

Forensic DNA database and criminal investigation in the Sahel region: a need to update the national security policy?

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Abstract

Ongoing terrorist attacks in the Sahel region call for strengthening the security system by using human DNA identification technology. In this context, public opinion must be considered when establishing solid standards and universal safeguards for one of the most invasive forms of surveillance and profiling. For this purpose, we gathered internet users' opinions in Burkina Faso (a country located in the Sahel region) on the use of DNA technology to support criminal investigations. The results revealed that 91.7% (431) of the 470 participants believed that this technology is currently necessary for the Burkina Faso's criminal justice system. However, the respondents expressed concerns about the custody and management of a national forensic DNA database. In this particular security setting, the public opinion of this study may provide leaders and political policymakers with clues for considering genetic fingerprints and implementing a national forensic DNA database to support criminal investigations in Burkina Faso whilst also considering the ethical implications.

Keywords: terrorism; Sahel region; DNA database; security policy; public opinion; Burkina Faso

Introduction

Since the second half of the 1980s, science has made it possible to identify individuals using highly variable genetic sequences of human DNA. The prominent tool currently used in forensic genetics is the short tandem repeat (STR) locus [1]. These target areas of DNA are, for the most part, unique to each human being (except for identical twins). Nearly 40 years after this discovery, related technologies have evolved considerably in several aspects [2]. Thus, over the last 20 years, it has been considered a new gold standard for forensic science identification [3].

Furthermore, DNA databases that store autosomal STR profiles have emerged as powerful tools for investigating crime worldwide [4]. Currently, the primary trend is the matching or comparison of a set of core STR locus profiles from crime scenes with those stored in criminal or offender DNA databases [5]. This constitutes one of the most significant crime-fighting inventions in modern human history, supplying critical information and saving officers time and resources. Although DNA databases are widely used, they

also raise concerns about privacy, data security, and fairness [6]. Thus, what is the status of DNA technology in the Sahel region, particularly in the Burkina Faso (BF)?

Since January 2016, following the Cappuccino and Hotel Splendid attacks claimed by terrorist organizations [7], the security situation in BF, a developing country located in the middle of West Africa, has undergone a remarkable turnaround. Since then, the country has been subjected to a series of terrorist attacks in its northern and eastern regions, many of which have had devastating repercussions. The security system has constantly evolved to address this new threat, which the 21 million BF population [8] initially knew only about through media. This adaptation of the security system requires implementing the latest technology to provide scientific solutions to the justice system and to update the national security policy. According to the International Criminal Police Organization (INTERPOL) [9] report published in 2020, only 11 countries in Africa have used DNA profiling for police investigations. Of these, only seven have reported a DNA database. In West Africa, only

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the Republic of Ghana and the BF have acknowledged the use of DNA profiling in police investigations [10]. However, none of these West African countries has a national forensic DNA database (NFDD) to support criminal investigations. From a legislative perspective, until now, no specific laws in criminal justice have been dedicated to DNA fingerprinting in the BF. Moreover, because of the lack of forensic laboratories in the country, most paternity tests and forensic examinations of crime scene materials to identify criminals, for example, are still sent to foreign countries such as France, Spain, and Belgium. This method is very expensive and time-consuming for the country, as the demand is growing [11]. According to some testimonials, many criminal trials have not been made or have not obtained a satisfactory outcome because of the lack of local expertise in DNA fingerprinting. In a developing country like BF, where many public resources compete for attention and funding, combined with new security challenges that threaten the country's stability, it seems essential to probe public opinion on the use of scientific advancements involving DNA in BF. For this purpose, we designed a survey to be administered to internet users of BF. Based on the results of the public view, we discussed public awareness about using DNA evidence in the courtroom and the need to update national security laws for BF and, eventually, for all Sahel states. This article could provide leaders and political policymakers with guidance to consider DNA evidence to aid criminal investigations in the BF and Sahel region countries, whilst keeping ethical concerns in mind.

Materials and methods

Sampling

This was convenience sampling, as the respondents were internet users who mainly belonged to the middle class of society. The participants were required to be at least 16 years old to participate in the survey. We limited the number of surveys completed by each respondent to one using Google Forms during the data collection. Most multiple-choice questions were mandatory, and could not be omitted. However, questions that allowed participants to include a written statement to justify a decision or to express a personal opinion were optional.

The questionnaire (Supplementary Table S1) was written in French. It was accessible from 21 February to 5 April 2021. The authors sent the link to the targeted groups through various channels (WhatsApp, Facebook, and e-mail). The participants were also encouraged to share the link with their Burkinabe colleagues and friends.

Questions submitted to the participants

The questionnaire consisted of eight parts beginning with sociodemographic characteristics (gender, age, education, and occupation). The second part assessed respondents' knowledge of using DNA to solve crimes and how they learned about it. The third part concerned public opinion regarding the general aspects of running an NFDD. This section included questions about the need for an NFDD to support criminal investigations in BF, the authority that should manage such a database, and the criteria that should motivate the registration of DNA profiles. The fourth section of the survey requested the public's view on including convicted criminals' DNA profiles in the NFDD and their retention times. In the fifth section, respondents were asked to consider factors that would make the NFDD a relevant resource for DNA surveillance. In the sixth section, respondents were asked to give their

opinions on the violation of privacy concerning the establishment of an NFDD. The question was whether the respondents voluntarily provided their DNA profiles to such an NFDD.

