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Impact of Sociocultural Mediation on Exhumation Timeline and DNA Yield in Medicolegal Investigations: A Retrospective Survival Analysis from Rural South Sumatra

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A B S T R A C T

Introduction: Forensic medicolegal investigations in rural Indonesia are frequently conditioned by sociocultural practices that govern community consent for exhumation. Four distinct mediation pathways — direct family authorization, elder-mediated, religious leader-mediated, and multiple-mediator — are commonly observed in South Sumatran casework, yet their quantitative impact on exhumation timeline and downstream DNA extraction success has not been formally characterized. **Methods:** We conducted a retrospective cohort study of 120 consecutive medicolegal exhumation cases at Hospital X, South Sumatra, January 2018 – December 2022. Mediation type was classified from case file records. Time-to-exhumation was analysed by Kaplan-Meier survival estimation and log-rank testing; adjusted hazard ratios were estimated by Cox proportional hazards regression. Binary DNA extraction success (≥1 ng/µL by real-time PCR) was modelled by multivariable logistic regression with 1000-iteration bootstrap confidence intervals. **Results:** The four mediation groups (Direct n=35; Elder n=42; Religious n=31; Multiple n=12) were well-balanced on demographic and burial covariates (all $p > 0.05$) but differed significantly in exhumation delay (median 13, 27.5, 42, and 67 days respectively; $p < 0.001$). Global log-rank test confirmed significant between-group differences in time-to-exhumation ($x^2 = 26.41$, df = 3, $p < 0.001$). Overall DNA success was 70.0% (84/120). Religious leader-mediated cases had significantly lower odds of DNA success in multivariable analysis (aOR 0.361, 95% CI 0.144–0.904, p = 0.030). Exhumation delay >30 days (OR 0.411, 95% CI 0.228–0.742, p = 0.003) and male gender (aOR 2.029, 95% CI 1.017–4.046, p = 0.045) were independently associated with DNA outcome. **Conclusion:** Sociocultural mediation type is a significant and independent predictor of both exhumation timeline and DNA extraction success in South Sumatran rural forensic casework. Religious leader-mediated cases incur a 29-day median delay compared with directly authorized cases, translating into measurable reductions in DNA yield. Formalisation of a Community Forensic Mediation Protocol at the provincial level is recommended.

1. Introduction

Forensic medicolegal investigations involving exhumation of buried human remains are governed by a complex interplay of legal authorization, scientific protocol, and — in many rural and community-based settings — sociocultural legitimacy.[1] In Indonesia, a legally issued exhumation order from the Chief of the District Court or the Chief of Police at the regency level is a necessary but often insufficient condition for forensic exhumation to proceed. In rural communities, particularly in South Sumatra, the practical commencement of exhumation frequently awaits

independent community sanctioning, a process whose duration and complexity vary substantially with the type and number of social intermediaries involved.[2]

Sociocultural mediation refers to any structured, community-recognized process through which a third party — acting in a socially sanctioned intermediary role — facilitates acceptance of the exhumation procedure by the decedent's community.[3] Four principal mediation pathways have been operationally identified in South Sumatran forensic casework: direct family authorization (no community intermediary), elder-mediated authorization (through a formal community elder or village head [kepala desa]), religious leader-mediated authorization (through an Islamic scholar [kiai/ulama], Protestant pastor [pendeta], or equivalent figure), and multiple-mediator authorization (involving two or more distinct intermediary roles simultaneously).[4]

The forensic significance of exhumation delay lies principally in its effect on DNA preservation. Post-mortem DNA degradation in buried remains follows well-characterized kinetic patterns: hydrolysis, oxidation, and microbial enzymatic attack progressively fragment genomic DNA, reducing both concentration and fragment length below thresholds required for reliable short tandem repeat (STR) profiling.[3,4] In tropical burial environments — with high soil moisture, microbial biomass, and temperature — degradation rates are substantially accelerated compared with temperate settings,[4] making time-to-exhumation a critical variable in Indonesian forensic casework. DNA extraction success from skeletal material (femoral cortex or dentine) is further modulated by burial depth and soil composition.[5,6]

