

Fingerprint identification in health and demographic surveillance - does it live up to its promise?

Kobus Herbst
Colin Newell

Africa Centre for Health and Population Studies, UKZN

Introduction

- Fingerprint matching has been proposed as a record linkage method for use in health and demographic surveillance settings¹.
- Feasibility in health settings has been demonstrated²⁻⁴.
- Empirical evaluation of the performance of fingerprint identification in comparison with traditional matching approaches have not been reported.

1. Serwaa-Bonsu, A., et al., *First experiences in the implementation of biometric technology to link data from Health and Demographic Surveillance Systems with health facility data*. *Glob Health Action*, 2010. **3**.
2. Yu, K.L., et al., *Fingerprint identification of AIDS patients on ART*. *Lancet*, 2005. **365**(9469): p. 1466.
3. The SonLa Study Group, *Using a fingerprint recognition system in a vaccine trial to avoid misclassification*. *Bull World Health Organ*, 2007. **85**(1): p. 64-7.
4. Weibel, D., et al., *Demographic and health surveillance of mobile pastoralists in Chad: integration of biometric fingerprint identification into a geographical information system*. *Geospat Health*, 2008. **3**(1): p. 113-24.



Name Matching

- Record linkage based on matching individual attributes:
 - First, Middle, Last and Maiden Names
 - Sex
 - Date of Birth
 - National Identity Number
 - Place of Residence
- Techniques to deal with spelling variation in names¹:
 - Soundex method
 - Levenshtein distance
- Limitations
 - Lack sensitivity - Spelling mistakes, name changes, illiteracy, transcription errors
 - Lack specificity - Different individuals may have the same/similar names

1. Navarro G (2001). "A guided tour to approximate string matching". *ACM Computing Surveys* 33 (1): 31-88. [doi:10.1145/375360.375365](https://doi.org/10.1145/375360.375365)