The seventh section of the questionnaire asked respondents whether they knew the current means available to support criminal investigations in BF. In this regard, we inquired whether respondents believed that the national police used DNA in criminal investigations. In addition, we asked whether the national police should be equipped with scientific and, especially, genetic laboratories to support criminal investigations, knowing the financial burden that such an initiative could create for the state budget. Furthermore, respondents responded to the question, "Do you think forensic DNA analysis should be performed by the private sector or by an independent state institution?" The final part, which was optional, invited the public to discuss their thoughts and concerns regarding the survey with the authors of the study. Owing to the complexity of the data, only the significant results are presented.

Statistical evaluation of the data

Microsoft Excel was used to record the data, and the Statistical Package for Social Sciences version 23.0 (<https://www.ibm.com/support/pages/downloading-ibm-spss-statistics-23>) was used to analyze the data. Responses were compared using Pearson's Chi-square test, and the results are presented as counts and percentages. To analyze variations in the results, we considered the variables of gender, age, educational level, and profession. Statistical significance was set at $P < 0.05$.

Results

Demographic characteristics parameters

During the survey window, 470 participants completed the questionnaire and submitted their responses online (Table 1). Of these, 81.1% ($n = 381$) were male and 18.9% ($n = 89$) were female. The participants were mostly young, with 64.5% ($n = 303$) aged between 16 and 35 years, 35.1% ($n = 165$) aged between 36 and 60 years, and only 0.4% ($n = 2$) aged over 60 years. Furthermore, a majority (63.0%) of the participants had a university education (27.0% held a PhD), and only 10% had a high school education level. Based on the respondents'

Table 1. Demographic characteristics of respondents ($N = 470$).

| Item | n (%) ^a |
|--|----------------------|
| Gender | |
| Male | 381 (81.1) |
| Female | 89 (18.9) |
| Age (years) | |
| 16–35 | 303 (64.5) |
| 36–60 | 165 (35.1) |
| Over 60 | 2 (0.4) |
| Education level | |
| High school diploma | 47 (10.0) |
| Bachelor's or master's degree | 296 (63.0) |
| Doctoral degree | 127 (27.0) |
| Profession ^b | |
| <i>Lawyer, prosecutor, etc.</i> | 65 (13.8) |
| <i>Police officer, forensic expert</i> | 94 (20.0) |
| <i>Professor, researcher, etc.</i> | 72 (15.3) |
| <i>Student</i> | 119 (25.3) |
| Other | 120 (25.5) |

^aPercentages may not sum up to 100 due rounding. ^bBold: professional; italic: insiders; normal: laypersons

professions, 33.8% were classified as experts or forensic professionals, 40.6% as insiders, and 25.5% as laypersons.

Assessment of respondents' knowledge about the utilization of DNA to solve crimes

In determining the level of awareness of the prominent role of DNA in solving crimes, 64.9% of the participants felt that they were reasonably well informed about the potential of using DNA to solve crimes compared with 17.9% who said that they did not have enough information on this subject. The remaining 14.9% were unsure of the details needed to respond to this question and 2.3% were undecided (Figure 1A). Amongst the respondents, a plurality of 30.6% said they had learned about the ability of DNA to solve crimes from the media, 29.9% learned from their high school, 19.3% from fictional films, 5.8% from reading books, and 14.4% from other outlets (Figure 1B).

Respondents' opinions on the importance, custody, and management of the NFDD

Most respondents (91.7%) felt that establishing a DNA database to support criminal investigations in BF was essential (Table 2). Respondents were divided according to their views on who should be responsible for the custody and management of an NFDD; a slight plurality of 33.8% felt that the custody and management of an NFDD should be entrusted to an autonomous state institution other than the national police (Table 3). In comparison, 24.5% of respondents believed that the database should be assigned to the National Police Service. Similarly, 23.4% believed that it should be the responsibility of the Ministry of Security, while only 2.6% replied that it should not be entrusted to any of the institutions mentioned. In terms of profession, the majority of

laypersons (44.2%) preferred management by an autonomous institution, followed by insiders (36.6%), and experts (22.6%). This result indicates that laypersons seemed to have more confidence in independent institutions ($P = 0.01$). Indeed, in the comments section, many respondents defended these answers by stating that custody and management of the NFDD should not remain the sole prerogative of the main actors, namely, professionals in the criminal justice system.

Respondents' views on the criteria for retaining DNA profiles in an NFDD

Figure 1E shows the responses to questions on the types of offences that should lead to retention of the DNA profiles of offenders. The majority (51.7%) felt that the DNA profiles of individuals responsible for all crimes and offences should be stored in the NFDD. However, 33.6% would like this to be limited to all crimes and 13.2% would favour it being limited to severe crimes.

