is intended to reduce ambiguity when assigning scores, particularly when hazard-specific data are limited.

2. Staff Training and Competency

Criteria	Raw Score
All staff are highly trained and competent for the specific activity	1
Most staff are highly trained and competent; a few are moderately trained	2
Few staff are highly trained and competent; most are moderately trained	3
Most or all staff are poorly trained and/or not competent for the specific activity	4

3. Engineering Controls

Criteria	Raw Score
All required engineering controls are in place, properly certified, and maintained	1
Most required engineering controls are in place, properly certified, and maintained	2
Few/most required engineering controls are in place; some of those are not properly certified or maintained	3
Few/no required engineering controls are in place; some/all of those are not properly certified or maintained	4

4. Administrative Controls

Criteria	Raw Score
All necessary administrative controls are in place and appropriately maintained	1
Most necessary administrative controls are in place and appropriately maintained	2
Few/most necessary administrative controls are in place; some of those are not properly maintained	3
Few/no necessary administrative controls are in place; some/all of those are not properly maintained	4

5. Procedural Controls

Criteria	Raw Score
All necessary procedural controls are in place and appropriately maintained	1
Most necessary procedural controls are in place and appropriately maintained	2
Few/most necessary procedural controls are in place; some of those are not properly maintained	3
Few/no necessary procedural controls are in place; some/all of those are not properly maintained	4

6. PPE

Criteria	Raw Score
All necessary PPE is in use and appropriately maintained	1
Most necessary PPE is in use and appropriately maintained	2
Few/most necessary PPE is in use; some of those are not properly maintained	3
Few/no necessary PPE is in use; some/all of those are not properly maintained	4

Consequence Factor Criteria

1. Hazard Severity Characteristics

Criteria	Raw Score
Exposure to the hazard would not cause any morbidity or mortality	1
Exposure to the hazard could cause morbidity primarily in immunocompromised or elderly individuals	2
Exposure to the hazard could cause serious morbidity but limited mortality	3
Exposure to the hazard would result in high rates of morbidity and mortality	4

2. Vaccines and Therapeutics

Criteria	Raw Score
Highly effective vaccines and therapies are available, and all staff are vaccinated against this disease	1
Highly effective vaccines and/or therapies are available, but only some staff are vaccinated against this disease	2
Vaccines and/or therapies are available, but their efficacy is limited	3
No vaccines or therapies are available for the disease caused by this hazard	4

Important Note: Evidence-Based Scoring

Risk characterization should be evidence-based. Raw scores should accurately represent documented conditions, including training records, maintenance logs, standard operating procedures (SOPs), incident reports, certification records, or other pertinent operational documentation. In situations where documentation is incomplete or there is uncertainty regarding hazard characteristics, evaluators are advised to assign conservative (higher) scores and clearly document the rationale behind these decisions. Institutions should retain this supporting information as part of the risk assessment record to ensure transparency, consistency, and reproducibility of the assessment process.

Likelihood and Consequence Weighting

Once raw scores are selected, predefined weights are applied to reflect the relative emphasis assigned to each factor in this example framework. Within each category, likelihood and consequence factors are weighted to total 100%, representing their relative contribution within each component of risk, as shown in Figure 1.

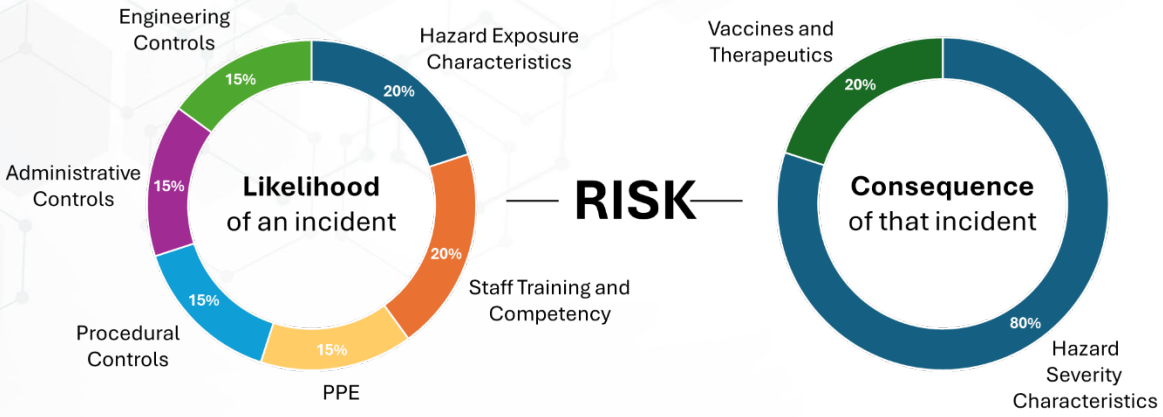


Figure 1. Relative weighting of likelihood and consequence factors used in the semi-quantitative risk characterization methodology, showing each factor's contribution to its respective likelihood or consequence score.

In this example framework, hazard exposure characteristics and staff training and competency receive greater weight because subject-matter experts considered them major contributors to exposure potential and incident occurrence. Engineering, administrative, and procedural controls are weighted equally to reflect their complementary roles in reducing exposure risk. PPE is also included as a protective measure, while recognizing that its effectiveness depends on correct and consistent selection, use, and maintenance.

For consequence, hazard severity characteristics receive greater weight because they are the primary driver of potential impact following exposure. Vaccines and therapeutics are also considered because effective medical countermeasures can reduce the severity of outcomes.