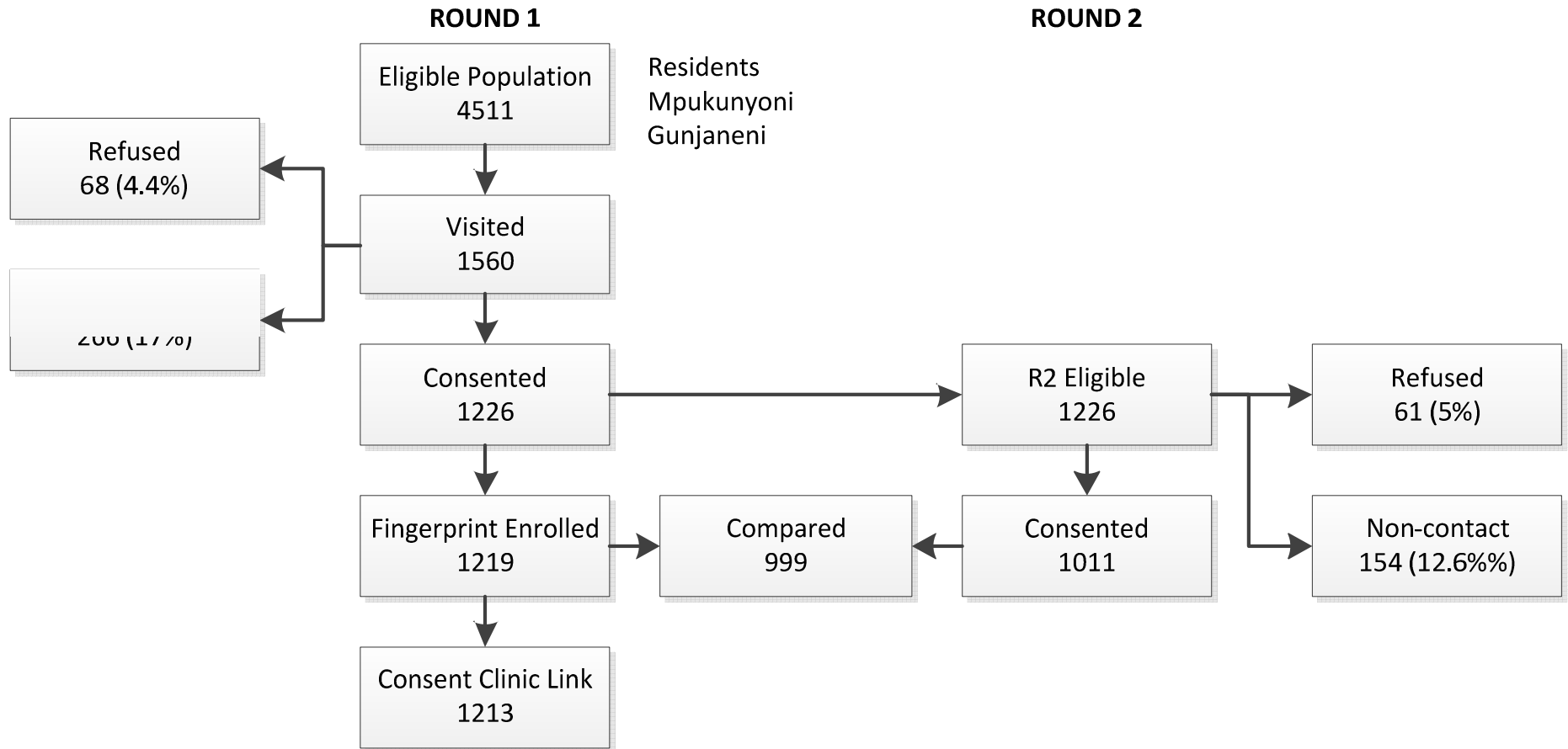


Methods

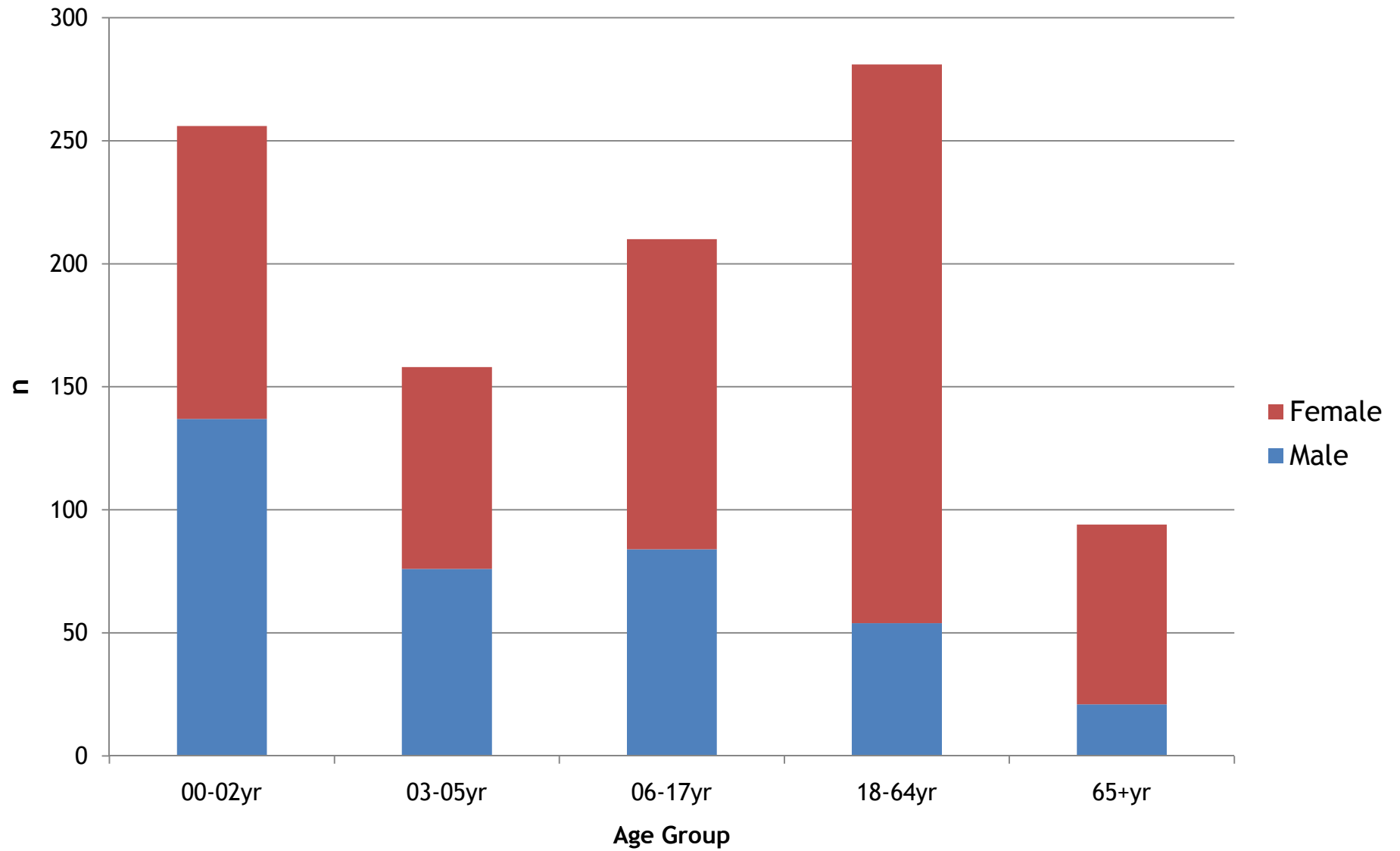
- A subset of households within the catchment areas of 2 clinics in the DSA visited
- Written consent to obtain fingerprints and to use fingerprints to link to clinic records
- Individuals enrolled in first visit revisited 6 months later and repeat fingerprints obtained
- Over the preceding 2 years an electronic medical record system was used in the six clinics in the DSA that collected fingerprints from registered patients
- Ethical approval from UKZN Biomedical Ethics Review Committee



Study Population



Age-Sex Breakdown of Fingerprint Evaluation Group (n=999)