Regarding how long the DNA profile should be retained in the NFDD, 64% of respondents stated that it should be retained indefinitely. In comparison, only 25.5% preferred that the profiles be held until the death of the offenders and 8.1% preferred that the DNA profiles be kept in the database until the acquittal of the offenders in question (Figure 1F).

What are the main factors that make a DNA database a relevant resource for genetic monitoring?

Next, 49.6% of respondents felt that establishing an NFDD could be justified in the context of family tracing (Supplementary Table S1A). This proportion was 79.6% when addressing specific concerns such as natural disasters and terrorist attacks (Supplementary Table S1B). On the other hand, when the question was about international collaboration in the fight

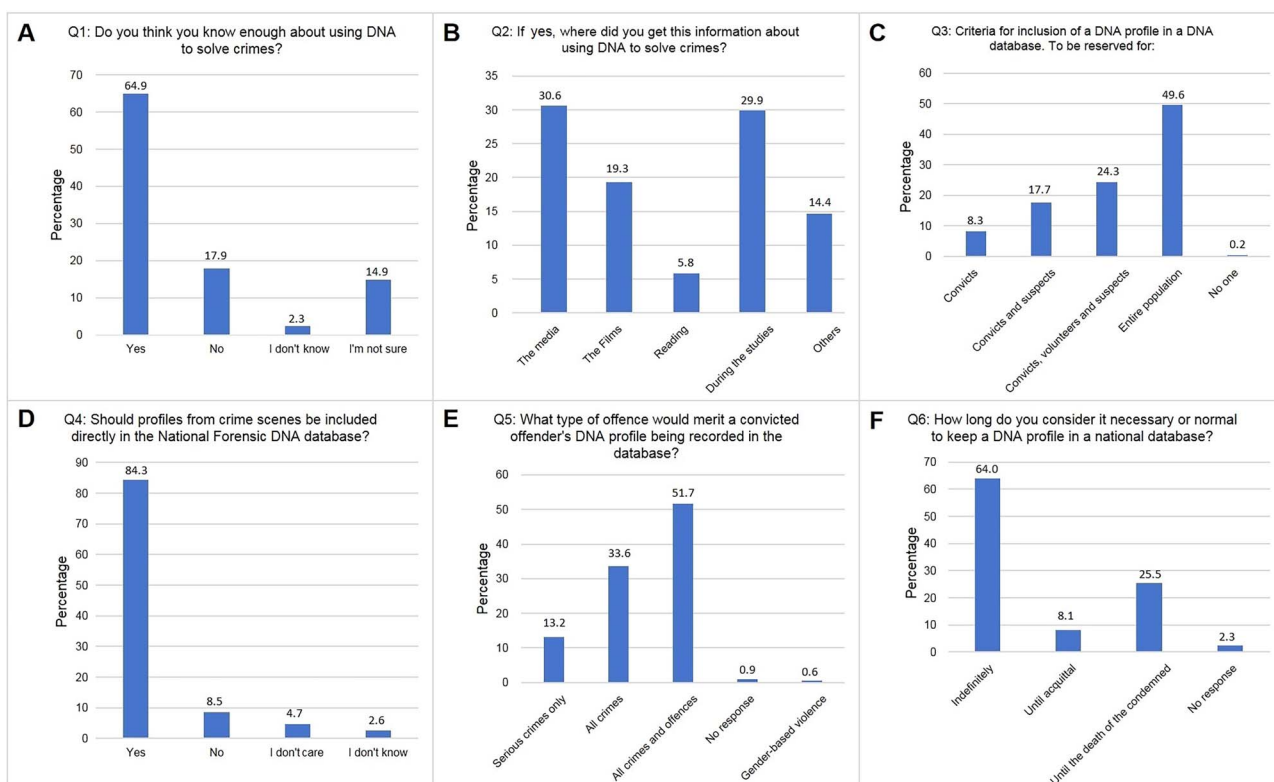


Figure 1 Respondents' level of knowledge about DNA and their views on its use. Percentages may not add up to 100 due to rounding.

Table 2. Respondents' views (n (%))^a on the importance and administration of a DNA database for Burkina Faso (including responses to the survey question "In the context of criminal investigations, do you think that the creation of a national forensic DNA database in Burkina Faso is: important, not important, ineffective, or useless?").