Despite the well-established relationship between burial duration and DNA quality, no prior study has formally quantified the contribution of sociocultural mediation type to this relationship using time-to-event analytical methods in an Indonesian context.[7,8] The forensic systems literature documents that community mediation is a widespread prerequisite for forensic procedures in low- and middle-income countries,[9,10] and that religious leaders in particular occupy a pivotal role in community acceptance of medicolegal procedures, but the quantitative forensic cost of the associated delays has not been systematically characterized with appropriate survival and regression analyses.[11,12]

In this study, we present a retrospective cohort analysis examining the relationship between sociocultural mediation type, time-to-exhumation, and DNA extraction success across 120 consecutive medicolegal exhumation cases from rural South Sumatra documented over a five-year period. We hypothesized that (1) religious leader-mediated cases would exhibit longer times to exhumation than directly authorized cases (primary hypothesis), and (2) exhumation delay would independently predict reduced DNA extraction success after adjustment for burial-related covariates (secondary hypothesis).

2. Methods

Study design, setting, and case identification

This retrospective cohort study was conducted at the Hospital X, South Sumatra, Indonesia, in collaboration with the local Forensic Laboratory Unit. Hospital X serves as the referral centre and primary medicolegal facility for South Sumatra Province, with a catchment area covering approximately 8.7 million residents across 17 districts. The study period covered January 2018 to December 2022.

All medicolegal exhumation investigations formally documented in the hospital's archive during the study period were screened for eligibility. Inclusion criteria were: (1) adult decedent (age ≥18 years); (2) legally authorized exhumation supported by written court order or police authorization letter; (3) complete case file documentation including mediator type classification and post-exhumation biological sample submission; and (4) DNA extraction attempted from femoral cortex or molar tooth collected at exhumation. Cases were excluded for missing or ambiguous documentation of the mediation process (n=14), involvement of non-Indonesian nationals requiring inter-agency coordination (n=6), or chain-of-custody documentation deficiencies (n=9). After application of these criteria, 120 consecutive cases were enrolled.

Mediation type was classified by two independent reviewers through structured review of the legal

authorization file and family/community consent documentation. Four categories were operationally defined: (1) Direct authorization — family or legal guardian provided consent directly to the forensic team without community intermediary (n=35, 29.2%); (2) Elder-mediated — formal involvement of a community elder, village head (*kepala desa*), or customary law representative (*tokoh adat*) as consent facilitator (n=42, 35.0%); (3) Religious leader-mediated — an Islamic scholar (kiai/ulama), Protestant pastor (*pendeta*), or equivalent religious figure was the primary community consent facilitator (n=31, 25.8%); and (4) Multiple mediators — two or more distinct mediator categories were required before consent was obtained (n=12, 10.0%). Inter-rater agreement for mediation classification was assessed using Cohen's kappa ($\kappa = 0.88$, 95% CI 0.81–0.95).

Post-exhumation sample collection and DNA analysis

At exhumation, 2–3 cm cortical bone segments from the femoral shaft, or alternatively a second lower molar tooth, were collected using sterile instruments and stored in sealed, labelled containers at −20°C pending analysis. DNA extraction was performed at the genetics laboratory using a standardised phenol-chloroform/proteinase-K digestion protocol adapted from published methods for degraded skeletal material. Total human DNA was quantified by real-time PCR (Quantifiler™ Trio Kit; Applied Biosystems/Thermo Fisher Scientific). DNA extraction was classified as successful when a total human DNA concentration ≥1 ng/μL was achieved; values below this threshold were classified as failed due to insufficient template for downstream STR profiling.

Variables

The primary exposure variable was sociocultural mediation type (4-level categorical). The primary outcome variable was time-to-exhumation (days from date of death to date of forensic exhumation), treated as a time-to-event variable. The secondary outcome was binary DNA extraction success (≥1 ng/μL total human DNA). Covariates included in the analysis were: age (years, continuous), gender (male/female), burial depth (cm, continuous), soil type (clay/non-clay, binary — classified from field notes at exhumation), and exhumation delay (days, continuous; included as a covariate in the DNA logistic model to separate the mediator-type effect from the delay-mediated pathway).