Fingerprint Technology

- Secugen Hamster Plus finger print readers¹
- Griaule Fingerprint SDK²
- Fingerprint Enrolment:
 - Left & Right Thumb
 - Left & Right Heel, children <2 years old
- Match
 - At least one fingerprint pair exceeding threshold value
 - Each fingerprint compared to every other fingerprint

1. <http://www.secugen.com/products/php.htm>

2. http://www.griaulebiometrics.com/page/en-us/fingerprint_sdk



Name Matching

- Staged matching process using SQL Server Transact SQL queries
- Matching Score ranging from 20 - 9
 - 20 - Perfect match on names, sex, DoB and Id nr
 - 9 - Manual review of potential matches
 - 19-10 Partial matches using Soundex, Levenshtein and approximate date matching

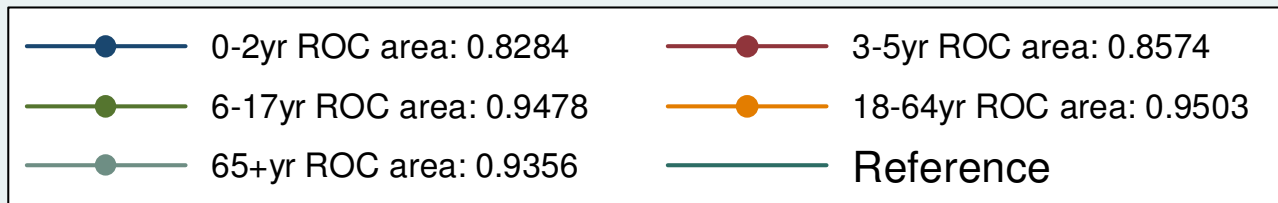
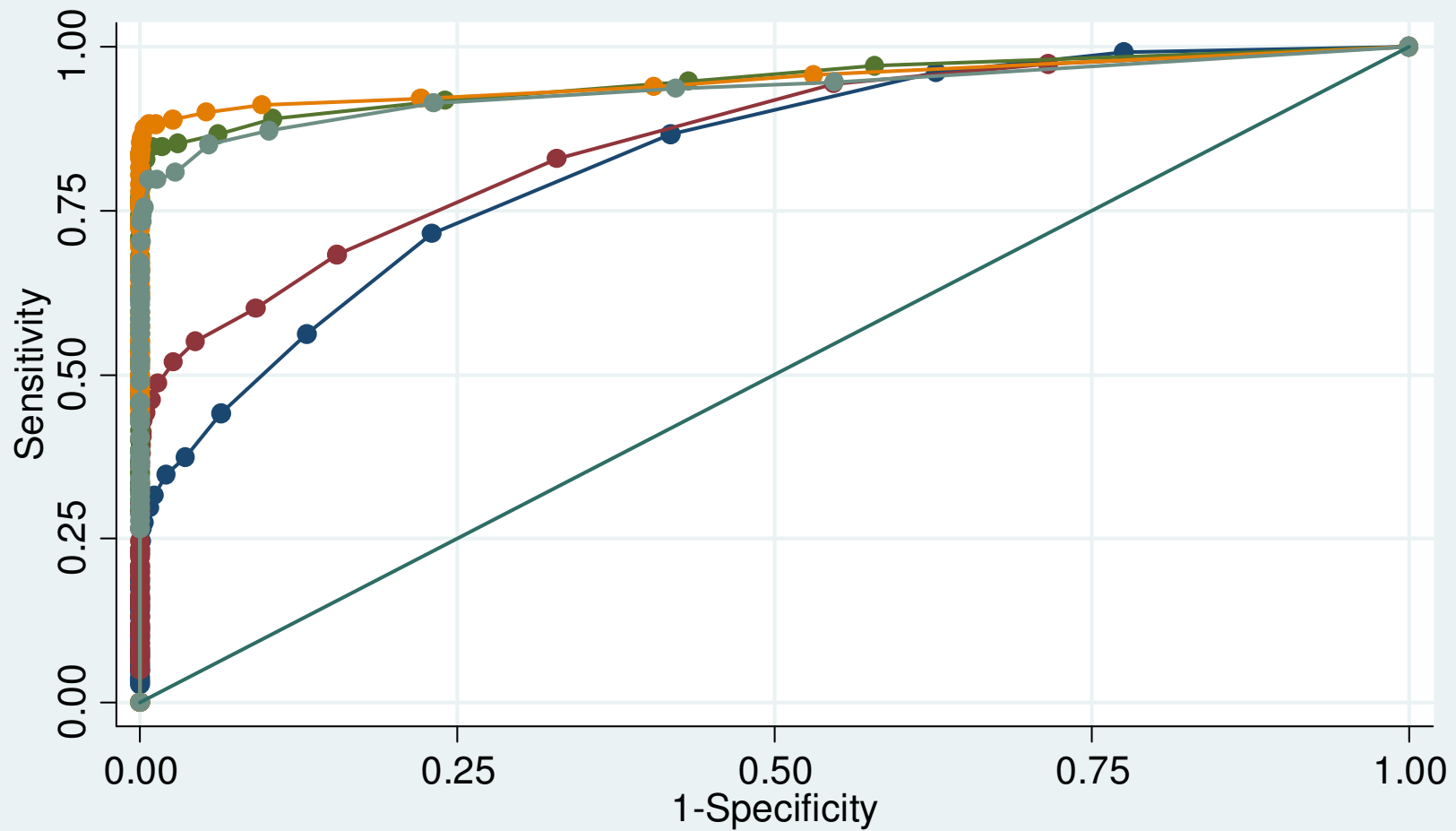