The weighting structure reflects subject-matter expert judgment informed by laboratory biosafety practice and incident experience. Institutions may adjust the criteria, weights, or matrix thresholds to align with local hazards, procedures, policies, and risk tolerance, provided that any modifications are documented and applied consistently across assessments.

Calculating Weighted Likelihood and Consequence Scores

As previously mentioned, the tool calculates weighted factor scores from raw data and sums them by category to generate the Total Likelihood Score and Total Consequence Score.

The scoring process is as follows:

1. For each factor, multiply the raw score by its assigned weight to calculate the weighted factor score.
    - For example, a raw score of 3 with a weighting of 20% results in a contribution of 0.6 to the overall score (3 × 0.20 = 0.6).
2. Sum all weighted likelihood factor scores to determine the Total Likelihood Score.
3. Sum all weighted consequence factor scores to determine the Total Consequence Score.

These aggregate values represent the combined influence of the assessed factors and serve as the foundation for visualizing outcomes within the risk matrix. The tool performs these calculations automatically to enhance consistency and minimize the potential for user error.

Example Calculation

The example below outlines the calculation of the Total Likelihood Score and Total Consequence Score for the risk associated with a "specimen mix-up during unpackaging." This scenario demonstrates how various elements collectively influence overall risk assessment within a laboratory context.

Step 1: Total Likelihood Score

Each likelihood factor receives a raw score, which is multiplied by its weight to get the weighted value.

Likelihood Factor	*Raw Score*	*Weight (%)*	*Weighted Score*
Hazard Exposure Characteristics	4	20%	0.8
Staff Training and Competency	2	20%	0.4
Engineering Controls	1	15%	0.15
Administrative Controls	1	15%	0.15
Procedural Controls	2	15%	0.3
PPE	1	15%	0.15
		Total Likelihood Score	1.95

Interpretation:

The Total Likelihood Score of 1.95 is a relative measure of likelihood for this scenario, based on the combined influence of the six likelihood factors.

Step 2: Total Consequence Score
Each consequence factor receives a raw score, which is multiplied by its weight to get the weighted value.

Consequence Factor	*Raw Score*	*Weight (%)*	*Weighted Score*
Hazard Severity Characteristics	4	80%	3.2
Vaccines and Therapeutics	3	20%	0.6
	Total Consequence Score		3.8

Interpretation:
The Total Consequence Score of 3.8 reflects the potential severity of outcomes in this scenario, based on the combined influence of the two consequence factors.

A more comprehensive example demonstrating the application of this methodology across multiple risks within a laboratory workflow is provided in Appendix A.

Risk Matrix

After calculating both the Total Likelihood Score and the Total Consequence Score, the risk matrix integrated within the tool offers a structured visual representation for interpreting risk characterization outcomes. The matrix displays each evaluated risk by plotting:

- The Total Likelihood Score on the Y-axis (range: 1–4)
- The Total Consequence Score on the X-axis (range: 1–4)

Figure 2 depicts the point corresponding to the example scenario described in the previous section (specimen mix-up during unpackaging), illustrating how the calculated Total Likelihood Score and the Total Consequence Score correspond to a position within the risk matrix.

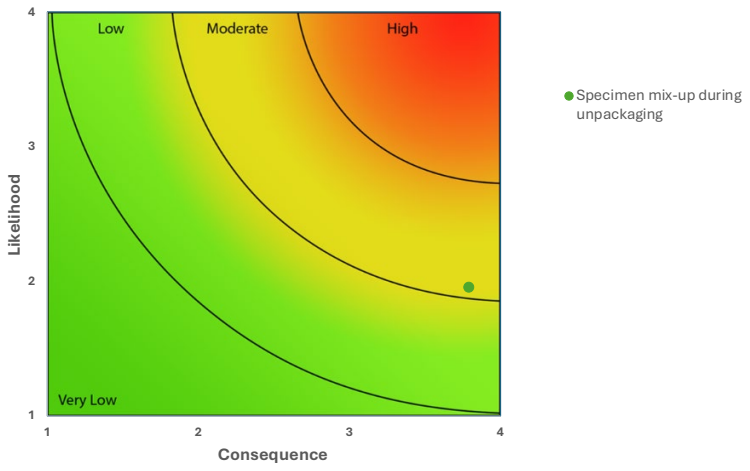


Figure 2. Risk matrix displaying the example scenario, with total likelihood scores plotted on the Y-axis and total consequence scores on the X-axis to illustrate overall risk positioning.

The matrix utilizes a green-to-red color gradient to indicate escalating levels of concern:

- Green denotes very low to low risk, reflecting minimal likelihood, minimal consequence, or both.
- Yellow signifies moderate risk, corresponding to moderate likelihood and/or consequence.
- Red represents high risk, indicating increased likelihood and severe consequences.

This matrix supports prioritization by visually distinguishing risks based on their relative likelihood score and consequence score. Risks positioned in the upper-right region of the matrix are typically regarded as higher-priority concerns. In contrast, those in the lower left are generally lower-priority and may be acceptable under existing controls.

Note on Customizing Matrix Thresholds

Institutions are encouraged to customize risk matrix thresholds to align with their specific needs, policies, and risk tolerance. This includes defining what constitutes very low, low, moderate, and high risk to ensure that risk-based decisions are tailored to organizational priorities and accurately reflect local operational realities.