| Item | Important N = 431 (91.7) | Not important N = 28 (6.0) | Ineffective N = 6 (1.3) | Useless N = 5 (1.1) | P-value |
|--|-----------------------------|-------------------------------|----------------------------|------------------------|---------|
| Gender | | | | | |
| Male ($n = 381$) | 350 (91.9) | 26 (6.8) | 3 (0.8) | 2 (0.5) | 0.080 |
| Female ($n = 89$) | 81 (91.0) | 2 (2.2) | 3 (3.4) | 3 (3.4) | |
| Age | | | | | |
| 16–35 ($n = 303$) | 279 (92.1) | 18 (5.9) | 3 (1.0) | 3 (1.0) | 0.266 |
| 36–60 ($n = 165$) | 151 (91.5) | 9 (5.5) | 3 (1.8) | 2 (1.2) | |
| Over 60 ($n = 2$) | 1 (50.0) | 1 (50.0) | 0 (0.0) | 0 (0.0) | |
| Education level | | | | | |
| High school ($n = 47$) | 47 (100.0) | 0 (0.0) | 0 (0.0) | 0 (0.0) | 0.530 |
| Bachelor's or master's ($n = 296$) | 270 (91.2) | 19 (6.4) | 4 (1.4) | 3 (1.0) | |
| Doctoral ($n = 127$) | 114 (89.8) | 9 (7.1) | 2 (1.6) | 2 (1.6) | |
| Profession ^b | | | | | |
| Lawyer, prosecutor ($n = 65$) | 62 (95.4) | 3 (4.6) | 0 (0.0) | 0 (0.0) | 0.597 |
| Police officer, forensic expert ($n = 94$) | 88 (93.6) | 6 (6.4) | 0 (0.0) | 0 (0.0) | |
| <i>Professor, researcher ($n = 72$)</i> | 62 (86.1) | 7 (9.7) | 2 (2.8) | 1 (1.4) | |
| <i>Student ($n = 119$)</i> | 108 (90.8) | 6 (5.0) | 3 (2.5) | 2 (1.7) | |
| Other ($n = 120$) | 111 (92.5) | 6 (5.0) | 1 (0.8) | 2 (1.7) | |

^aPercentages may not add up to 100 due to rounding. ^bBold: professional; italic: insiders; normal: laypersons.

Table 3. Respondents' views (n (%))^a on the importance and administration of a DNA database for Burkina Faso (including responses to the survey question "who should be responsible for the custody and management of a national DNA database in Burkina Faso: Ministry of Security, Ministry of Justice, National Police Service, Autonomous institution?").

| Item | Ministry of Security N = 110 (23.4) | Ministry of Justice N = 74 (15.7) | National Police Service N = 115 (24.5) | Autonomous institution N = 159 (33.8) | Other N = 12 (2.6) | P-value |
|--|---|---|--|---|-----------------------|---------|
| Gender | | | | | | |
| Male ($n = 381$) | 90 (23.6) | 58 (15.2) | 97 (25.5) | 127 (33.3) | 9 (2.4) | 0.803 |
| Female ($n = 89$) | 20 (22.5) | 16 (18.0) | 18 (20.2) | 32 (36.0) | 3 (3.4) | |
| Age | | | | | | |
| 16–35 ($n = 303$) | 72 (23.8) | 48 (15.8) | 73 (24.1) | 103 (34.0) | 7 (2.3) | 0.986 |
| 36–60 ($n = 165$) | 38 (23.0) | 26 (15.8) | 41 (24.8) | 55 (33.3) | 5 (3.0) | |
| Over 60 ($n = 2$) | 0 (0.0) | 0 (0.0) | 1 (50.0) | 1 (50.0) | 0 (0.0) | |
| Education level | | | | | | |
| High school ($n = 47$) | 15 (31.9) | 7 (14.9) | 18 (38.3) | 6 (12.8) | 1 (2.1) | 0.013 |
| Bachelor's or master's ($n = 296$) | 73 (24.7) | 47 (15.9) | 72 (24.3) | 98 (33.1) | 6 (2.0) | |
| Doctoral ($n = 127$) | 22 (17.3) | 20 (15.7) | 25 (19.7) | 55 (43.3) | 5 (3.9) | |
| Profession ^b | | | | | | |
| Lawyer, prosecutor ($n = 65$) | 15 (23.1) | 14 (21.5) | 14 (21.5) | 20 (30.8) | 2 (3.1) | 0.010 |
| Police officer, forensic expert ($n = 94$) | 31 (33.0) | 12 (12.8) | 35 (37.2) | 16 (17.0) | 0 (0.0) | |
| <i>Professor, researcher ($n = 72$)</i> | 12 (16.7) | 11 (15.3) | 21 (29.2) | 25 (34.7) | 3 (4.2) | |
| <i>Student ($n = 119$)</i> | 26 (21.8) | 22 (18.5) | 24 (20.2) | 45 (37.8) | 2 (1.7) | |
| Other ($n = 120$) | 26 (23.4) | 15 (12.5) | 21 (17.5) | 53 (44.2) | 5 (4.2) | |

^aPercentages may not add up to 100 due to rounding. ^bBold: professional; italic: insiders; normal: laypersons.

against organized crime with various security services, such as INTERPOL, the acceptance rate of all respondents dropped to 63.4% (Table 4). However, 89.8% of respondents thought that the fight against terrorism and organized crime was a very convincing reason for using DNA to support criminal investigations in BF (Table 5). Therefore, we assume that the fight against terrorism and organized crime will be the main reason that could prompt the implementation of an NFDD in BF and achieve full support and collaboration of the population.