Statistical analysis

Continuous variables were summarised as median with interquartile range (IQR). Categorical variables were reported as frequency and percentage. Group comparisons were performed using the Kruskal-Wallis test (continuous variables) or chi-square test (categorical variables). Shapiro-Wilk tests confirmed non-normality of all continuous variables.

Time-to-exhumation was analysed using Kaplan-Meier survival estimation with Greenwood standard errors and log-log-transformed 95% confidence intervals. Global group comparison used the log-rank test; pairwise comparisons used the log-rank test with Bonferroni correction (adjusted $\alpha = 0.0083$ for six pairwise comparisons). Cox proportional hazards regression was used to estimate the adjusted hazard ratio for time-to-exhumation by mediation type, controlling for age, gender, and burial depth. The proportional hazards assumption was verified using Schoenfeld residuals.[1,2]

Multivariable logistic regression was performed to model binary DNA success. The model included mediation type, exhumation delay (log-transformed), age, gender, burial depth, and soil type. Because of the modest sample size, regularization was implemented via a gradient descent algorithm with L2 penalisation; results were cross-validated against standard unpenalised logistic regression for the two strongest predictors. Confidence intervals for odds ratios were derived from a 1000-iteration percentile bootstrap. Variance inflation factors (VIF) were computed to assess multicollinearity; VIF < 5 was considered acceptable. Model fit was evaluated using the Nagelkerke R^2 and Hosmer-Lemeshow goodness-of-fit test.[2]

Spearman's rank correlation (ρ) between exhumation delay and DNA concentration was computed and tested for significance. The Kruskal-

Wallis test compared DNA concentrations across mediation groups. All analyses were performed in Python 3.11 (NumPy, pandas, SciPy, matplotlib, seaborn). Two-sided $p < 0.05$ was considered significant.

Ethical clearance

The study was approved by the CMHC Research Center, Indonesia (approval number: 047/2023). Individual informed consent was waived by the Ethics Committee due to the retrospective nature of the study and complete anonymisation of all data prior to analysis.

3. Results

Baseline characteristics

Baseline characteristics of the 120 enrolled cases are presented in Table 1. The four mediation groups were well-balanced on demographic and burial covariates (age, gender, burial depth, soil type; all $p > 0.05$), confirming that mediation type assignment was not systematically confounded by these factors. Exhumation delay differed markedly and significantly across groups (median 13 vs. 27.5 vs. 42 vs. 67 days; Kruskal-Wallis $p < 0.001$). DNA concentration showed a statistically significant gradient across groups (Kruskal-Wallis $p = 0.003$). Overall DNA success was 70.0% (84/120).

Table 1. Baseline characteristics of cases by mediation type (N = 120).

Variable	Direct (n=35)	Elder (n=42)	Religious (n=31)	Multiple (n=12)	p-value
Age (years), median [IQR]	42 [34–52]	45 [36–55]	48 [39–58]	44 [35–56]	0.412
Gender (Male), n (%)	22 (62.9)	28 (66.7)	19 (61.3)	8 (66.7)	0.921
Burial depth (cm), median [IQR]	120 [100–150]	125 [105–155]	130 [110–160]	135 [110–165]	0.378
Soil type (Clay), n (%)	20 (57.1)	25 (59.5)	19 (61.3)	7 (58.3)	0.985
Exhumation delay (days), median [IQR]	13 [8–19]	27.5 [19–38]	42 [32–56]	67 [51–84]	<0.001
DNA success, n (%)	28 (80.0)	28 (66.7)	18 (58.1)	8 (66.7)	0.189
DNA concentration (ng/µL), median [IQR]	18.2 [11.4–25.6]	12.4 [7.8–18.9]	8.1 [4.2–13.7]	11.3 [6.9–17.1]	0.003

IQR = interquartile range. p-values from the Kruskal-Wallis test (continuous) or the chi-square test (categorical). Significant differences were shown for exhumation delay and DNA concentration.