Using Matrix Results to Support Decision-Making

Institutions use the placement of each risk within the matrix as one input when evaluating risk acceptability and determining what mitigation actions, if any, are necessary. After comparing a risk's position against internal benchmarks, evaluators should:

- **Support risk evaluation:** Use the matrix results, supporting documentation, and institutional criteria to determine whether each risk is acceptable, controllable with additional mitigation, or unacceptable. Risk acceptance is a policy and management decision informed by the risk characterization results, regulatory requirements, available controls, resource constraints, and the benefits of the work.
- **Document decisions:** Clearly explain why a risk is accepted, changed, or rejected to ensure the assessment remains transparent and justifiable.
- **Implement mitigation measures:** Develop or amend controls for risks that exceed institutional criteria or require additional risk reduction. Evaluators should also examine which factors contributed most to high likelihood scores, as these often highlight areas where greater control or improvement is required.
- **Communicate findings:** Present the results and possible recommendations to supervisors, biosafety staff, and leadership, supporting collaborative decision-making and effective allocation of resources.
- **Monitor and reassess:** Track the effectiveness of implemented controls and reassess risks as conditions change to ensure continued effectiveness.

By utilizing the matrix, institutions can promote consistent assessments, foster communication among stakeholders, and better direct mitigation efforts to where they are most needed.

Limitations of the Tool

This tool is intended to support structured, semi-quantitative risk characterization and prioritization. It should not be interpreted as a predictive model, a validated probability model, or a substitute for professional judgment, biosafety expertise, institutional review, or regulatory requirements.

The raw scores used in this tool are ranked categories rather than exact scores. Although the tool applies numerical weights and calculations to these scores, the resulting values should be interpreted as relative risk characterization scores rather than measured probabilities or mathematically precise estimates of risk. A score of 4 should not be interpreted as twice the risk of a score of 2.

The tool may be inappropriate when sufficient information is not available to define the hazard, procedure, exposure pathway, existing controls, or likely consequences; when decisions require formal quantitative microbial risk assessment; when regulatory requirements prescribe specific containment or control measures; or when highly uncertain, novel, or high-consequence work requires more detailed expert review.

The weighting structure reflects tool-specific assumptions about the relative contribution of each factor. Errors in category selection, category definitions, or weighting assumptions can affect the final likelihood and consequence scores and may shift a risk into a different matrix region. This could result in over-prioritization, under-prioritization, false precision, or inconsistent results across assessors. Institutions modifying weights or thresholds should document the rationale, apply changes consistently, and consider whether reasonable changes in weights would alter risk prioritization or management decisions.

To improve consistency, users should document assumptions and uncertainties, involve appropriate subject-matter experts, and periodically compare tool outputs with incident reports, audit findings, nonconformances, and other local performance data.

Using the Semi-Quantitative Risk Characterization Tool

Download the Semi-Quantitative Risk Characterization Tool: Semi-Quantitative Risk Characterization Tool Excel Workbook

The tool incorporates embedded formulas and macro-driven functionality that enable automated computations and visualization. Customizing these components may necessitate proficiency in Microsoft Excel formulas and macros. Organizations seeking to tailor the tool to their unique requirements are encouraged to modify the existing workbook or develop a modified version utilizing the calculation methodology outlined in this document.

It is important to note that the methodology described herein is independent of any particular software platform and can be deployed using standard spreadsheet functions or other analytical tools, provided calculations are performed consistently.

Enabling Macros

For optimal performance, this tool requires macros to be enabled. In many cases, macros can be enabled when opening the file. If macros are disabled, try one of the options below, starting with Option A and progressing as needed until the issue is resolved. Follow institutional IT and security policies before changing file or macro security settings.

Option A: Check for a Security Warning

(most common when first opening the file)

1. Open the file and look for a yellow security banner at the top of the Microsoft Excel window (e.g., “Macros have been disabled” or “Security Warning”).
2. If the banner appears, select “Enable Content” to allow macros to run.

Option B: Check File Properties

(common for files downloaded from email or the internet)

1. Right-click the Microsoft Excel file and select Properties.
2. Under the General tab, look for a Security message.
3. If present, select “Unblock”, then choose Apply and OK.

Option C: Save as a Macro-Enabled Workbook

(use if the file format may be restricting macros)

1. Open the file, even if macros are disabled.
2. Go to File > Save As.
3. Select “Excel Macro-Enabled Workbook (*.xlsm)” as the file type.
4. Save and close the file.
5. Reopen the newly saved version.

Option D: Adjust Macro Settings
(advanced option)

1. Open a blank Microsoft Excel workbook.
2. Navigate to File > Options > Trust Center > Trust Center Settings > Macro Settings.
3. Select "Enable all macros" *(only if you trust the file source)*.
4. Click OK, then reopen the tool.

If you continue to experience issues, contact your IT department for assistance.

Instructions for Use

This section outlines how to use the Semi-Quantitative Risk Characterization Tool to enter risk information, apply raw scores, and review results.

Before You Begin

Before using the tool, it's important to clearly identify risks as part of the overall biological risk assessment. This involves recognizing hazards, determining how exposure might occur, and describing specific situations that could lead to an incident.

For instance, a laboratory could identify a risk like "specimen mix-up during unpackaging" based on workflow analysis, process review, or prior incidents.

In practice, prior steps involve reviewing relevant information to support scoring decisions. This may include SOPs, training and competency records, equipment certification and maintenance logs, incident reports, and other documentation related to the procedure being assessed. Evaluators should use this information to determine appropriate raw scores for each likelihood and consequence factor before entering values into the tool.

Once risks are defined and supporting information is reviewed, the tool is used to characterize each risk.

Overview of Workbook Structure

The workbook contains two main tabs:

- **Risk Calculation Tab:** Enter risk descriptions, raw scores for likelihood and consequence, and assessor info. Scores are calculated automatically and sent to the Risk Results Tab.
- **Risk Results Tab:** Shows the plots of Total Likelihood Scores and Total Consequence Scores on the matrix, enabling users to compare risk levels and make informed decisions.