Genetic database and privacy concerns

Overall, 53.4% of respondents believed that using DNA fingerprints would not invade privacy (Table 6). This may be why, surprisingly, 54.7% would be willing to provide their

DNA profiles to voluntarily enrich an NFDD. As mentioned previously, most people justify their answer by the fact that it can be used, for example, to identify themselves or their family members in the event of a disaster or disappearance. Therefore, participants were relatively less concerned about the risk of privacy invasion because, amongst the total respondents, less than half were apprehensive about this question. Indeed, 40.9% answered "important concern", and 33.2% expressed "minor concern" to the question: What is your level of concern about the risk of invasion of privacy for citizens? Even though the respondents did not seem to be very concerned about the risk of privacy invasion, surprisingly, 72.3% expressed anxiety about the possible misuse of the NFDD. Amongst the concerns identified by the respondents in the comments section were the risk of errors in DNA profiling

Table 4. Reasons (*n* (%))^a for setting up a genetic database (includes responses to the survey question: "What can be the reasons for setting up a genetic database: in the framework of the cooperation with International Criminal Police Organization (INTERPOL)?").

| Item | Yes N = 302 (64.3) | No N = 29 (6.2) | Yes, but on condition N = 114 (24.3) | I do not know N = 25 (5.3) | P-value |
|---|-----------------------|--------------------|---|-------------------------------|---------|
| Gender | | | | | |
| Male (381) | 248 (65.1) | 20 (5.2) | 98 (25.7) | 15 (3.9) | 0.007 |
| Female (89) | 54 (60.7) | 9 (10.1) | 16 (18.0) | 10 (11.2) | |
| Age | | | | | |
| 16–35 (<i>n</i> = 303) | 196 (64.7) | 20 (6.6) | 67 (22.1) | 20 (6.6) | 0.529 |
| 36–60 (<i>n</i> = 165) | 105 (63.6) | 9 (5.5) | 46 (27.9) | 5 (3.0) | |
| Over 60 (<i>n</i> = 2) | 1 (50.0) | 0 (0.0) | 1 (50.0) | 0 (0.0) | |
| Education level | | | | | |
| High school (<i>n</i> = 47) | 38 (80.9) | 0 (0.0) | 8 (17.0) | 1 (2.1) | 0.001 |
| Bachelor's or master's (<i>n</i> = 296) | 199 (67.2) | 14 (4.7) | 65 (22.0) | 18 (6.1) | |
| Doctoral (<i>n</i> = 127) | 65 (51.2) | 15 (11.8) | 41 (32.3) | 6 (4.7) | |
| Profession ^b | | | | | |
| Lawyer, prosecutor (<i>n</i> = 65) | 48 (73.8) | 1 (1.5) | 15 (23.1) | 1 (1.5) | 0.013 |
| Police officer, forensic expert (<i>n</i> = 94) | 73 (77.7) | 2 (2.1) | 16 (17.0) | 3 (3.2) | |
| <i>Professor, researcher</i> (<i>n</i> = 72) | 45 (62.5) | 7 (9.7) | 18 (25.0) | 2 (2.8) | |
| <i>Student</i> (<i>n</i> = 119) | 68 (57.1) | 10 (8.4) | 29 (24.4) | 12 (10.1) | |
| Other (<i>n</i> = 120) | 68 (56.7) | 9 (7.5) | 36 (30.0) | 7 (5.8) | |

^aPercentages may not add up to 100 due to rounding. ^bBold: professional; italic: insiders; normal: laypersons.

Table 5. Reasons (*n* (%))^a for setting up a genetic database (includes responses to the survey question: "What can be the reasons for setting up a genetic database: As part of the fight against terrorism and organised crime?").

| Item | Yes N = 422 (89.8) | No N = 3 (0.6) | Yes, but on condition N = 38 (8.1) | I do not know N = 7 (1.5) | P-Value |
|---|-----------------------|-------------------|---------------------------------------|------------------------------|---------|
| Gender | | | | | |
| Male (381) | 340 (89.2) | 2 (0.5) | 34 (8.9) | 5 (1.3) | 0.449 |
| Female (89) | 82 (92.1) | 1 (1.1) | 4 (4.5) | 2 (2.2) | |
| Age | | | | | |
| 16–35 (<i>n</i> = 303) | 280 (92.4) | 2 (0.7) | 16 (5.3) | 5 (1.7) | 0.142 |
| 36–60 (<i>n</i> = 165) | 140 (84.8) | 1 (0.6) | 22 (13.3) | 2 (1.2) | |
| Over 60 (<i>n</i> = 2) | 2 (100.0) | 0 (0.0) | 0 (0.0) | 0 (0.0) | |
| Education level | | | | | |
| High school (<i>n</i> = 47) | 45 (95.7) | 1 (2.1) | 1 (2.1) | 0 (0.0) | 0.098 |
| Bachelor's or master's (<i>n</i> = 296) | 270 (91.2) | 1 (0.3) | 20 (6.8) | 5 (1.7) | |
| Doctoral (<i>n</i> = 127) | 107 (84.3) | 1 (0.8) | 17 (13.4) | 2 (1.6) | |
| Profession ^b | | | | | |
| Lawyer, prosecutor (<i>n</i> = 65) | 58 (89.2) | 0 (0.0) | 7 (10.8) | 0 (0.0) | 0.596 |
| Police officer, forensic expert (<i>n</i> = 94) | 86 (91.5) | 1 (1.1) | 5 (5.3) | 2 (2.1) | |
| <i>Professor, researcher</i> (<i>n</i> = 72) | 63 (87.5) | 1 (1.4) | 7 (9.7) | 1 (1.4) | |
| <i>Student</i> (<i>n</i> = 119) | 106 (89.1) | 1 (0.8) | 8 (6.7) | 4 (3.4) | |
| Other (<i>n</i> = 120) | 109 (90.8) | 0 (0.0) | 11 (9.2) | 0 (0.0) | |