Results

- Fingerprint matching evaluation
 - Comparison of fingerprints taken at first and second visit of the same individual against matching the individual's fingerprint against those of all other individuals with fingerprints in the second round (n=999)
- Name matching evaluation
 - Comparison of performance of fingerprint matching of individuals with fingerprints to clinic database against name matching of the same individuals against the clinic database (n=1213, 37339)



Receiver-operating Curve



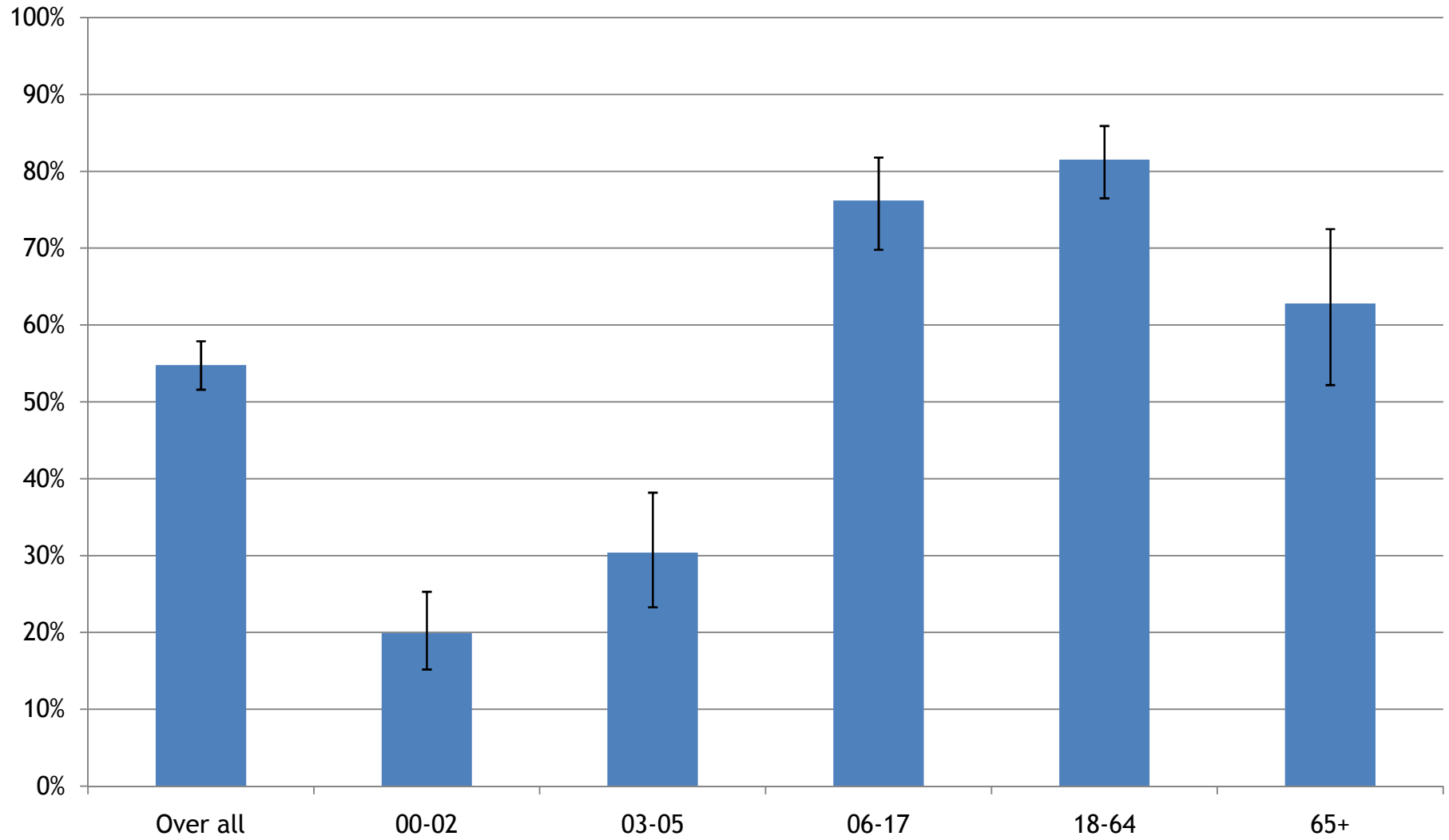
Matching Threshold Values

Threshold	Overall		00-02yr		03-05yr		06-17yr		18-64yr		65+yr	
	Sens	Spec	Sens	Spec	Sens	Spec	Sens	Spec	Sens	Spec	Sens	Spec
16	57.36%	99.98%	23.44%	99.97%	36.71%	99.97%	76.67%	99.99%	82.92%	99.99%	64.89%	99.99%
17	56.36%	99.99%	22.66%	99.98%	36.08%	99.98%	76.19%	99.99%	81.49%	100.00%	62.77%	100.00%
18	55.06%	99.99%	20.70%	99.99%	33.54%	99.99%	76.19%	100.00%	80.43%	100.00%	61.70%	100.00%
19	53.95%	100.00%	19.92%	99.99%	32.91%	99.99%	74.29%	100.00%	79.00%	100.00%	61.70%	100.00%
20	53.15%	100.00%	18.75%	100.00%	32.28%	99.99%	73.81%	100.00%	77.94%	100.00%	61.70%	100.00%
21					30.38%	100.00%						



Sensitivity of Fingerprint Identification by Age Group

$P(\text{FP Match} \mid \text{Same Individual})$



Why?