The following steps describe how to enter and evaluate risks within the tool.

1. Enter Institution-Specific Information

1.1. Access the Risk Calculation tab (Figure 3).

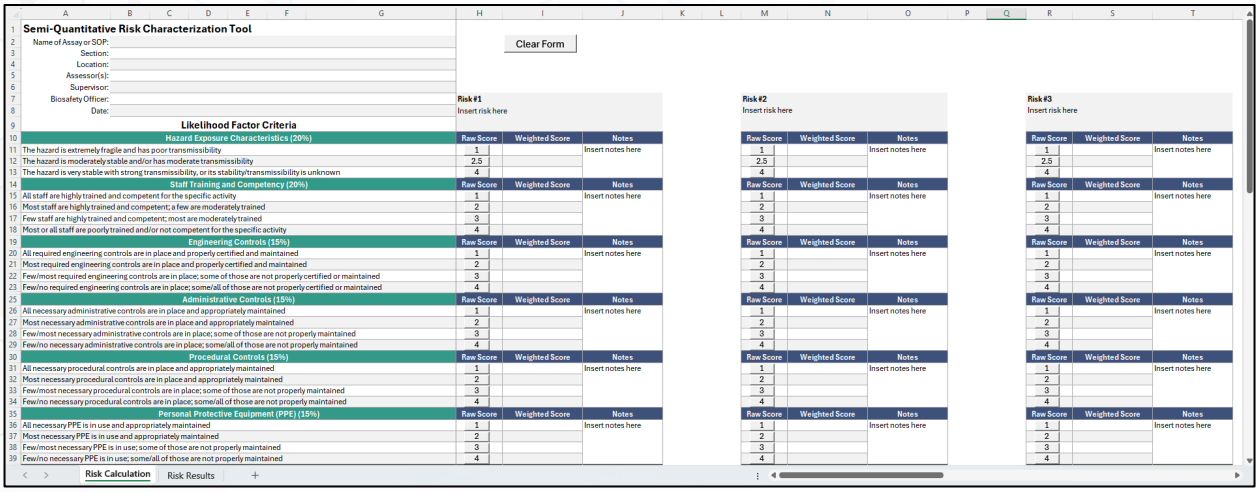


Figure 3. Overview of the Risk Calculation tab in the tool, where users enter risk descriptions, assign raw scores, and input assessment information.

1.2. Input the institution-specific information into the appropriate fields:

- 1.2.1. Name of Assay or SOP: Specify the procedure under assessment.
- 1.2.2. Section: If only part of a broader procedure is being evaluated, indicate the relevant section.
- 1.2.3. Location: State the location where the procedure is carried out (e.g., specific laboratory or facility).
- 1.2.4. Assessor(s): Provide the names of individuals conducting the risk assessment.
- 1.2.5. Supervisor: Identify the supervisor responsible for reviewing or approving the assessment.
- 1.2.6. Biosafety Officer: Name the biosafety professional involved in reviewing the assessment, if applicable.
- 1.2.7. Date: Record the date on which the assessment takes place.

Note: These fields automatically populate on the Risk Results Tab.

2. Document and Score Risks

2.1. Identify up to five risks to be evaluated based on previously defined scenarios. These risks will be recorded as Risk 1 through Risk 5 in the tool.

2.2. Enter each risk into the designated fields in the Risk Calculation tab (Figure 4).

- 2.2.1. Record a clear and concise risk description (e.g., specimen mix-up during unpackaging).

6	Supervisor:			
7	Biosafety Officer:		Risk #1	
8	Date:		Specimen mix-up during unpackaging	
9	**Likelihood Factor Criteria**			
10	**Hazard Exposure Characteristics (20%)**	**Raw Score**	**Weighted Score**	**Notes**
11	The hazard is extremely fragile and has poor transmissibility	1		Insert notes here
12	The hazard is moderately stable and/or has moderate transmissibility	2.5		
13	The hazard is very stable with strong transmissibility, or its stability/transmissibility is unknown	4		

Figure 4. Example of a risk entry field in the Risk Calculation tab, showing how a risk description (e.g., specimen mix-up during unpackaging) is recorded.