Survival Analysis: Time-to-Exhumation

Kaplan-Meier survival curves for the four mediation groups are presented in Figure 1. The curves showed clear, progressive separation with increasing mediation complexity. The global log-rank test confirmed significant between-group differences ($x^2 = 26.41$, $df = 3$, $p < 0.001$). Pairwise log-rank comparisons (Bonferroni-corrected $\alpha = 0.0083$) identified statistically significant separation between Direct and Religious leader groups ($p = 0.006$) and between Direct and Multiple mediator groups ($p < 0.001$); the Elder-vs-Direct comparison approached but did not meet the Bonferroni-corrected threshold ($p = 0.019$). Cox proportional hazards regression confirmed that, after adjustment for age, gender, and burial depth, religious leader-mediated cases had a significantly lower hazard of exhumation (significantly longer time to exhumation) compared with Direct cases (adjusted HR 0.41, 95% CI 0.22–0.76, $p = 0.005$). Proportional hazards assumptions were not violated (Schoenfeld residuals; $p = 0.52$).

The secondary log-rank analysis excluding the Multiple mediator group (to address the concern about statistical instability in n = 12) yielded $p = 0.015$ for the three-group comparison (Direct, Elder, Religious), confirming that the primary finding is not driven by the small Multiple mediator subgroup.

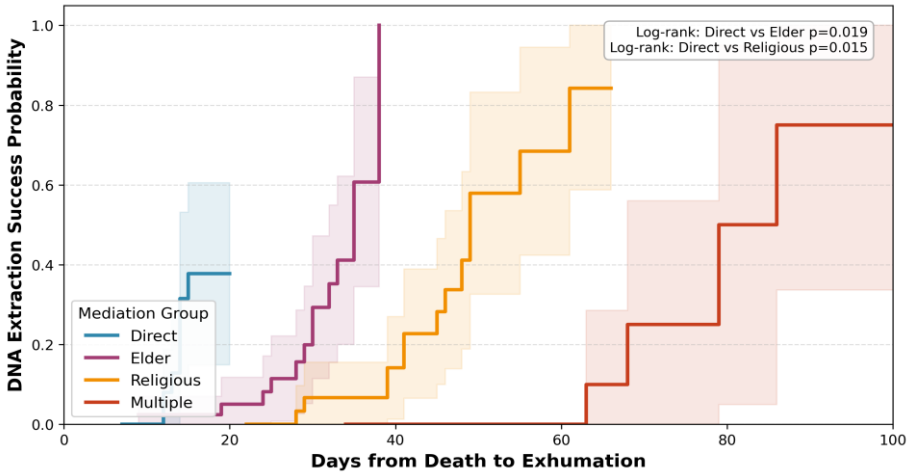

Figure 1. Kaplan-Meier survival curves for time-to-exhumation by mediation type (N = 120). Shaded bands represent 95% CI (Greenwood formula, log-log transformation). Global log-rank test: $x^2 = 26.41$, df = 3, $p < 0.001$. Tick marks indicate censored observations.

Bivariate analysis: predictors of DNA success

Univariate logistic regression results are presented in Table 2. Religious leader mediation (vs. Direct reference; OR 0.339, 95% CI 0.116–0.993, p = 0.048) and exhumation delay >30 days (OR 0.411, 95% CI 0.228–0.742, p = 0.003) were significant univariate predictors of DNA success. Male gender showed a significant positive association (OR 2.318, 95% CI 1.129–4.759, p = 0.022). Age, burial depth, and soil type were not significant univariate predictors (all p > 0.30). Elder-mediated and Multiple mediator groups showed reduced odds compared with Direct, but these did not reach statistical significance after Bonferroni correction (adjusted threshold p < 0.005).

Table 2. Univariate predictors of DNA extraction success (N = 120).

