Nederlands Forensisch Instituut
Ministerie van Veiligheid en Justitie

Framework for Registration, Classification and Evaluation of errors in the Forensic DNA

Typing Process

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Transparency and accountability in forensics

- Transparency is a key characteristic of forensic institutes and their professionals: they are open in the clear disclosure of processes, guidelines but also failures.
- Forensic institutes like the NFI are answerable for their actions and there is redress when the investigation does not meet the quality standards.

Daubert validity factors for scientific evidence

- Whether the technique upon which the evidence rests has been scientifically tested.
- Whether the technique has been subjected to peer review or publication.
- General acceptance in the scientific community.
- Known or potential **rate of error.**

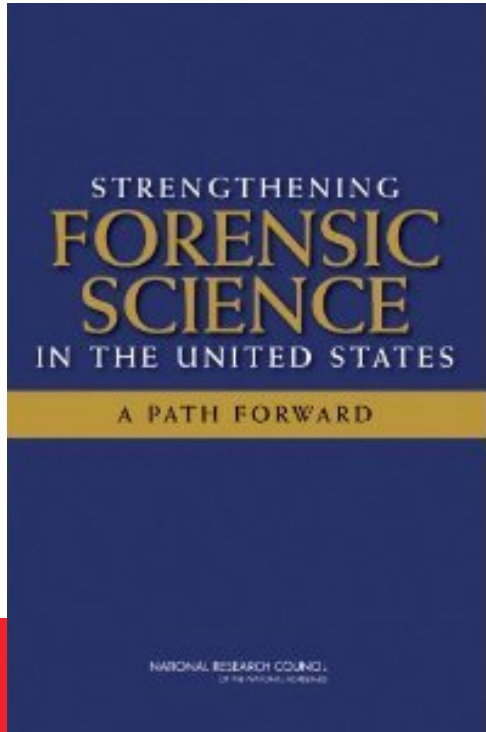
The Daubert standard does not provide a specific definition for rate of error.

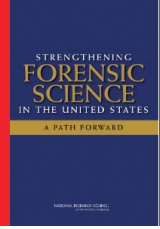
The Quality Management System

- Achieving a 99,9% level of quality means accepting a 0,1% error rate.
- Some failures can have great consequences.

Definition of the error rate in forensic science

- The National Research Council has defined **error rates** as **misidentifications** *"proportions of cases in which the analysis led to a false conclusion (as the percent of incorrectly identified cases among all those analysed)".*

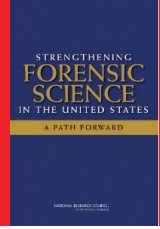




Error rate in forensic science

The error rate includes both type 1 (false positive) errors and type 2 (false negative) errors.

- A type 1 error in forensic DNA analysis is the event where the DNA profile of the reference sample from a suspect is incorrectly concluded to match with the crime sample;
- A type 2 error is the event of wrongly reporting a non DNA match between two samples when in truth there is one.



Error rate in forensic science

- To prevent false convictions facts on the rate of type I errors is of particular relevance to the criminal justice system.

- Lack of knowledge of the true rate of error creates an important element of uncertainty about the value of DNA evidence[1].

1. William C. Thompson, Franco Taroni and Colin G. G. Aitken (2003); How the Probability of a False Positive Affects the Value of DNA Evidence *J Forensic Sci* ***48*** *1-8*

Type 1 and type 2 errors at the NFI 2008-2012

Definition:

- Wrongful DNA match (or non match) reported to the authorities (public prosecutor)
- Misidentification notified by internal control or external notification by police or prosecution service
- Characteristic: all defenses have failed

	2008	2009	2010	2011	2012
Type 1 error	2	1	0	0	0
Type 2 error	4	3	1	2	4
Type 1 and type 2 error	0	2	0	0	2
Total (2008-12 = 21)	6	6	1	2	6