2.3. Add relevant context in the Notes section to support scoring decisions.

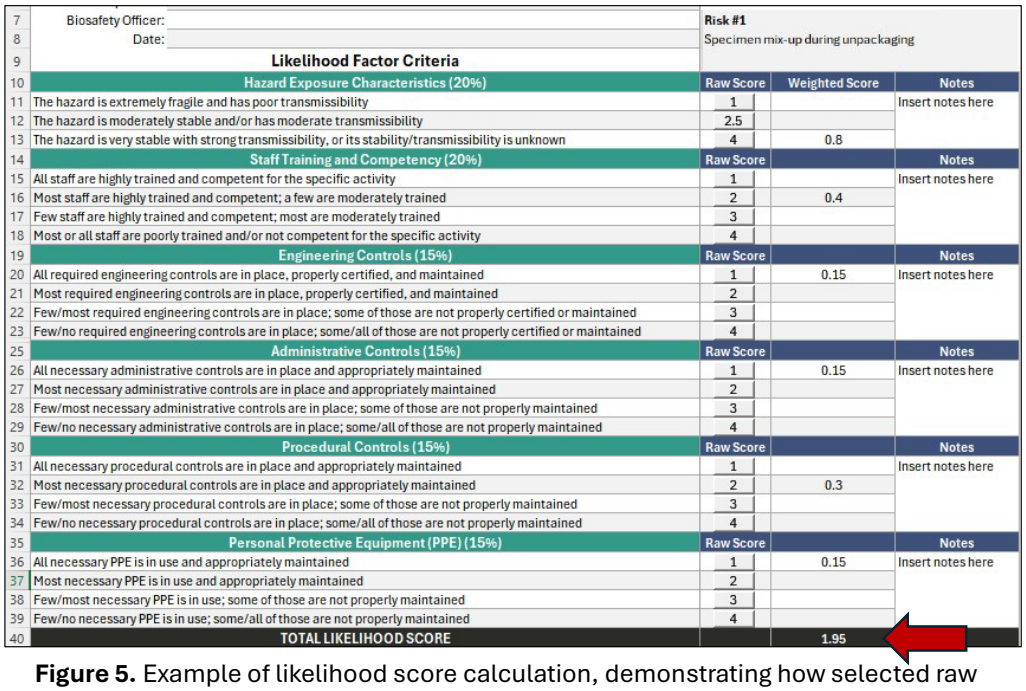
3. Assign Likelihood Scores

3.1. Evaluate Risk 1 using the six likelihood factors:

- 3.1.1. Hazard Exposure Characteristics
- 3.1.2. Staff Training and Competency
- 3.1.3. Engineering Controls
- 3.1.4. Administrative Controls
- 3.1.5. Procedural Controls
- 3.1.6. Personal Protective Equipment (PPE)

3.2. Select the corresponding raw score in the Raw Score column (Figure 5).

- 3.2.1. The Total Likelihood Score will be displayed automatically at the bottom of the Likelihood Factor Criteria Table as individual raw scores are selected.



7	Biosafety Officer:		Risk #1	
8	Date:		Specimen mix-up during unpackaging	
9	**Likelihood Factor Criteria**			
10	**Hazard Exposure Characteristics (20%)**	**Raw Score**	**Weighted Score**	**Notes**
11	The hazard is extremely fragile and has poor transmissibility	1		Insert notes here
12	The hazard is moderately stable and/or has moderate transmissibility	2.5		
13	The hazard is very stable with strong transmissibility, or its stability/transmissibility is unknown	4	0.8	
14	**Staff Training and Competency (20%)**	**Raw Score**		**Notes**
15	All staff are highly trained and competent for the specific activity	1		Insert notes here
16	Most staff are highly trained and competent; a few are moderately trained	2	0.4	
17	Few staff are highly trained and competent; most are moderately trained	3		
18	Most or all staff are poorly trained and/or not competent for the specific activity	4		
19	**Engineering Controls (15%)**	**Raw Score**		**Notes**
20	All required engineering controls are in place, properly certified, and maintained	1	0.15	Insert notes here
21	Most required engineering controls are in place, properly certified, and maintained	2		
22	Few/most required engineering controls are in place; some of those are not properly certified or maintained	3		
23	Few/no required engineering controls are in place; some/all of those are not properly certified or maintained	4		
25	**Administrative Controls (15%)**	**Raw Score**		**Notes**
26	All necessary administrative controls are in place and appropriately maintained	1	0.15	Insert notes here
27	Most necessary administrative controls are in place and appropriately maintained	2		
28	Few/most necessary administrative controls are in place; some of those are not properly maintained	3		
29	Few/no necessary administrative controls are in place; some/all of those are not properly maintained	4		
30	**Procedural Controls (15%)**	**Raw Score**		**Notes**
31	All necessary procedural controls are in place and appropriately maintained	1		Insert notes here
32	Most necessary procedural controls are in place and appropriately maintained	2	0.3	
33	Few/most necessary procedural controls are in place; some of those are not properly maintained	3		
34	Few/no necessary procedural controls are in place; some/all of those are not properly maintained	4		
35	**Personal Protective Equipment (PPE) (15%)**	**Raw Score**		**Notes**
36	All necessary PPE is in use and appropriately maintained	1	0.15	Insert notes here
37	Most necessary PPE is in use and appropriately maintained	2		
38	Few/most necessary PPE is in use; some of those are not properly maintained	3		
39	Few/no necessary PPE is in use; some/all of those are not properly maintained	4		
40	**TOTAL LIKELIHOOD SCORE**		1.95	

Figure 5. Example of likelihood score calculation, demonstrating how selected raw scores are weighted and combined to produce the total likelihood score.

Note: Please select only one raw score for each factor. If multiple raw scores are mistakenly clicked for a single factor, select the incorrect weighted score and use the delete function to remove it from the Weighted Score column. Do not enter weighted scores manually, as these values are automatically generated.

4. Assign Consequence Scores

4.1. Evaluate Risk 1 using the two consequence factors:

4.1.1. Hazard Severity Characteristics

4.1.2. Vaccines and Therapeutics

4.2. Select the corresponding raw score in the Raw Score column (Figure 6).

4.2.1. The Total Consequence Score will be displayed automatically at the bottom of the Consequence Factor Criteria Table as individual raw scores are selected.

42	Consequence Factor Criteria			
43	Hazard Severity Characteristics (80%)	Raw Score	Weighted Score	Notes
44	Exposure to the hazard would not cause any morbidity or mortality	1		Insert notes here
45	Exposure to the hazard could cause morbidity primarily in immunocompromised or elderly individuals	2		
46	Exposure to the hazard could cause serious morbidity but limited mortality	3		
47	Exposure to the hazard would result in high rates of morbidity and mortality	4	3.2	
48	Vaccines and Therapeutics (20%)	Raw Score		Notes
49	Highly effective vaccines and therapies are available, and all staff are vaccinated against this disease	1		Insert notes here
50	Highly effective vaccines and/or therapies are available, but only some staff are vaccinated against this disease	2		
51	Vaccines and/or therapies are available, but their efficacy is limited	3	0.6	
52	No vaccines or therapies are available for the disease caused by this hazard	4		
53	TOTAL CONSEQUENCE SCORE		3.8	

Figure 6. Example of consequence score calculation, showing how weighted factor scores are combined to produce the total consequence score.