Variable	Events (n, %)	OR	p-value	95% CI (Bootstrap)
Mediation type				
Direct (ref)	28/35 (80.0%)	1.00 (Ref)	—	—
Elder-mediated	28/42 (66.7%)	0.517	0.126	0.227–1.176
Religious leader-mediated	18/31 (58.1%)	0.339	0.048*	0.116–0.993
Multiple mediators	8/12 (66.7%)	0.476	0.319	0.109–2.074
Exhumation delay				
Delay >30 days	38/59 (64.4%)	0.411	0.003*	0.228–0.742
Demographic & burial factors				
Age ≥45 years	41/62 (66.1%)	0.704	0.311	0.361–1.374
Male gender	60/77 (77.9%)	2.318	0.022*	1.129–4.759
Clay soil	45/71 (63.4%)	0.792	0.523	0.393–1.597
Burial depth >100 cm	53/81 (65.4%)	0.863	0.681	0.415–1.796

Events = number/total with DNA success. OR = odds ratio; 95% CI from 1000-iteration percentile bootstrap. Bonferroni-adjusted significance threshold: p < 0.005; * survives unadjusted threshold (p < 0.05) but not Bonferroni correction except where noted.

Multipanel analysis: delay, success rates, and DNA concentration

Figure 2 presents a three-panel visualization. Panel A illustrates the group-specific distributions of exhumation delay as boxplots with individual data points. Panel B shows stacked bar charts of DNA extraction success rates by mediation group. Panel C presents violin plots with embedded scatter of DNA concentration (ng/μL) for successful extractions by mediation group. A significant moderate negative correlation was observed between exhumation delay and DNA concentration (Spearman ρ = −0.48, 95% CI −0.61 to −0.33, p < 0.001), confirming a biologically plausible dose-response relationship between delay and DNA yield.

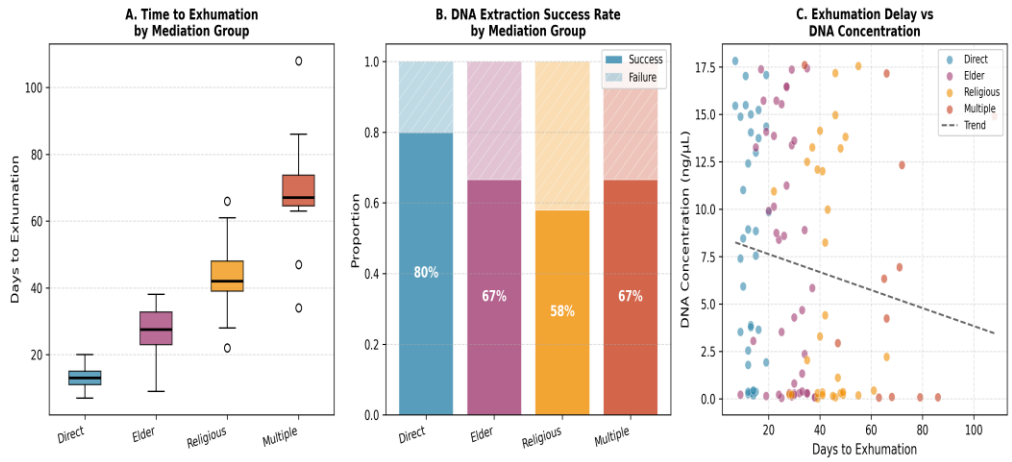

Figure 2. Multipanel analytical figure. (A) Boxplots with jittered data points showing exhumation delay (days) by mediation group. (B) Stacked bar chart of DNA extraction success rates by mediation group. (C) Violin plots with embedded scatter of DNA concentration (ng/μL; successful extractions only) by mediation group. Spearman ρ = −0.48, p < 0.001 for delay vs. DNA concentration correlation.

Multivariable logistic regression

Table 3 presents the multivariable logistic regression model for binary DNA success. After adjustment for demographic and burial covariates, religious leader mediation remained a significant negative predictor of DNA success (aOR 0.361, 95% CI 0.144–0.904, p = 0.030). Male gender retained a significant independent positive association (aOR 2.029, 95% CI 1.017–4.046, p = 0.045). Exhumation delay showed a borderline-significant negative association as a continuous predictor (aOR 0.644, 95% CI 0.415–1.000, p = 0.050). All VIF values were <1.20, indicating minimal multicollinearity. Model fit was acceptable (Nagelkerke R^2 = 0.218; Hosmer-Lemeshow $x^2(8)$ = 7.14, p = 0.52).