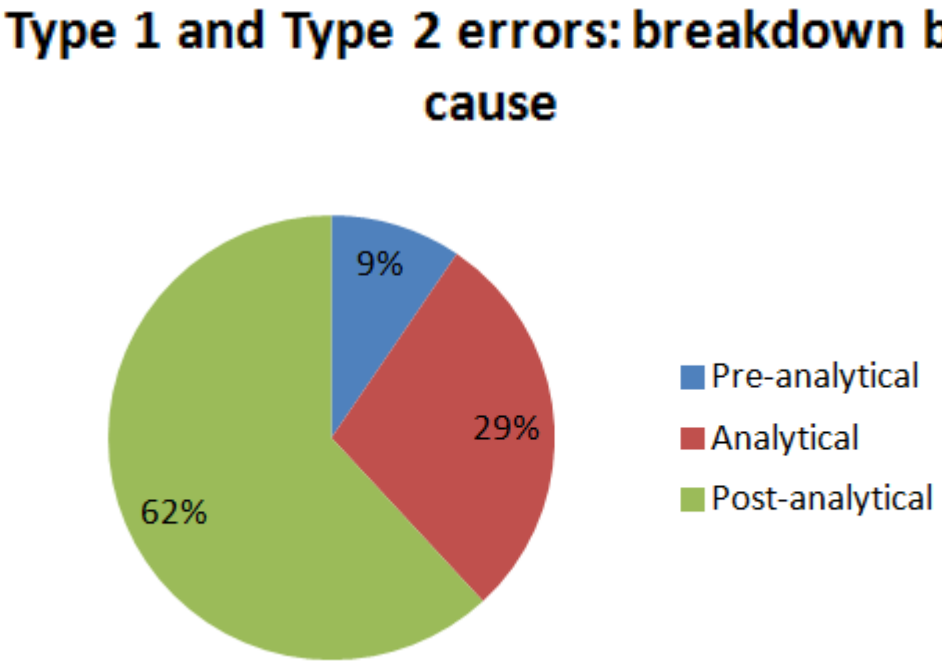
Type 1 and Type 2 errors: breakdown by cause

Errors can occur at various stages in the DNA typing process:

- Pre-analytical (sample collection, labeling and storage).
- Analytical (occurring within the laboratory and profile analysis).
- Post-analytical, whereby a correct analysis result is generated but is incorrectly evaluated or reported.

Type 1 and Type 2 errors: breakdown by cause

Conclusion: the source of most of the misidentification errors are in the post-analytical phase.



Errors 2008-2012 **(total= 21)**	
Pre-analytical	2
Analytical	6
Post-analytical	13

Error rate in forensic DNA typing

- The approach to focus exclusively on research into the rate of type 1 and type 2 errors will only partly provide insight in the actual quality status of forensic DNA laboratories.
- The actual absolute number of such errors is expected (and shown) to be low and does not allow for a comprehensive statistical evaluation or recognizing trends in the error rate of the forensic DNA typing community.

Error rate in forensic DNA typing

- It can be anticipated that a significant number of wrongful conclusions on the source of the DNA will stay undetected.
- Most cases with an incorrect DNA identification result will be noticed by the laboratory before the forensic report is released.
- Difficult to compare misidentification rates with error rates in other fields of laboratory science (i.e. clinical laboratories and genetic testing centers).

Broadening the scope of error rate

- Robust quality management is a requirement for the accreditation status of the Netherlands Forensic Institute (NFI).
- For that reason the NFI management has incorporated a registration system that allows for the registration of quality issues.
- An "*internal quality issue notification*" in relation to the laboratory analysis of biological samples is made after *any event that could lead to a failure or diminished quality of the result*.

Aim of this study

- To develop a structured procedure for the identification, classification and scoring of quality issues within a forensic DNA laboratory which can be incorporated into routine practice.
- It must allow for the prioritization of corrective actions and prevent the possibility to happen again.

Quality Issue Notifications

- The NFI has created a culture in which the existence of risk is recognized and error prevention is recognized as everybody’s responsibility.
- Notification of quality issues is part of the standard process of quality improvement.
- Notifications take place in a blame free environment.
- All staff members are authorized to report quality issues.
- Dictum: don't accept error, learn from it.