4.3. Repeat steps 3 and 4 for each risk.

5. Review Risk Results

5.1. Navigate to the Risk Results tab (Figure 7).

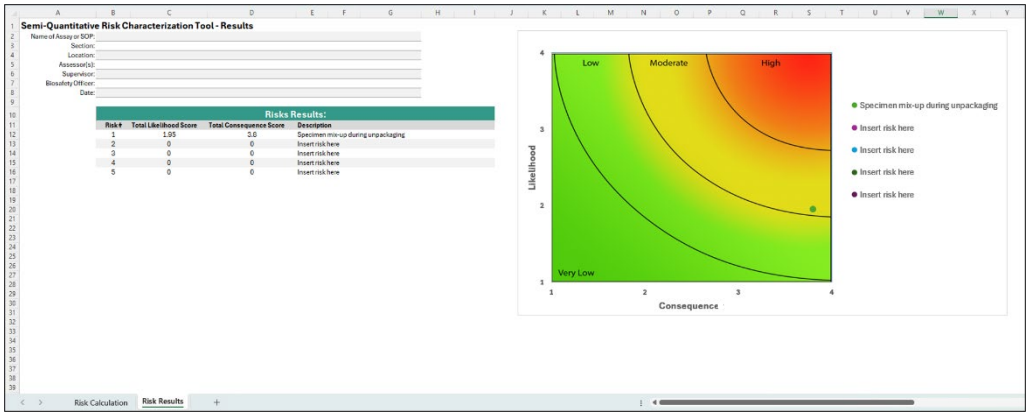


Figure 7. Overview of the Risk Results tab displaying calculated likelihood and consequence scores and corresponding visualization on the risk matrix.

5.2. Verify that the risk results table displays the correct information for:

5.2.1. Risk Number

5.2.2. Total Likelihood Score
5.2.3. Total Consequence Score
5.2.4. Description

5.3. Confirm that each risk is plotted on the risk matrix according to its calculated scores (Figure 8).

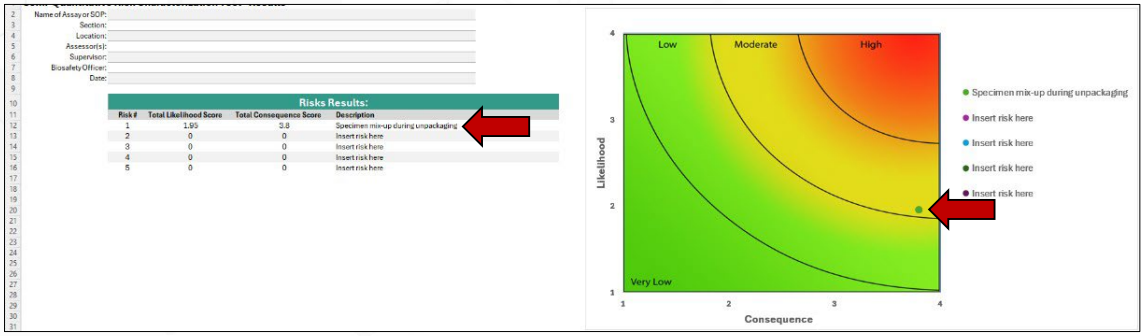


Figure 8. Risk results table and corresponding risk matrix showing plotted risks based on calculated likelihood and consequence scores.

5.4. Use the risk matrix to support risk evaluation and management decisions. Do not rely solely on matrix color or score to determine acceptability.
5.5. Save a copy of the completed risk characterization file for institutional records.
5.6. Discuss the results with supervisors, biosafety personnel, and/or leadership.

6. Clear the Form for a New Assessment

6.1. Return to the Risk Calculation Tab.
6.2. Click the “Clear Form” button at the top of Column I (Figure 9).

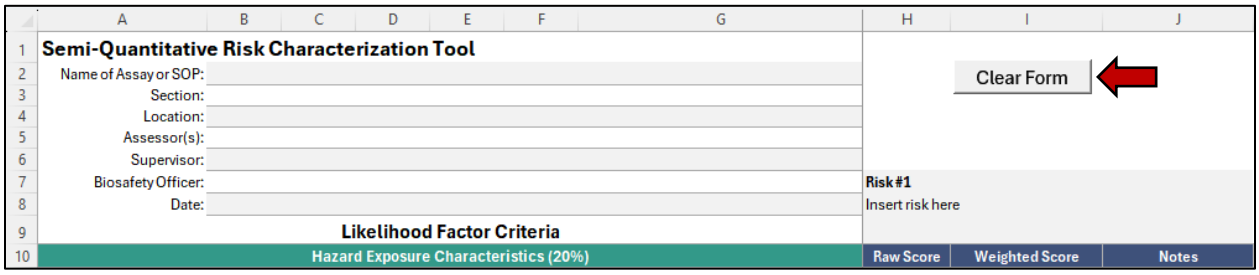


Figure 9. Location of the “Clear Form” button in the Risk Calculation tab, used to reset risk entries and scoring fields for a new assessment.

6.3. Ensure that the following fields have been reset:
6.3.1. Risk Titles
6.3.2. Weighted Scores
6.3.3. Notes
6.4. Confirm that the Risk Results tab and matrix are cleared.
6.5. Begin a new assessment if evaluating additional risks.

Note: Institution-specific information entered in step 1 will not be cleared automatically and must be manually modified between assessments.