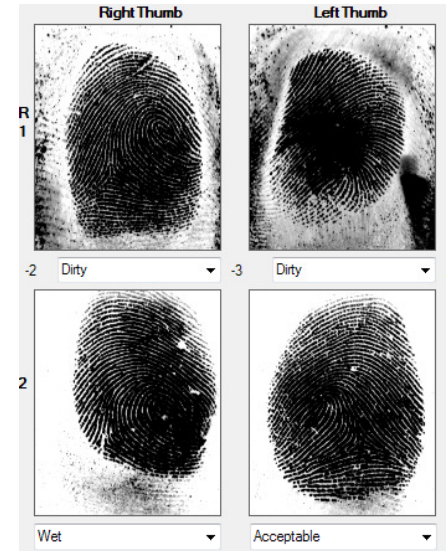
Positioning



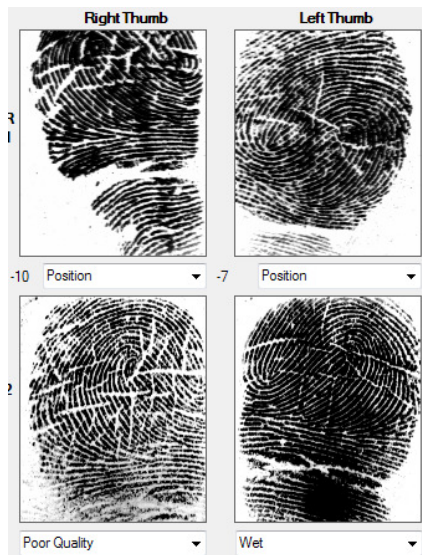
Dry Prints



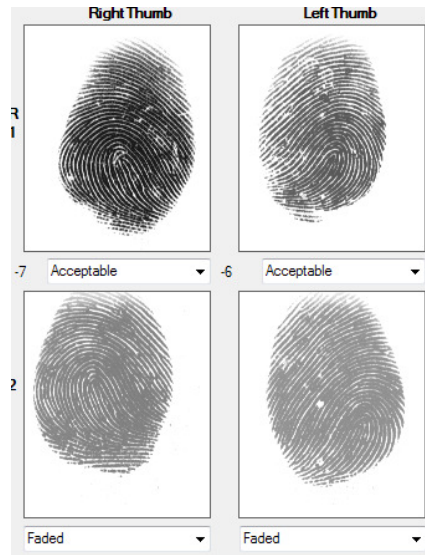
Wet Prints



Dirty Sensor



Poor Quality



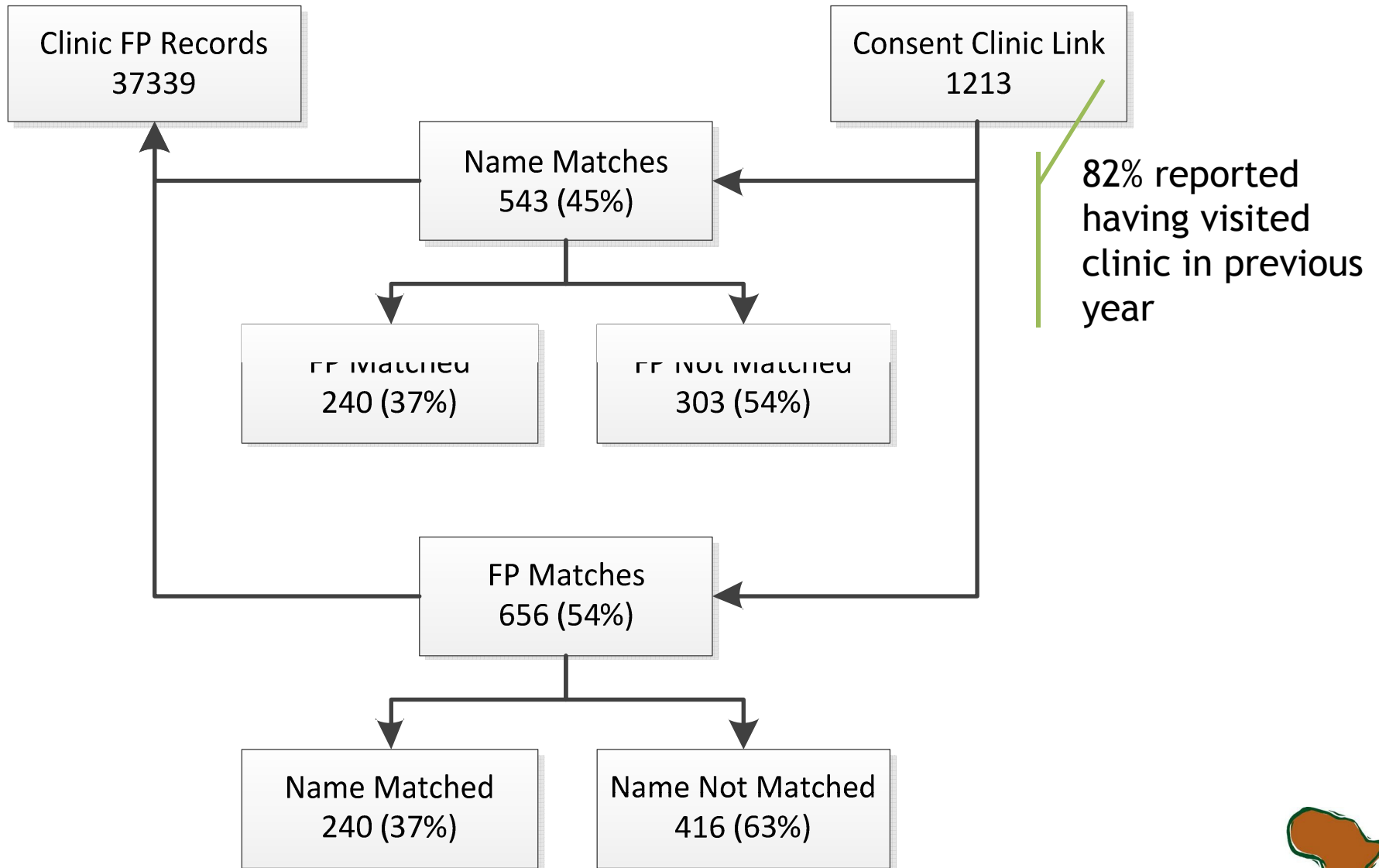
Faded



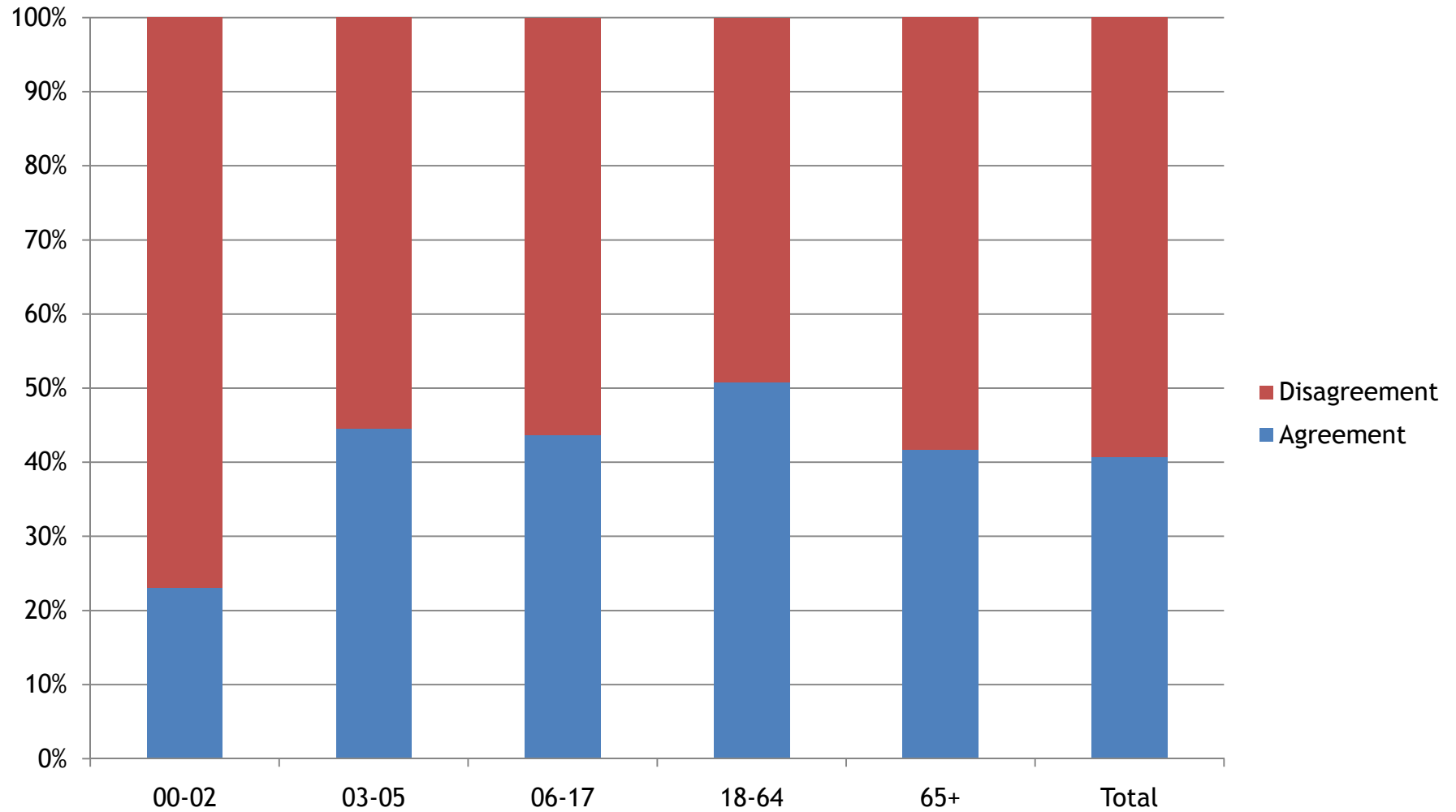
Combination



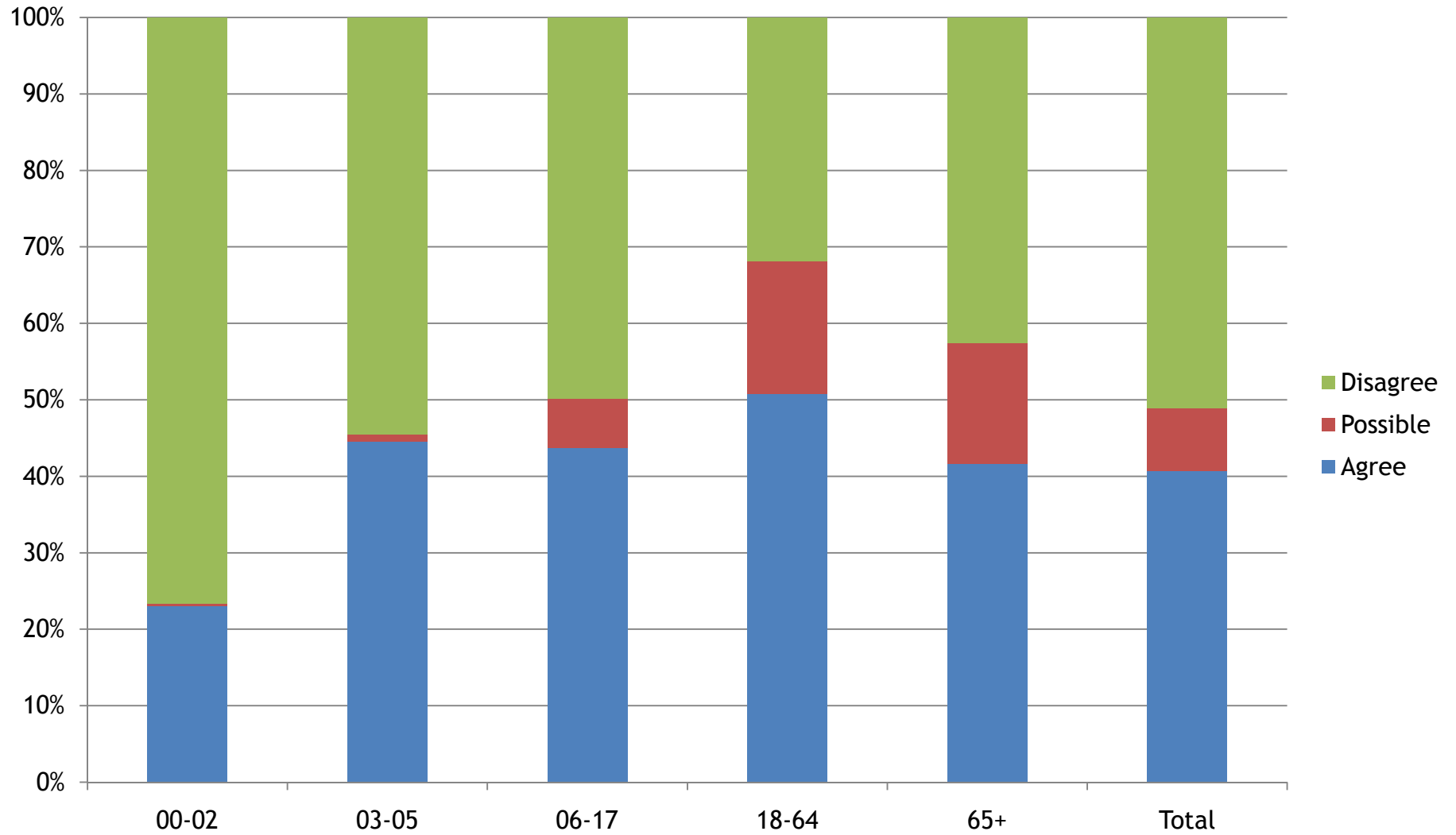
Name Matching Comparison



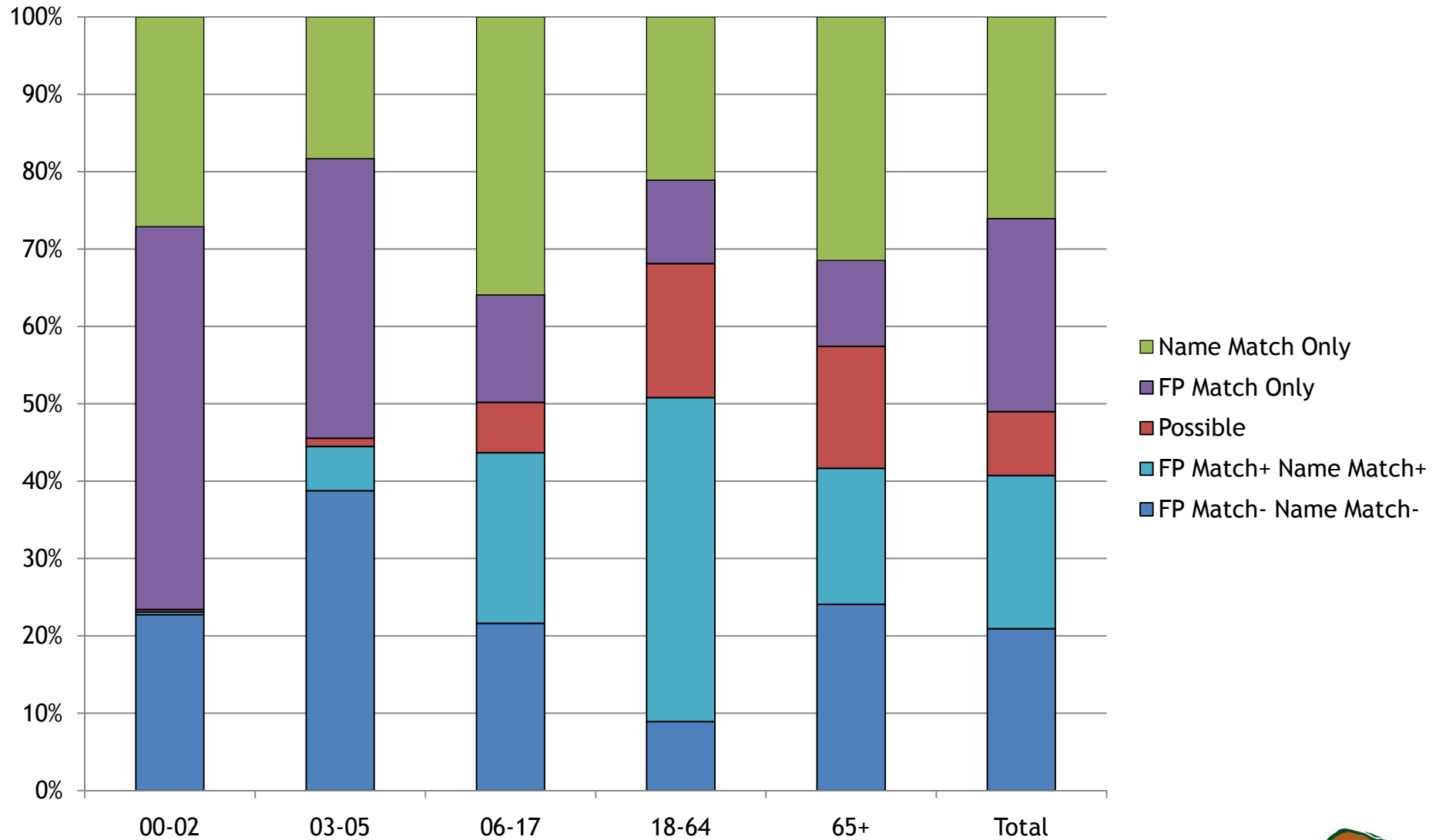
Agreement between Fingerprint Matching and Individual Attribute Matching (n=1231)



Possible Linkages Identified by Fingerprint Matching (n=1231)



Consolidated Results Name and Fingerprint Matching (n=1231)



Fingerprint Match Only

- 100% Specificity is not really that but:
 - A false positive rate of 0.0046%
 - = 1.7 false matches per individual being compared out of 37 339 comparison population
 - = 2062 possible false matches from the 1213 comparisons!
- Problem : How do I choose which individuals with fingerprint match only to include in the true matches?



Name Match Only

- Fingerprint match sensitivity low = $\Pr(\text{Fingerprint Match} \mid \text{Same Individual})$
- So:
 - Which cases should be excluded because they are false name matches
 - Or
 - Which cases should be included because they are false negative fingerprint matches



Conclusions

- Not possible to use fingerprint matching as a gold standard against which name matching can be evaluated.
- Fingerprint information can improve matching success rates when used in conjunction with more traditional name matching techniques, but the improvement is not dramatic
- Fingerprint-only matching cannot be used as an alternative to name matching.



Acknowledgements

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