QOL Quality Issue Notification

The NFI Quality On Line (QOL) system which is available on all workstations in the laboratory contains an automated, web-based system designed to make notifications.

The QOL notification holds the following headings:

Description of the quality issue

1. Cause
2. Scale (number of samples effected)
3. Action and measures taken to correct the failure and prevent future incidents
4. Operational nature of the improvement

CSAO "De vier O system" CCKL (clinical lab): Oorzaak, Omvang, Oplossing en Operationaliteit

Assessment of Quality Issue Notifications

- All notifications are scrutinized by the QC manager of the biology department.
- Notifications are categorized and graded by potential and actual impact.

Referring to similar areas of laboratory science

i.e. Laboratory Medicine

A 'quality failure' in relation to a laboratory test is defined as any failure to meet the required output quality necessary for optimal patient care.

Maurice J O'Kane, P L Mark Lynch and Noel McGowan Ann Clin Biochem 2008; 45: 129–134

Quality failures in Laboratory Medicine

Review of the literature

Laboratory	Medical laboratory[1]	Medical laboratory[2]	Molecular genetic testing center[3]	Medical laboratory[4]
Year of Publication	1997	1998	1999	2007
Data collection period	3 months	3 years	1 year	3 months
No. of tests	40 490	676 564	88 394	51 746
No. of errors	189	4135	293	160
Frequency (% of test results)	0.47%	0.61%	0.33%	0.31%

1. Plebani M, Carraro P. Clin Chem 1997;43:1348–51
2. Stahl M, Lund ED, Brandslund I. Clin Chem 1998;44:2195–7.
3. Hofgartner WT, Tait JF. Am J Clin Pathol 1999;112:14–21.
4. Carraro P, Plebani M. Clin Chem 2007; 53:1338-1342

Quality failures in genetic testing

Quality Assessment of the Genetic Test for Familial Hypercholesterolemia in The Netherlands

Iris Kindt,[1] Roeland Huijgen,[2] Marieke Boekel,[1] Kristiaan J. van der Gaag,[3] Joep C. Defesche,[2] John J. P. Kastelein,[2] and Peter de Knijff[3]

"Mutation analysis of the other 1001 samples resulted in 10 discrepant results between the counter-expertise and reference laboratories. The overall accuracy of the reference laboratory was 99.8%, with two false positive results identified by the counter-expertise laboratory. ***Conclusion.*** *The currently used mutation analysis is associated with a very low error rate. Therefore, we do not recommend routine use of duplicate testing".*

[5] **Cholesterol 2013, Article ID 531658**

Interactive question

- What is considered an ‘acceptable’ error rate in forensic DNA testing?

- Forensic DNA typing laboratories make a certain inescapable minimum number of errors, no matter how diligent they may be.
- No official body or forensic laboratory has published yet standards on the acceptable rate of error or desirable goals for the accuracy of the forensic investigation and report.

Forensic Biology and DNA analysis at the NFI: number of quality issue notifications 2008-2012

	2008	2009	2010	2011	2012
No. of DNA-analyses	66.391	82.896	89.977	100.407	132.456
No. of notifications	328	329	435	526	572
Frequency (%)	0,5%	0,4%	0,5%	0,5%	0,4%

Laboratory	Med lab[1]	Med lab[4]	Med lab[2]	Genetic test center[3]	Genetic test center[5]
Frequency (% of test results)	0.47%	0.31%	0.61%	0.33%	0,1 %

Different categories of notifications

	2008	2009	2010	2011	2012
a. External origin	23	10	23	54	100
b. External contamination	3	0	5	24	22
c. Opportunity for improvement	11	6	3	(2)	(10)
d. Positive response	19	9	11	6	17
e. Clerical (no adverse outcome)	29	25	92	77	82
f. Not related to case work	13	9	20	10	5
g. Other (NFI related)	230	270	281	355	346
Total	328	329	435	526	572

Categories of quality issues of type g (NFI related) by cause

	2008	2009	2010	2011	2012
g. Other (NFI related)	230	270	281	355	346
Contamination	49	56	57	130	135
Human Error	105	124	135	139	114
Technical Problem	17	28	37	21	19
Deviation quality Document	0	0	3	5	2
Capacity / Planning	1	1	0	1	0
Deviation from Competence Matrix	0	1	0	0	0
Sample Mix Up	24	32	25	30	34
Other	34	28	24	29	40
Ongoing	0	0	0	0	2

Total number of contamination notifications

	2008	2009	2010	2011	2012
Contamination NFI related [g]	49	56	57	130	135
External [b]	3	0	5	24	22
Not related to casework [f]	1	2	10	4	3
Total contaminations	53	58	72	158	160

Who contaminated?