^aPercentages may not add up to 100 due to rounding. ^bBold: professional; italic: insiders; normal: laypersons.

and the use of the DNA database for personal purposes or political reasons.

What do participants think about genetic fingerprints and national police services in BF?

Respondents' awareness of the means used by the national police to support criminal investigations in BF demonstrated that 40.2% of the participants thought that BF national police services did not currently use DNA profiles in criminal investigations and only 27.4% believed the opposite (Table 6). Therefore, the plurality of respondents is at least partially aware of how national police operate. Indeed, as mentioned previously, the use of DNA by the national police is not common in BF; it is only used on rare occasions or in exceptional cases where a court orders it, and accredited laboratories usually process biological samples collected in foreign countries, such as France. However, many respondents (93.6%) felt that the forensic department should be equipped with forensic laboratories capable of carrying out DNA tests (Table 6). In addition, 72.3% believed that forensic DNA testing should

not be entrusted to the private sector for several reasons. Furthermore, only 45.3% of the respondents agreed that DNA profiling should be assigned to an autonomous state institution other than the police. We can, therefore, conclude from the responses in Table 6 that a large proportion of respondents would like DNA profiling to be entrusted to the police rather than to private individuals or laboratories.

Discussion

According to the National Institute of Statistics and Demography (INSD), in 2019, 77.9% of the population was under 35 years of age [12]. This may explain the large proportion of younger respondents in the survey. Indeed, 64.5% of the respondents were aged between 16 and 35 years. Although women represent the majority of the BF population, they were underrepresented in the survey, comprising only 18.9% of the participants. We selected internet users, and the population was primarily from the middle class. Because of women's

Table 6. Participants' responses on (*n (%)*)^a the issue of invasion of privacy.

| Questions | Answers | | | | |
|--|---------------------------------|--------------------------------|--|-------------------------------|----------------------------|
| DNA database in BF: Do you think this would be an invasion of citizens' privacy? | Yes 59 (12.6) | No 251 (53.4) | Maybe 160 (34.0) | | |
| Would you be willing to voluntarily donate your DNA to a possible genetic database? | Yes 257 (54.7) | No 25 (5.3) | Yes, but on condition 157 (33.4) | Maybe 31 (6.6) | |
| What is your level of concern about the risk of invasion of privacy? | Very concerned 192 (40.9) | Minor concern 156 (33.2) | No concern 74 (15.7) | - | No response 23 (4.9) |
| Are you concerned about the misuse of this database? | Very concerned 340 (72.3) | Minor concern 81 (17.2) | No concern 35 (7.4) | I do not care 11 (2.3) | No response 3 (0.6) |
| Do you think the police use DNA profiles in criminal investigations? | Yes 129 (27.4) | No 189 (40.2) | Maybe 88 (18.7) | I do not know 64 (13.6) | |
| Do you think that the national police should be equipped with scientific and especially genetic laboratories to support criminal investigations? | Yes 440 (93.6) | No 15 (3.2) | Maybe 15 (3.2) | I do not know 0 (0) | |
| Do you think that the private sector should carry out forensic DNA testing? | Yes 51 (10.9) | No 340 (72.3) | Maybe 58 (12.3) | I do not know 21 (4.5) | |
| Or do you think forensic DNA testing should be carried out by an autonomous state institution other than the police and gendarmerie? | Yes 213 (45.3) | No 169 (36.0) | Maybe 74 (15.7) | I do not know 14 (3.0) | |

^aPercentages may not add up to 100 due to rounding.

lower literacy level in BF, they are underrepresented with regard to asking for answers from internet users. In BF, men have a higher literacy level than women (by almost 20 percentage points) according to a 2014 report from the INSD [13]. This could explain, in part, the low participation of the women in this study.

Level of awareness of the use of DNA and NFDD to solve crimes

In determining participants' awareness of using DNA to solve crimes, 64.9% of the respondents said that they knew enough about the potential of DNA to solve crimes. Compared with other African countries, our result is slightly higher than the 53.3% reported in a similar study in Nigeria [14]. However, our results should be low compared with those of some African countries, such as South Africa, where criminal law on forensic procedures already exists in the Amendment Act of 2013, which established their NFDD [15]. In addition to South Africa, there are currently eight other African countries, including Mauritius, Egypt, Morocco, Algeria, Tunisia, Namibia, Botswana, and Sudan, where there are operational NFDDs [9, 16] with specific DNA policies. These countries demonstrate significant awareness of the critical role of DNA in solving crimes by hosting an operational NFDD. Globally, awareness of the use of DNA or DNA databases for forensic investigations is in progress [17]. Indeed, according to the "INTERPOL Global DNA Profiling Survey 2019" report, 89 states used DNA profiling in police investigations, whereas 70 reported having a DNA database [9].