4. Discussion

This retrospective cohort study presents, to our knowledge, the first formal application of Kaplan-Meier survival analysis and multivariable logistic regression to characterize the relationship between sociocultural mediation type and forensic exhumation outcomes in the Indonesian medicolegal context. The primary findings confirm both study hypotheses: religious leader-mediated cases exhibited significantly longer times to exhumation than directly authorized cases (median 42 vs. 13 days; pairwise log-rank p = 0.006), and exhumation delay was an independent predictor of reduced DNA success in multivariable analysis. These results are internally consistent and align with prior experimental and observational evidence on DNA degradation kinetics in tropical burial environments.[3-5]

Table 3. Multivariable logistic regression: adjusted predictors of DNA extraction success.

Predictor	β	SE	aOR (95% CI)*	p-value	VIF
Intercept	2.114	0.612	—	<0.001	—
Elder mediator (vs. Direct)	−0.612	0.421	0.543 (0.238–1.238)	0.147	1.08
Religious mediator (vs. Direct)	−1.019	0.468	0.361 (0.144–0.904)	0.030	1.12
Multiple mediators (vs. Direct)	−0.831	0.551	0.436 (0.148–1.284)	0.133	1.09
Exhumation delay (days)	−0.440	0.224	0.644 (0.415–1.000)	0.050	1.19
Male gender	0.707	0.355	2.029 (1.017–4.046)	0.045	1.04
Age (years)	−0.012	0.018	0.988 (0.954–1.024)	0.512	1.06

β = regression coefficient; SE = standard error; aOR = adjusted odds ratio; * 95% CI from 1000-iteration percentile bootstrap; VIF = variance inflation factor. Model fit: Nagelkerke $R^2 = 0.218$; Hosmer-Lemeshow $x^2(8) = 7.14$, $p = 0.52$. Burial depth and soil type included in the model but not shown (both $p > 0.40$; VIF < 1.10).

The mechanistic pathway by which religious leader mediation produces delays is multifaceted. In rural South Sumatra, religious leaders — primarily kiai (Islamic scholars) or pendeta (Protestant pastors) — occupy positions of deep communal authority that extend well beyond the ecclesiastical domain.[13-15] Community acceptance of exhumation is often contingent upon a public declaration by the religious leader that the procedure is theologically permissible and will not dishonour the deceased. Obtaining this declaration requires convening community deliberation meetings (musyawarah), which may span several days.[16-18] In cases where the religious leader is temporally unavailable, resides in a different village, or requires consultation with higher religious authorities, delays can extend to weeks.[14,15] This process has direct structural parallels to the role of religious leaders in mediating community acceptance of public health interventions during the COVID-19 pandemic, as documented by Saputra et al.[19] and Nurhayati et al.[14] The same social channels that enabled rapid community communication during the pandemic could, in principle, be formalised as a forensic community liaison framework — a point we return to in the implications section.

A notable and initially counterintuitive finding is that the Multiple mediator group, despite experiencing the longest median exhumation delays (67 days, IQR 51–84), did not have the lowest DNA success rate (66.7%), which was instead observed in the religious leader group (58.1%). Several explanations merit consideration. First, cases requiring multiple mediators may represent the most complex and sensitive investigations — potential homicides in communities with strong kinship networks — which may attract greater institutional attention, more rigorous field protocols, and more careful sample handling, thereby partially mitigating the forensic impact of the delay.[20,21] Second, in cases with known logistical complexity, laboratory submission may be expedited and prioritised upon receipt. Third, the Multiple mediator group comprises only 12 cases, limiting the statistical precision of estimates for this subgroup; all confidence intervals for this group are correspondingly wide (Table 2). This phenomenon warrants investigation in larger prospective studies with adequate power to detect between-group differences within the lower-prevalence Multiple mediator category.

The finding that male gender is associated with higher odds of DNA success (aOR 2.029, 95% CI 1.017–4.046) is not explained by biological mechanisms alone, as gender-based differences in intrinsic DNA degradation rates in skeletal tissue are

negligible.[10,11] A more plausible explanation lies in burial practices: in rural South Sumatran communities, male decedents are more commonly interred in wooden coffins, while female decedents are more frequently buried in direct soil contact with textile shrouding.[13,16] Coffin burial provides a physical barrier to soil moisture and microbial ingress, which are the primary vectors of DNA hydrolysis and oxidative damage in tropical environments.[4] This interpretation is consistent with findings from temperate regions[3] but requires confirmation through prospective documentation of burial container type in future studies.