	2008	2009	2010	2011	2012
Total contaminations	53	58	72	158	160
Contamination with DNA from a staff member	21	18	17	26	53
Contamination with DNA from another sample	29	40	50	108	84
External DNA contamination	3	0	5	24	23

DNA contamination in the media

Detectives contaminate DNA traces

Laatste update: 17 april 2010 09:06

AMSTERDAM - Bij twee moordonderzoeken zijn DNA-sporen van politiemensen in de databank van het Nederlands Forensisch Instituut (NFI) beland.

Foto: NU.nlRob van der Woude

Dat blijkt uit onderzoek van de Utrechtse politie. Onderzocht wordt of ook in andere onderzoeken sprake is van vermenging of contaminatie.

Twee forensisch rechercheurs lieten hun sporen onbedoeld achter op onderzoeksmateriaal. Sinds 2008 moet iedereen die in het forensisch laboratorium komt wangslijm laten afnemen om bij eventuele vermenging van DNA-sporen deze vroegtijdig te kunnen signaleren.

Gebleken is dat twee sporen overeenkomen met het profiel van de betreffende rechercheurs.

Contaminatie

Het tweede DNA-spoor betreft het onderzoek naar de gewelddadige dood van een 93-jarige vrouw uit Utrecht in 2005. Het onderzoek in deze zaak is nog niet afgerond, wellicht mede door de besmetting van het DNA-spoor.

In de toekomst worden alle medewerkers van de forensische opsporing in de zogenoemde DNA-eliminatiedatabank van het NFI op genomen, om contaminatie tijdig te signaleren, meldt de Utrechtse politie zaterdag.

Number of reference DNA profiles in the elimination database from external crime scene workers

Before 2008	158
2008	174
2009	241
2010	410
2011	567
2012	620
2013	820
Total 09 Sept 2013	3060

What was contaminated?

	2008	2009	2010	2011	2012
Total contaminations	53	58	72	158	160
Contamination in control (blank, negative and positive control)	23	28	39	102	46
Contamination in a reference sample	9	5	6	8	40
Contamination in a crime sample	20	23	18	46	72
Contamination in wipe sample (bench monitoring)	1	2	9	2	2

Intensity of the DNA contamination in the control samples

	2008	2009	2010	2011	2012
Contamination in control (blank, positive control)	23	28	39	102	46
Sporadic contamination	9	8	17	74	18
Gross contamination (source identified)	13	12	18	24	21
Gross contamination (source not identified)	1	8	4	4	7

Potential impact of registered Quality Issue Notifications

There is an important difference in impact between quality issues that have an adverse outcome on the forensic investigation and failures that have been recognized and corrected in an early stage of the investigation.

Grading by seriousness of Quality Issues that have a potential impact on the outcome of the investigation

0 Registered quality issue has no effect on the conclusions of the NFI report.

1. Registered quality issue has a potential adverse outcome but can be corrected.

2. Registered quality issue has a potential adverse outcome and can not be corrected.

Potential impact of registered Quality Issue Notifications (NFI related)

	2008	2009	2010	2011	2012
0. No adverse outcome	39	22	78	158	125
1. Potentially negative outcome; repairable	144	197	138	155	137
2. Potentially negative outcome; irreversible	47	51	65	42	81
Under Investigation	0	0	0	0	3
Total	230	270	281	355	346

The actual impact of Quality Issue notifications

Over the period 2008-2012 we observed a total of 286 notifications where a failure with a potential negative outcome could not be corrected. We have investigated the actual impact of these notifications for the conclusions in the NFI report.