The consequences of terrorism on the national security system seemed to have greatly influenced the respondents in

this study. This is likely why we noted that 91.7% of the respondents considered it essential to set up a DNA database to support criminal investigations in BF. This assertion is further reinforced when we asked respondents why establishing a DNA database might be necessary: 89.8% replied in favour of the framework for the fight against terrorism and organized crime. People also favour the utilization of DNA databases to support criminal investigations in BF because they belong (mainly) to the highly educated population. As terrorist threats spread, the Sahel region urgently requires a collective response [18], including the sharing of security information (DNA profiles) between states, especially concerning terrorist attacks. Additionally, DNA can be used to identify missing people and mutilated remains [19].

Central concerns about violations of citizens' privacy

The percentage of respondents willing to accept the inclusion of their genetic profile in the NFDD was 54.7%. They likely took this position to enrich the NFDD in the event of family searches and other disasters, but 72.3% also expressed concerns about the misuse of this genetic database. Respondents also shared privacy violation concerns from similar studies conducted in Germany [20], Spain [21, 22], and Portugal [23], where the population, while knowing about the benefits of using DNA in police investigations, was also concerned about its possible misuse.

One solution to this concern raised by the respondents was to entrust database management to an autonomous state institution. As revealed in our study, 33.8% of the respondents preferred this option amongst several choices. This finding is

consistent with the results reported by Gamero et al. [22]. They also reported that respondents preferred this type of management and stated that 59.7% considered custody to remain in the hands of the National Agency for DNA Profiles, an autonomous state institution with judicial backing of the latter. Moreover, institutions such as INTERPOL offer member states a guide to best practices for establishing an NFDD [19]. In addition, there is a report from the Forensic Genetics Policy Initiative group entitled “Establishing Best Practice for Forensic DNA Databases” [24]. This initiative has been commended by gathering specialists from various fields and backgrounds (including genetics, political science, sociology, law, and ethics). This group provided valuable remarks and advice for those planning to set up an NFDD [25].

Furthermore, DNA profiles and associated names can be stored separately with limited access to prevent falsification and misuse [26]. Finally, BF policymakers can take inspiration from existing systems. Thus, a responsible NFDD project must strike a reasonable balance between public security and individual rights and freedom, as noted by several international organizations committed to this task [27–28]. These three aspects should also consider what is politically and morally correct and what is ethically acceptable regarding international law.

What does the law in BF state about using DNA in criminal cases?

From a legislative point of view, it must be said that BF’s laws are sufficiently permissive regarding the use of scientific processes as proof. Regarding personal status (recognition of paternity, filiation, etc.), we can cite Articles 446, 454, 456, and 720 of the current “BF: code des personnes et de la famille” in English (BF: Personal and Family Code) [29]. In this document, Article 446, for example, stipulates that “When, by application of legal provisions, a child is attached to several fathers, the courts shall settle the dispute by determining the most likely paternity by all means of proof. In the absence of sufficient evidence, they shall have regard to the possession of status”. These provisions provide the possibility of using any means to prove the existence of fact. The use of the law of the words “all means” allows recourse to scientific evidence. Generally, lawyers and prosecutors refer to these texts or articles when ordering a DNA test, for example, in paternity disputes. In addition, in criminal cases, provisions 252-3 and 261-104 and the following articles in the Criminal Procedure Code in French (“Code de Procédure Pénale”) also allow recourse to scientific procedures by ordering an expert report as a method of proof, as mentioned in the document [30]. As such, article 253-2 of the BF Criminal Procedure Code stipulates the following: “Any investigating or trial court in the event that a technical question arises may, either at the request of the public prosecutor, either systematically or at the request of the parties, order an expert report. The experts carry out their mission under the control of the investigating judge or the magistrate to be designated by the court that ordered their expertise. When the investigating judge considers that he should not grant a request for expertise, he must issue a reasoned order, which may be appealed in the forms and time limits provided for in article 261-133 of this law”. Apart from the openings made by the BF legislation to exploit genetic fingerprints, there are no specific laws in this area dedicated to using DNA fingerprints. Therefore, in this situation, we recommend that legislators implement an in-country DNA policy that clearly stipulates the technique for

collecting DNA samples. How long should DNA profiles be stored in an NFDD, and which institution should be in charge of the custody and management of a DNA database? Finally, when a particular profile can be added to the NFDD, and what is the extent of its use?

Is DNA still the queen of evidence?