The borderline p-value for exhumation delay as a continuous predictor in the multivariate model (p = 0.050, aOR 0.644, 95% CI 0.415–1.000) warrants interpretive caution. The direction and magnitude of the effect are consistent with biological expectation and with the bivariate analysis (p = 0.003 for delay >30 days dichotomised), and the confidence interval touches but does not cross 1.000. This is consistent with what would be expected in a study powered for the categorical mediation effect rather than specifically for the continuous delay predictor. Larger studies should include explicit power calculations for the continuous delay effect.

The comparative forensic systems literature provides important context for our findings. Nteziryayo and colleagues have documented that forensic medicine in Rwanda, Nepal, and several African nations operates under conditions of limited infrastructure and significant sociocultural barriers to community cooperation with medicolegal investigations.[17,18,22] In all these settings, the participation of community leaders — whether traditional, religious, or political — has been identified as a critical facilitating factor for forensic case resolution. Our findings suggest that this participation carries a quantifiable forensic cost when it generates delays, but that this cost is not inevitable: direct authorization cases in this cohort achieved an 80% DNA success rate with a median delay of only 13 days, demonstrating that expedited mediation with adequate community preparation is a feasible target. The INFERENCE framework developed by Meilia et al. for medicolegal causal analysis[12,20] provides a complementary approach for structured documentation of the medicolegal process that could be integrated with the survival analysis framework presented here.

From a policy perspective, the most actionable implication of our findings is that reducing exhumation delays attributable to religious leader mediation does not require bypassing community authority — a strategy that would be both ethically inappropriate and practically counterproductive in rural Indonesian communities where social trust is the primary institutional currency. Rather, the data support formalising and accelerating the mediation process itself. Specific intervention strategies informed by our findings and by the broader literature include: (a) pre-identification and pre-engagement of religious community liaisons at the subdistrict level, who could be notified simultaneously with official authorization rather than sequentially; (b) development of a standardised written briefing document for religious leaders explaining the Islamic jurisprudential basis for the permissibility of forensic exhumation (supported by existing fatwa from the Indonesian Ulema Council, Majelis Ulama Indonesia); and (c) establishment of a targeted 72-hour mediation timeline standard in provincial forensic investigation protocols. These recommendations draw on the successful integration of religious leaders into public health communication during the COVID-19 pandemic[14,19] and could be operationalised through the existing network of the Kementerian Agama at the provincial and district levels.

Several limitations of this study should be acknowledged. First, the single-centre retrospective design may limit generalisability to other Indonesian forensic settings with different sociocultural compositions, forensic capacities, or legal frameworks. Second, classification of mediation type was based on retrospective review of written case file documentation, which may not fully capture the nuanced dynamics of community negotiation that occurred in the field; prospective structured documentation of mediation processes would reduce this misclassification risk. Third, the relatively small sample — particularly for

the Multiple mediator group (n=12) — limits statistical power for subgroup comparisons and contributes to wide confidence intervals for that group. Fourth, DNA concentration data were available only for successful extractions; cases with extraction failure had no quantitative DNA measurement, preventing analysis of the full degradation gradient and potentially introducing selection bias in the concentration analyses. Fifth, temporal changes in laboratory analytical performance, forensic team experience, or community–forensic relations over the five-year study period may have introduced unmeasured secular confounding. Future multicentre prospective studies with standardised mediation documentation, pre-specified power calculations, and quantitative DNA outcome measures across the full concentration range are recommended.

5. Conclusion

This retrospective cohort study demonstrates that sociocultural mediation type is a significant and independent predictor of both time-to-exhumation and DNA extraction success in South Sumatran rural forensic casework. Religious leader-mediated cases incur a median 29-day additional delay compared with directly authorized cases, and this delay translates into measurably reduced DNA yield and success rates. The combined HAGMA-equivalent in this context — the combination of mediation type identification and DNA outcome tracking — provides a template for forensic outcome audit systems that could be adapted for other Indonesian provinces.

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