0. Failure corrected if necessary; no further consequences are expected and no revised report submitted
1. Failure with an adverse outcome for the investigation and conclusions in the report, failure is corrected after release of the forensic report and a revised report had to be submitted.
2. Failure with an adverse outcome for the investigation and conclusions in the report; failure is irreversible. Failure has been stated in the original forensic report.
3. Failure with an adverse outcome for the investigation and conclusions in the report; failure is irreversible. Failure is detected after release of the forensic report and a revised report had to be submitted.
4. Actual impact unknown.

The actual impact of Quality Issue notifications (NFI related)

	2008	2009	2010	2011	2012
Negative outcome; potentially irreversible	47	51	65	42	81
0. Failure without adverse outcome	22	16	36	20	17
1. Failure with adverse outcome; failure corrected; revised forensic report	0	0	3	0	1
2. Failure with adverse outcome; irreversible; stated in the forensic report	21	32	23	22	60
3. Failure with adverse outcome; irreversible; revised forensic report	4	3	3	0	0
4. Actual impact unknown	0	0	0	0	3

The actual impact of Quality Issue notifications

The expected negative outcome for the crime case.

- In cases, where failures have been repaired early, the NFI can reliably assume that there are no further consequences.
- The actual judicial impact of other notifications is difficult to conclude by the NFI on itself; the importance of the forensic investigation for the crime case varies and the survey involves examination of the criminal file and feedback from the judicial authorities.

Quality Issue Notifications made transparent

http://www.forensischinstituut.nl/nfi/kwaliteit/kwaliteitsrapportages

Jaar 2010

Meldings-nummer	Datum melding	Datum voorval	Melding	Categorie oorzaak	Heeft de melding geleid tot een gewijzigd rapport?	Oplossing	Categorie oplossing
IM-00809	04-01-10	04-01-10	Aangevraagd onderzoek niet uitgevoerd en uit Promis verwijderd zonder overleg.	04. Menselijke fout	nee	De reden van de verwijdering is in het dossier opgenomen. Afgesproken dat er geen vooronderzoeksactiviteiten worden verwijderd zonder overleg met de coördinator.	01. Aanpassing standaard werkwijze
IM-00810	04-01-10	04-01-10	profiel niet correct door monsterverwisseling.	09. Monsterverwisseling	nee	Aanvullend onderzoek bevestigd de verwisseling.	02. Incidenteel afwijkende werkwijze
IM-00811	07-01-10	07-01-10	Een DNA-kenmerk welke niet voldeed aan de opname criteria is toch opgenomen in	04. Menselijke fout	nee	De fout is hersteld en besproken met de betreffende medewerker. Afspraak gemaakt dat als er OL allelen in een profiel staan deze niet meer in worden geaccepteerd.	01. Aanpassing standaard werkwijze
IM-00813	07-01-10	07-01-10	Deel van het spoor tijdens vooronderzoek op de grond gevallen.	04. Menselijke fout	nee	Het voorval is gemeld in de rapportage.	02. Incidenteel afwijkende werkwijze
IM-00814	07-01-10	07-01-10	Mogelijke verwisseling tijdens inzetten van PCR.	04. Menselijke fout	nee	Melding is besproken met de betrokken medewerker. Beide monsters zijn op PCR over gegaan en de verkregen resultaten hiervan zijn vrijgegeven.	02. Incidenteel afwijkende werkwijze
IM-00815	08-01-10	08-01-10	Het SIN op de wattenstaafkoker is niet gelijk aan het SIN op pergamijnenzakje.	04. Menselijke fout	nee	De medewerker van de sporenploeg heeft uitgelegd dat de SIN op de wattenstaafkoker leidend is en heeft foto's van de bemonsteringen gestuurd (in dossier gevoegd). Van deze constatering is melding gemaakt in de rapportage.	99. Overig
IM-00816	08-01-10	08-01-10	Verwisseling in omschrijving van het sporenmateriaal.	04. Menselijke fout	nee	De fout is hersteld en besproken bij het vooronderzoeksoverleg.	02. Incidenteel afwijkende werkwijze
IM-00817	08-01-10	08-01-10	Verkeerde extractiesticker op het zakenformulier geplakt.	04. Menselijke fout	nee	De fout is hersteld.	03. Administratie aangepast
IM-00818	11-01-10	11-01-10	Verwisseling blanco en positieve controle bij een chemicaliën testrun	09. Monsterverwisseling	nee	De melding is besproken er is afgesproken dat deze stap voortaan ook gecontroleerd gaat worden door een tweede persoon. Dit is verwerkt in het desbetreffende werkvoorschrift.	01. Aanpassing standaard werkwijze
IM-00819	12-01-10	12-01-10	Uitslag van onderzoek en bemonsteringsstrategie niet op waarnemingsblad vermeld en foto's niet (meer) aanwezig.	04. Menselijke fout	nee	Melding besproken. Het verbeteren van de schaduwstappen wordt verder afgehandeld onder IM-00602.	02. Incidenteel afwijkende werkwijze
IM-00823	15-01-10	15-01-10	Verkeerde locatie in Promis van een DNA extract.	04. Menselijke fout	nee	Besproken in overleg.	02. Incidenteel afwijkende werkwijze
IM-00824	20-01-10	20-01-10	Verkregen profielen niet conform gemeten DNA-concentraties.	04. Menselijke fout	nee	Vervolgonderzoek is uitgevoerd.	02. Incidenteel afwijkende werkwijze
IM-00826	21-01-10	21-01-10	Contaminatie van een referentie	01. Contaminatie	nee	Aanvullend onderzoek is uitgevoerd. Nieuwe isolatie resulteerde in enkelvoudige profielen. Verbeterde werkwijze is afgesproken.	01. Aanpassing standaard werkwijze