Although the contribution of genetic fingerprint evidence is critical in the current criminal justice system [31], it is not a panacea for all criminal cases in which it may be involved. Indeed, it is essential to remember that a match between DNA collected as evidence at a crime scene and the profile of a person registered in a database does not provide enough clues to conclude that the person is the source of the trace, especially in the case of a so-called “partial match” [21]. Such a profile match would not necessarily mean that the accused person is guilty. This decision is left to a judge who gives the final verdict in a conviction based on other evidence. This reminder follows the overconfidence in and expectations of DNA evidence from non-specialists because of media coverage orchestrated by police TV series. This could also explain why 49.6% of the respondents suggested that the DNA profiles of the entire population should be retained by the NFDD (Figure 1C). At this point, caution should be exercised to avoid the transformation of an NFDD into a universal DNA database for the country. Specific legislation and scientific procedures that meet international standards should be implemented to prevent erroneous conclusions and management. As suggested by Makanje [31], the admissibility of expert evidence in criminal proceedings must always be questioned for its reliability and safeguarding. There is also a need to establish strong standards to assess the competence of forensic personnel and the reliability of equipment and results [10, 32] before delivering any accreditation, not only in the BF, but also in all member countries of the Sahel region. This could be helpful, especially for ongoing terrorist attacks that call for collaboration (e.g., database searches and international data sharing) between all states of the Sahel region.

Finally, it should also be remembered that DNA evidence will not give a “Yes” or “No” answer: it can only ever be expressed in terms of probability. Therefore, DNA evidence can only be presented in terms of probability, such as very strong, very weak, or everything in between. In this regard, the use of a national allelic reference database to support statistical calculations or estimate the frequency of each possible allele and genotype in the local population is always required when a DNA profile from a crime scene matches a specific suspect [33–35]. Recently, new population data providing forensic parameters for 29 Y-chromosome STR loci amongst the ethnolinguistic groups of BF have been published [36]. Such a dataset with forensic parameters will be helpful in supporting statistical calculations regarding the match between DNA from a crime scene and DNA from an NFDD. However, additional studies providing forensic parameters specific to the BF population on at least 16 autosomal STR loci should be conducted to fill this gap.

What could be considered as a limitation of this study?

The relatively small-scale survey (470 respondents) can be explained by the fact that the study was conducted online. In low-income countries, the internet is still not accessible. However, by conducting the survey, we aimed to address the study of maximally educated people who use the internet as

a mandatory part of their daily routine. We also assumed that they were likely to understand the questions better because DNA is taught at school and precisely during high school training. This could also explain why 33.8% of the respondents were forensic experts or professionals and 27.0% held a PhD.

We wished to generalize the survey, but there was an issue with the language. Formal schools (French and French Arabic) are the main literacy channels for the Burkinabe population, regardless of age, gender, or residence (urban or rural areas). Targeting the general population requires that the questionnaire be translated into several languages. BF has at least 63 different ethnic groups with different languages [37], requiring more means and resources. This also constituted one of the limitations in probing the opinions of the general population. However, schooling in BF is mainly favourable in urban areas, where people also most often have access to the internet. The gross school attendance rate, all levels combined, is 73% in urban areas versus 38% in rural areas, according to a report from the INSD [38]. This reality could explain why the survey results should be considered as educated people's opinions instead of general public opinion.

Conclusion

Currently, the use of DNA to support criminal investigations in BF is still in its infancy, and there has been no public debate; therefore, little is known about the opinions of people who are not working in the field. This study is the first of its kind to be conducted in BF, and is part of a vision for future law to be drafted to establish and manage an NFDD to support criminal investigations. We are aware of the limitations of this study in terms of the representativeness of the data regarding the entire BF population. However, the results could provide preliminary information on how the public would receive or support such projects. The results of this study revealed that the respondents were generally very aware and supportive of using DNA for forensic enforcement purposes. However, the participants also expressed strong concerns about its management, particularly the legislation that should govern the custody, use, and control of the NFDD. In addition, the relatively high financial cost of acquiring such technology in the first place and its management in the second place must be considered. However, its future benefits will undoubtedly enhance security and allow the judiciary to close cases that require scientific technology. The security of a nation is a foundation for the emergence of economic development. This argument alone should be sufficient to devote special attention to the necessary means to any action that strengthens national security.

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Authors' contributions

Moutanou M.J. Zeye, Xiang Wu, Jacques Simporé conceived the study, and participated in its design. Moctar Zeba, Rachide Palenfo, Noe Dakio, Missa Millogo collected the data. Moutanou M.J. Zeye, Serge Y. Ouedraogo participated in the data analyses. Moutanou M.J. Zeye drafted the manuscript;

Silvere D. Zaongo, Abdou A. Zoure, Florencia W. Djigma revised the draft critically for important intellectual content. All authors contributed to and approved the final manuscript.

Compliance with ethical standards

The Pietro Annigoni Biomolecular Research Center (CERBA) approved the study. The respondents were informed that their participation in the survey was voluntary and unpaid. They were also informed that the information provided was strictly for academic research purposes and requested to provide honest responses to ensure the credibility of the study. Respondents' anonymity and confidentiality were fully respected. Therefore, their names and e-mail addresses were not recorded. Written informed consent was obtained from all participants.

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