Conclusion

Biological risk assessments are essential for identifying and managing hazards in laboratory settings. The Semi-Quantitative Risk Characterization Tool provides a structured and transparent method for evaluating risk using defined criteria, raw scores, and weighting. By applying this approach consistently, laboratories can improve the clarity and reproducibility of their risk evaluations.

Institutions may tailor the tool or its underlying scoring model to align with their specific needs, policies, and regulatory requirements. When used thoughtfully and supported by documented evidence and management oversight, this approach helps laboratories effectively manage biological risks, enhance safety, and support a culture of continuous improvement.

References

1. Centers for Disease Control and Prevention (CDC). 2020. Risk Assessment: The Foundation of Every Good Biorisk Management System. Reynolds M. Salerno. CDC Biosafety Symposium Presentation
2. Sandia National Laboratories. 2010. Biosafety Risk Assessment Methodology (BioRAMs).

Resources

- Centers for Disease Control and Prevention (CDC). 2024. Biological Risk Assessment Process
- Centers for Disease Control and Prevention (CDC). 2020. Biosafety in Microbiological and Biomedical Laboratories (BMBL) 6th Edition

Appendix A. Example Risk Characterization: PCR Workflow

This appendix presents an example illustrating the application of the Semi-Quantitative Risk Characterization Tool to assess multiple risks within a single laboratory workflow. The scenarios described are drawn from a polymerase chain reaction (PCR) process performed during testing for Highly Pathogenic Avian Influenza (HPAI) A (H5N1).

This example is intended solely for demonstration purposes and should not be viewed as prescriptive guidance. Institutions are advised to tailor risk definitions, scoring methodologies, and interpretations according to their specific procedures, hazards, and operational contexts.

1. Scenario Overview

This scenario involves a public health laboratory tasked with conducting real-time reverse transcription polymerase chain reaction (rRT-PCR) testing during an HPAI A (H5N1) outbreak. The facility receives specimens from various states and serves as the reference center for influenza A testing.

H5N1 is primarily transmitted through respiratory aerosols, mucous membrane exposure, and contact with contaminated surfaces. Infection may result in severe illness and mortality in humans; however, medical countermeasures are available.

2. Workflow Description

The major stages of the PCR workflow are illustrated in Figure A1.

Figure A1. Hypothetical PCR workflow illustrating key stages from specimen receipt through post-amplification handling and waste management.

For this example, the initial stages of specimen receipt and unpackaging and nucleic acid extraction were selected based on incident reports and documented nonconformances indicating increased potential for procedural errors and exposure. As we proceed, our attention will be directed toward these preliminary phases.

3. Identified Risks

The following risks were identified within the selected workflow stages:

1. Specimen mix-up during unpackaging
2. Improper use of the biosafety cabinet (BSC) during specimen extraction

3. Improper inactivation during specimen extraction
4. Improper handling of waste after specimen extraction
5. Misuse of personal protective equipment (PPE) during specimen extraction.

4. Risk Characterization Results

Each identified risk was evaluated using the likelihood and consequence criteria defined in this tool.

Example Risk: Specimen Mix-Up During Unpackaging

Likelihood Assessment

Raw scores were assigned across the six likelihood factors based on current laboratory conditions, including hazard characteristics, staff competency, and existing controls.

- Total Likelihood Score: 1.95

Consequence Assessment

Consequence scoring considered hazard severity and the availability of medical countermeasures.

- Total Consequence Score: 3.8

The remaining risks were evaluated using the same methodology. A summary of results is presented in Figure A2.

Risk Results:			
Risk #	**Total Likelihood Score**	**Total Consequence Score**	**Description**
1	1.95	3.8	Specimen mix-up during unpackaging
2	3.2	3.8	Improper use of the BSC during specimen extraction
3	2.1	3.8	Improper inactivation during specimen extraction
4	2.25	3.8	Improper handling of waste after specimen extraction
5	3.05	3.8	Misuse of PPE during specimen extraction.

Figure A2. Summary of risk characterization results for identified PCR workflow risks, including total likelihood and consequence scores.

5. Risk Matrix Visualization

Total likelihood and consequence scores for each risk were plotted on the risk matrix (Figure A3). This visualization enables systematic comparison and prioritization across workflow stages.

Risks located in the upper-right region of the matrix represent higher-priority concerns due to the combination of elevated likelihood and consequence.

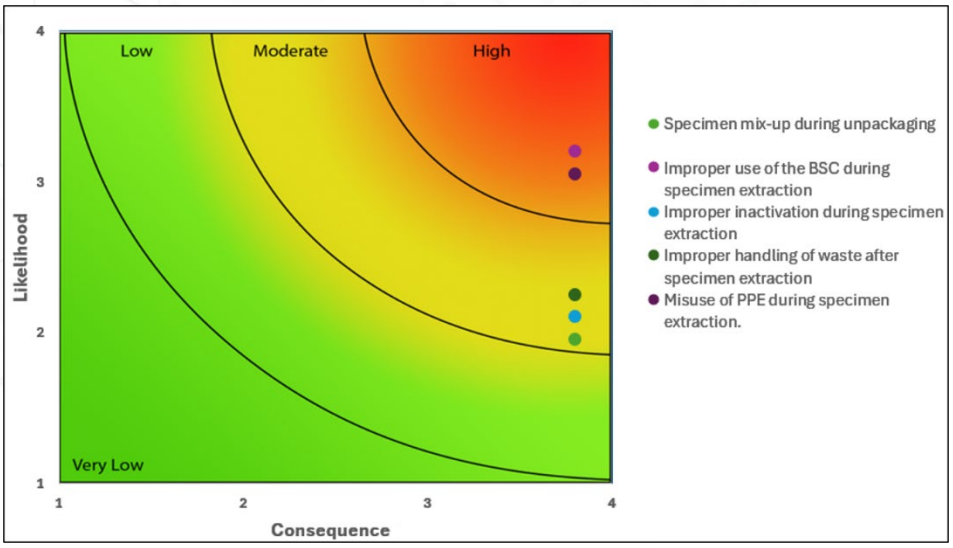


Figure A3. Risk matrix displaying the distribution of PCR workflow risks based on calculated likelihood and consequence scores. Higher-priority risks are positioned in the upper-right region of the matrix.