NFI errors in the press

za 10 sep 2011, 05:30

Telegraaf.nl openbaart interne NFI-registraties

Honderden fouten bij dna-onderzoek

door Jolande van der Graaf

AMSTERDAM - Bij dna-onderzoek naar zware misdrijven heeft het Nederlands Forensisch Instituut (NFI) vele honderden, soms onherstelbare fouten gemaakt. Dat blijkt uit interne foutenregistraties die De Telegraaf op last van de rechter in handen kreeg. De overzichten zijn in zijn geheel op deze website terug te vinden.

"Hundreds of errors in forensic DNA analysis at the NFI"

DNA errors in the Dutch parliament

POLITIEK

CDA wil opheldering over fouten bij NFI

10-09-2011 10:46 | ANP

Het CDA wil opheldering van staatssecretaris Fred Teeven (Veiligheid en Justitie) over bijna 1700 kleine en grote fouten die in de afgelopen veertien jaar geregistreerd zijn bij het NFI (Nederlands Forensisch Instituut). CDA-Tweede Kamerlid Madeleine van Toorenburg heeft mondelinge vragen gesteld en eist een onderzoek.

"Politicians want clarification on the reported error rate in forensic DNA analysis"

Independent review of NFI notifications

"Quality issue notifications as indicator of quality"

Meldingen als teken van kwaliteit

Rapportage van een onafhankelijk onderzoek naar de betekenis van meldingen van afwijkingen in DNA-onderzoeken van het Nederlands Forensisch Instituut in de periode januari 1997 tot en met december 2010.

