



**RECOMMENDATIONS
OF THE
SWGDM AD HOC WORKING GROUP ON
GENOTYPING RESULTS REPORTED AS LIKELIHOOD RATIOS**

Given the increasing usage and interest in probabilistic genotyping among forensic DNA testing laboratories, the Scientific Working Group on DNA Analysis Methods (SWGDM) empaneled an Ad Hoc Working Group to inform on matters relating to the reporting of likelihood ratios (LRs). This group was comprised of experts in the application of statistical principles to forensic evidence and forensic practitioners with expertise in the interpretation of mixed DNA specimens and probabilistic genotyping. Four paramount topics were evaluated by the Working Group through review of relevant scientific literature, consideration of published and shared empirical data from the testing of probabilistic genotyping systems, and discussion. These topics are as follows:

- Reporting likelihood ratio values to convey statistical weight, and a scale of supplementary verbal qualifiers based on the magnitude of likelihood ratios;
- Reporting a likelihood ratio that supports the defense proposition as an exclusion;
- The potential for adventitious support for a false proposition; and
- The conclusiveness of likelihood ratios relative to their magnitude.

These recommendations afford a framework to promote consistency among laboratories in reporting the results of direct comparisons of evidentiary and reference profiles. These recommendations apply to likelihood ratios derived from probabilistic and binary interpretation approaches, as well as kinship analyses. They provide guidance *ad interim* as SWGDM further develops its *Interpretation Guidelines for Autosomal STR Typing by Forensic DNA Testing Laboratories* to include probabilistic methods of interpretation. These recommendations are not intended to be applied to the results of familial and other database searching. This document was accepted by the membership of SWGDM, received approval of the Executive Board of SWGDM on July 12, 2018, and is not intended to be applied retroactively.

1. REPORTING OF QUANTITATIVE AND QUALITATIVE STATEMENTS TO CONVEY LIKELIHOOD RATIOS

Standard 11.2.6 of the *Quality Assurance Standards for Forensic DNA Testing Laboratories*

(QAS) requires that casework reports include a quantitative or qualitative statement to convey the results of DNA testing.

Recommendation 1.1: The numerical value for a likelihood ratio shall be reported as a quantitative estimate of statistical weight for both H_p - and H_a -supporting proposition pairs, with the exception of results deemed exclusionary as discussed in Recommendation 2.1.

$LRs > 1$ provide greater support for the prosecution proposition (H_p) than for the defense proposition (H_a). $LRs < 1$ may be reported as the reciprocal of the likelihood ratio to indicate the degree of support for H_a relative to H_p . In this manner, a likelihood ratio of 0.01 (1/100), for example, would reflect the probability of the DNA evidence being 100 times more likely if the DNA originated from an unknown, unrelated individual (H_a) than if it originated from the person of interest (H_p).

If likelihood ratios are calculated for different population groups (e.g., African American, Caucasian, Hispanic) or are generated through replicate analysis, and only a single likelihood ratio is to be reported, the lowest value should be used; however, all calculated values must be maintained in the case notes. A likelihood ratio that combines information from the different population groups (e.g., weighted averages of the likelihoods) may be used in lieu of the single lowest value (Triggs *et al.*, 2000).

Recommendation 1.2: A qualitative statement that conveys the degree of support indicated by the likelihood ratio may be reported in addition to the numerical value for the likelihood ratio. The qualitative statement, if provided, should be reported in accordance with the verbal scale provided herein.

To aid the court or other laypersons in understanding evidential strength, Ian Evett (1987) suggested a scale of verbal qualifiers to convey the degree of support for a given proposition as related to the magnitude of the likelihood ratio. The scale categorized likelihood ratio values as limited, moderate, strong and very strong in support of one proposition relative to an alternative proposition. The use of a verbal scale is supported across various disciplines of forensic science and has been adopted by the Association of Forensic Science Providers (AFSP, 2009) and the European Network of Forensic Science Institutes (ENFSI, 2015).