6. Risk Acceptability

Risk acceptability is determined by institutional decision-makers using the matrix results as one input. Matrix position should be considered together with institutional risk tolerance, regulatory requirements, available mitigation measures, resource constraints, uncertainty, and the benefits of the work.

For demonstration purposes only, this example assumes that the institution has established internal criteria for interpreting the matrix results. Under these example criteria, risks plotted in the high-risk region are treated as requiring mitigation before proceeding. Risks in moderate or lower regions may be acceptable under existing controls but should be monitored and periodically reassessed.

Based on these example criteria, the following risks were prioritized for targeted mitigation:

- Improper use of the BSC during specimen extraction
- Misuse of PPE during specimen extraction

These risks were selected because they were plotted in the high-risk region of the matrix. Final acceptance of any residual risk would be determined by the institution after mitigation is reviewed.

7. Targeted Mitigation of High-Priority Risks

Because consequence is largely determined by the biological agent and is not readily modifiable, mitigation efforts focus on reducing likelihood through strengthened controls and improved work practices.

Mitigation Example 1: Improper Use of the BSC During Specimen Extraction

Likelihood Factor	Current Score	Example Mitigation Strategy	Mitigated Score
Hazard Exposure Characteristics	4	Not modifiable	4
Staff Training and Competency	3	Targeted hands-on training; competency assessments; refresher training	1
Engineering Controls	3	Improve BSC certification and maintenance; restrict use to trained personnel	2
Administrative Controls	2	Maintain SOPs; reinforce supervisory oversight	2
Procedural Controls	4	Standardize workflows; implement step-by-step checklists	1
PPE	3	Reinforce PPE requirements during BSC use	2

Impact on Likelihood Score

- Before Mitigation: 3.20
- After Mitigation: 2.05

Mitigation Example 2: Misuse of PPE During Specimen Extraction

Likelihood Factor	Current Score	Example Mitigation Strategy	Mitigated Score
Hazard Exposure Characteristics	4	Not modifiable	4
Staff Training and Competency	3	Reinforce PPE training; competency evaluations; refresher training	1
Engineering Controls	2	Maintain existing controls	2
Administrative Controls	3	Strengthen PPE policies and enforcement	2
Procedural Controls	3	Standardize donning/doffing procedures; use visual guides	1
PPE	3	Ensure appropriate selection and availability	1

Impact on Likelihood Score

- Before Mitigation: 3.05
- After Mitigation: 1.9

These reductions shift both risks from high to moderate categories (Figure A4), demonstrating that targeted multi-factor interventions can reduce exposure likelihood, rather than relying on a single intervention.

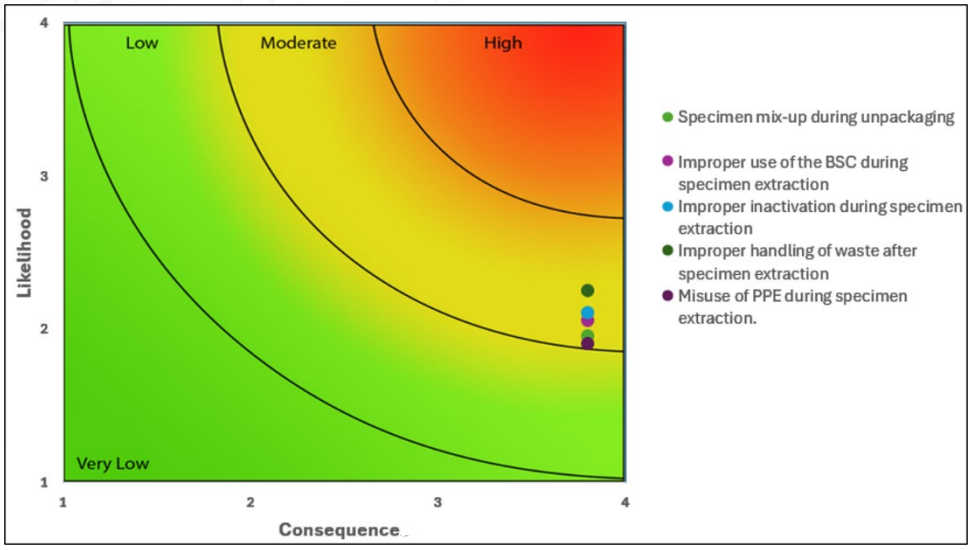


Figure A4. Risk matrix demonstrating the shift in risk levels following implementation of targeted mitigation measures, with previously high-risk scenarios reduced to moderate levels.

Evaluation and Continuous Improvement

Following implementation of mitigation measures, institutions should evaluate effectiveness through:

- Review of incident reports and nonconformances
- Audit findings and inspection results
- Performance indicators and quality metrics
- Assessment of staff competency and adherence to procedures

Risk assessments should be updated periodically and whenever changes occur in workflows, personnel, equipment, or hazards. Continuous evaluation helps ensure that control measures remain effective and that residual risks remain aligned with institutional risk criteria.