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Cost-Effectiveness Analysis of HIV/AIDS Programme for Policy Decision in Nigeria: An Appraisal of Evidence Using the Drummond Checklist

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Abstract

Amidst declining access to funding, the HIV/AIDS pandemic remains a confounding health issue in sub-Saharan countries, especially Nigeria. The selection and sustainability of numerous programmes aimed at encouraging and upscaling uptake and adherence to intervention have become more critical. Hence, the assessment of evidence on the economic evaluation of programmes' effectiveness to inform decisions on scale-up has become inevitable. While several approaches to valuation exist, cost-effectiveness analysis (CEA) is widely used by many researchers. In this study, an evaluation of research evidence on the cost-effectiveness analysis of a HIV/AIDS programme was undertaken. The weaknesses, and the need to incorporate other considerations, such as long-term utility cost measures (QALYs/DALYs) and forecast, as well as equity, diversity and inclusion, were discussed using the Drummond 10-question checklist. The author recommends the use or inclusion of a cost-utility analysis (CUA) or cost-benefit analysis (CBA) in the economic valuation of HIV/AIDS programmes for policy decision-making in Nigeria

Keywords: Cost-Effectiveness Analysis, Cost-Benefit Analysis, Cost-Utility Analysis, HIV/AIDS, Economic Evaluation, Drummond checklist

1. Introduction

Acquired immune deficiency syndrome (AIDS) is a severe condition caused by the human immunodeficiency virus (HIV). About 80% of the world's HIV population lives in sub-Saharan Africa (Ekwunife *et al.*, 2018). The high burden of HIV/AIDS in sub-Saharan Africa remains a serious public health concern, and several interventions have been proposed and implemented at huge costs to reduce the burden of the disease. Within the past two decades, global organs such as Joint United Nations Programme on HIV/AIDS (UNAIDS) and the World Health Organisation (WHO), and other donor organisations have committed huge financial resources to mitigate the transmission and adverse effects of the disease, especially in low- and medium-income countries (UNAIDS, 2016 and 2023). Despite the enormous resources deployed on interventions to reduce related morbidity and mortality, very little progress has been made, with adolescents mostly affected on account of nonadherence to antiretroviral therapy (ART) and poor retention in care. Huge resources are being spent on (i) screening to identify status, (ii) ART drugs for treatment, (iii) medications for opportunistic diseases and care, (iv) counseling and education for

voluntary screening, and behavioural change, (v) monitoring of treatment adherence, (vi) sensitization for community awareness to reduce exposure and transmission, support for programmes and lifestyle change, and reduce stigmatization of people living with HIV (PLHIV) (Philbin *et al.*, 2014). Amidst emerging global and regional public health challenges of new and re-emerging infectious diseases like COVID-19, Ebola, Lassa fever, Mpox, etc., and the prolonged global economic downturn, the funding for HIV intervention has continued to dwindle (Gwandure and Mayekiso, 2013; Oladele *et al.*, 2015; Serieux *et al.*, 2015; WHO, 2024). The sustainability of new HIV interventions depends on the perceived net benefits amidst limited and scarce resources. Hence, the use of economic evaluation models such as cost-effectiveness analysis (CEA), cost-benefit analysis (CBA), cost-utility analysis (CUA), cost-consequence analysis (CCA), and cost-minimisation analysis (CMA), to determine the actual and potential net-benefits of programmes, as well as the opportunity cost of forgone alternatives as a result of any incremental cost, and to guide policymakers in selecting a more cost-effective programme has become an imperative (Alfirevic *et al.*, 2016; Turner *et al.*, 2021). This has become even more imperative with the funding challenge worsened by the United States review and restriction policy on foreign aid since 20 January 2025 which has been forecasted to adversely affect the HIV/AIDS programme under USAID and PEPFAR (KFF, 2025; NACA, 2025; Nigeria Health Watch, 2025).

2. Cost-effectiveness of HIV/AIDS intervention programmes

Several studies have examined the cost-effectiveness of some HIV/AIDS interventions in adolescents across the world with positive net benefits. However, the majority of such studies were in high-income countries (MacPherson *et al.*, 2015), with very few studies in low-income high-burden countries (Ekwunife *et al.*, 2021). Economic evaluations of HIV/AIDS programmes to determine feasibility and effectiveness relative to costs have become imperative for the selection of more appropriate interventions for implementation. It is in light of the above construct that the economic evaluation work of Ekwunife *et al.* (2021) on the “Cost-effectiveness and feasibility of conditional economic incentives and motivational interviewing to improve HIV health outcomes of adolescents living with HIV in Anambra State, Nigeria” is being discussed using the Drummond 10-question checklist (Drummond *et al.*, 2015).

2.1 The HIV/AIDS Intervention Cost-Effectiveness Study by Ekwunife *et al.* (2021)

The study was conducted as a cluster-randomised controlled trial (c-RCT) of the importance of an adolescent-centered intervention based on the published protocol of Ekwunife *et al.* (2018). The study sought to determine if there was any economically justifiable basis for such incentive-based intervention given the limited resources available for HIV programmes (Ekwunife *et al.*, 2021, p. 2). The study aimed to evaluate the cost-effectiveness of an incentive-based intervention on the health outcomes of adolescents living with HIV in Anambra State, Nigeria (Ekwunife *et al.*, 2021, p. 3). The primary outcome was the percentage change in the number of participants with an undetected viral load (VL) of <20 copies/ml, between the intervention and control arms in the 12th month. The secondary outcomes were adherence to ART and hospital appointments, CD4⁺ count, and retention in care.