Prof. dr. P. de Knijff

Prof. dr. J. Lindemans

NFI process optimalization DNA NFIPOD

Bridging the gap between the pre and analytical stage of the process

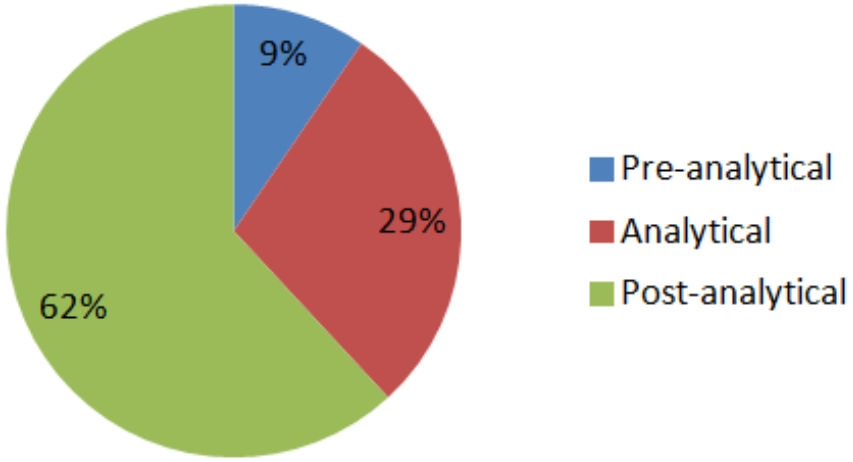
DNA NFIPOD

- Automated storing/retrieving of DNA extracts from -80 ^{o}C storage facility
- Automated sample preparing, liquid handling and analysis.
- Automating these processes will significantly reduce the risk of error in the pre-analytical and analytical process.

The post analytical process

Managing the post-laboratory phase of the total testing cycle is of equal importance.

A comprehensive process control through integration between automation and information management in the post analytical phase is expected to further improve the total testing process.



In conclusion 2008-2012

Number of DNA analyses	472,127
Number of quality issue notifications	2190
NFI related	1483
Potentially negative outcome for the CJS; irreversible	286
False inclusion; Wrong exclusion	21

Conclusions

- Quality Issue notifications have been comprehensively incorporated into the routine of the Biology department at the NFI.
- By means of a simple and consistent method for the identification, classification and grading of quality issues the notifications provide essential information on the cause of and on the potential and actual outcome.
- The notification system generates important information on the performance of the laboratory and provides objective information to prioritize corrective actions.

Publication on error rates accepted in FSI Genetics

Forensic Science International: Genetics XXX (2014) XXX–XXX

Contents lists available at ScienceDirect

Forensic Science International: Genetics

journal homepage: www.elsevier.com/locate/fsig

Error rates in forensic DNA analysis: Definition, numbers, impact and communication

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ABSTRACT

Forensic DNA casework is currently regarded as one of the most important types of forensic evidence, and important decisions in intelligence and justice are based on it. However, errors occasionally occur and may have very serious consequences. In other domains, error rates have been defined and published. The forensic domain is lagging behind concerning this transparency for various reasons.

In this paper we provide definitions and observed frequencies for different types of errors at the Human Biological Traces Department of the Netherlands Forensic Institute (NFI) over the years 2008–2012. Furthermore, we assess their actual and potential impact and describe how the NFI deals with the communication of these numbers to the legal justice system.

We conclude that the observed relative frequency of quality failures is comparable to studies from clinical laboratories and genetic testing centres. Furthermore, this frequency is constant over the five-year study period. The most common causes of failures related to the laboratory process were contamination and human error. Most human errors could be corrected, whereas gross contamination in crime samples often resulted in irreversible consequences. Hence this type of contamination is identified as the most significant source of error. Of the known contamination incidents, most were detected by the NFI quality control system before the report was issued to the authorities, and thus did not lead to flawed decisions like false convictions. However in a very limited number of cases crucial errors were detected after the report was issued, sometimes with severe consequences. Many of these errors were made in the post-analytical phase.

The error rates reported in this paper are useful for quality improvement and benchmarking, and contribute to an open research culture that promotes public trust. However, they are irrelevant in the context of a particular case. Here case-specific probabilities of undetected errors are needed. These should be reported, separately from the match probability, when requested by the court or when there are internal or external indications for error. It should also be made clear that there are various other issues to consider, like DNA transfer. Forensic statistical models, in particular Bayesian networks, may be useful to take the various uncertainties into account and demonstrate their effects on the evidential value of the forensic DNA results.

To err is human[1]

It should be in the genes of the forensic scientist to create solutions, find better alternatives and meet the challenges ahead.

[1] To Err is Human: building a safer health system. Committee on Quality of Health Care in America