A verbal qualifier may be used to express the degree of support for a specified proposition relative to an alternative proposition. It is intended to complement the expert’s opinion and should not be communicated without a numerical value for the likelihood ratio. When used in reports and testimony by forensic analysts within and among different laboratories, the use of the same verbal scale promotes a consistent representation of evidential weight. If a qualitative statement is reported in conjunction with the likelihood ratio, SWGDAM recommends the likelihood ratio ranges and terms provided

Table 1. Scale of verbal qualifiers for reporting likelihood ratios

LR for H_p Support and $1/LR$ for H_a Support	Verbal Qualifier
1	Uninformative
2 – 99	Limited Support
100 – 9,999	Moderate Support
10,000 – 999,999	Strong Support
$\geq 1,000,000$	Very Strong Support

in *Table 1*, adapted from published scales to reflect results from empirical testing (discussed below) for usage with results from all likelihood ratios. As exemplified for a two-person mixture, likelihood ratio results may be reported using the following quantitative and qualitative statements demonstrating application of the SWGDAM verbal scale:

The DNA typing results for Item 1 are 23 billion times more likely if they originated from SMITH and an unknown, unrelated individual than if they originated from two unknown, unrelated individuals. This analysis provides very strong support for the proposition that SMITH is a contributor to the DNA obtained from Item 1.

If a verbal qualifier is reported, the laboratory report should include the entire scale for purposes of providing context to any numerical value and may include an explanation of the scale, such as follows:

Equal (or nearly equal) support for both propositions results in a likelihood ratio of 1, which is qualified as Uninformative. As likelihood ratios increase in magnitude, the scale reflects stronger degrees of support. Likelihood ratios occur on a continuum; the categories recommended here have been chosen in part based on the observation that adventitious support for a proposition (e.g., $LR > 1$ for an individual whose DNA is not present in the sample; or $LR < 1$ for an individual whose DNA is present in the sample) is most commonly observed within the

Limited Support category and generally not expected within the Very Strong Support category.

2. REPORTING AN EXCLUSION BASED ON LIKELIHOOD RATIOS THAT SUPPORT THE DEFENSE PROPOSITION

Recommendation 2.1: A laboratory may establish a likelihood ratio value below which an individual may be excluded as a possible contributor rather than reporting a likelihood ratio value that supports the defense proposition.

Laboratories may adopt a level of support for H_d below which they conclude that the analysis supports reporting an exclusion. The numerical value upon which such a determination is based may be identified by the laboratory using data from internal validation (described in the SWGDAM *Guidelines for the Validation of Probabilistic Genotyping Systems*) or appropriate published studies of the sensitivity of a probabilistic genotyping system. In these studies, failure to return support for H_p when evaluating a true contributor to a mixture (e.g., low-level and/or partial profile) may occur merely due to the detection limits of the typing system (e.g., STR amplification kit and/or capillary electrophoresis instrument). With a sufficient dataset from low-level contributor testing, such studies may be used to identify a likelihood ratio value below which the preponderance of results correspond to true non-contributor testing; this value may be used to establish an upper bound for declaring an exclusion. It is recommended that this value be at most 1/100.

The likelihood ratio need not be reported for an exclusion, but the upper bound upon which the determination is made should be specified in the report. All calculated values must be maintained in the case notes.

3. REPORTING LIKELIHOOD RATIO VALUES THAT ARE CLOSE TO ONE

Recommendation 3.1: A likelihood ratio appropriately conveys the weight of the evidence and should not be reported as inconclusive based on its magnitude.

As likelihood ratios approach 1, the support for a given proposition decreases, and the probability of adventitious support for an incorrect proposition increases. However, with the exception of results deemed exclusionary as discussed in Recommendation 2.1, likelihood ratios appropriately express the strength of the evidence and should be reported no matter how low or high the numerical value.

Numerical values in the Limited Support for H_p range are comparable to Random Match Probabilities (RMPs) or Combined Probabilities of Inclusion (CPIs) that have been reported irrespective of magnitude (e.g., 1 in 5 or 1 in 100) despite the possibility that a non-contributor might not be excluded as a possible contributor to the evidence. As with RMPs or CPIs, likelihood ratios should not be deemed inconclusive to mitigate a potential risk of adventitious support.

Similarly, any analysis that provides Limited Support for H_d , no matter how close to 1, should be reported as support for H_d rather than as inconclusive. Calculations performed using different populations or replicate analyses that result in likelihood ratios supporting opposing hypotheses (e.g., 10 supporting H_p and 0.1 supporting H_d) should not be deemed inconclusive. If a single likelihood ratio is reported, the lowest value should be used as in Recommendation 1.1.

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