The study had two arms - an intervention arm and a comparison (control) arm. The intervention arm received conditional economic incentives and motivational interviews, while the control arm received only the routine standard-of-care treatment. The targeted population was adolescents aged 10-19 years (Ekwunife *et al.*, 2021, p. 3). The conditional economic incentives for the intervention arm were cash rewards of US\$5.6 when the viral load was <20 copies/ml for the first 3 months, US\$2.8 if the viral load remained suppressed for the subsequent 3 months and the following 6 months, and then US\$5.6 if the VL remained <20 copies/ml for another 1 year (Ekwunife *et al.*, 2021, p. 3).

The costs and efficacy of the intervention were determined based on the 2019 base year. The cost-effectiveness of the intervention over the standard of care was assessed using the incremental cost-effectiveness ratio (ICER) index, expressed as cost per additional patient who achieved an undetectable VL. The study found the ICER of the intervention compared to the standard of care as US\$1419 per additional patient with undetected VL and concluded that it was not cost-effective based on Woods *et al.* (2016) recommendation of ≤US\$1137 (i.e. 51% of the GDP per capita of Nigeria in 2019) per QALYs gained. The ICER threshold range for low- and medium-income

countries is 1-51% of GDP per capita (Woods *et al.* 2016). The authors however, pointed out that reducing the number of VL and CD4 tests by ≥ 1 in the intervention arm will make it cost-effective.

2.2. Drummond's checklist critical appraisal of the study

Using the Drummond 10-question checklist (Appendix 1), the study was well conducted as a c-RCT, with a clear aim (Doran, 2010; Drummond, 1987). The primary and secondary outcomes were well outlined to enable the identification of inputs of effectiveness (efficacy of intervention) and costs, and the conduct of the cost-effectiveness analysis (CEA). The costs and effects were activity-based and were appropriately identified and obtained from the right sources. The financial incentives used were based on the protocol, although other incentives such as free hospital meals/snacks, food items, household gift items, and socio-ecological skills would have been possible.

As acknowledged by Ekwunife and colleagues, studies have shown that cash incentives are not sustainable in the long run and usually do not produce a long-lasting behavioural change effect (Ekwunife *et al.*, 2021, p. 9). A “do nothing” alternative was not considered, probably because HIV conditions require care and treatment to achieve and maintain viral suppression in PLHIV and prevent progression to AIDS. Thus, the control arm received the standard of care without any incentives. The targeted adolescent population was not stratified into sub-groups by sex, age, location, or socioeconomic status after the cluster-randomisation. The protocol reflected what happens in regular practice when funding is provided for identified activities. Costs were adjusted to 2019 prices using the implicit price deflators - gross domestic product (GDP) deflators. There was no specific justification for the base year other than the year of study completion as specified in the protocol. An in-depth interview (IDI) was used to assess the perception of effectiveness and the feasibility (generalizability) of the intervention in hospitals in Nigeria from health care providers' perspectives.

2.3. Biases and weaknesses in the study

The outcome of the study may have been weakened by some factors such as sample size, omission of utility inputs and some of the shared resources in the calculation of CEA, and professional biases of IDI respondents. Limitations and potential bias may have arisen from cost variation between centers, small sample sizes, and selected measures of effectiveness (primary and secondary outcomes). The sample size was inadequate, which affected baseline viral suppression data between both arms, and this may have caused effect modification (Ekwunife *et al.*, 2021, p. 9). Long-term costs and consequences or extended CEA were generally not considered. The measured effectiveness was only restricted to the primary and secondary outcomes, which did not include utility inputs such as quality-adjusted life years (QALYs) gained measured by Life-5 Dimensions (EQ-5D™) instrument, and disability-adjusted life years (DALYs) averted (Alfirevic *et al.*, 2016). This affected the range of the costs and effects analysed. The IDI presented only the viewpoints of the healthcare providers (Doctors, Pharmacists, Nurses, and Medical Laboratory Scientists) and did not cover the perspective of other relevant parties such as the patients and community. Furthermore, capital costs covering hospital facilities (building and equipment), data collection costs, and indirect costs from patients and families were excluded (Ekwunife *et al.*, 2018, p. 6). Only operating costs covering items or components of the intervention (laboratory investigations, personnel costs for motivational interviewing, economic incentives, inpatient/outpatient costs, phone calls, and transportation) were included in the CEA (Ekwunife *et al.*, 2021, p. 4-5). The study did not specify the use of joint resources or shared costs, and no identified cost item was specified in the protocol that was omitted from measurement. Costs that did not reflect market values were also not identified or included.

The sources of resources were justified, and the costs were activity-based. Personnel costs were based on the salaries of hospital staff, while costs of medications (ART) and consumables were based on Global Fund Pooled Procurement Mechanism Reference Pricing for ART, and the buyer's median price of the International Medical Products Price Guide, respectively. Other costs were obtained directly from the hospital (out/in-patient cost), and activities (laboratory tests, phone calls, transportation) or as provided by previous survey studies (Ekwunife *et al.*, 2021, p. 3). All costs were adjusted to the 2019 base year. The analysis did not include discounting or the use of discount rates, because long-term projections were not considered.

The valuation of effects was appropriately done for a CEA. The study did not focus on the allocative efficiency question, which would have at best been evaluated by cost-benefit analysis, but on the technical efficiency or feasibility of the intervention. The effectiveness measures were based on the percentage of participants with viral suppression of ≤ 20 copies/ml, which is appropriate for incremental cost-effectiveness analysis (ICEA).

The statistical analysis was conducted at a 95% confidence interval (CI) with available patient data. The % difference between both arms in participants with undetected viral loads was statistically determined as 11.7% while it was 8.9% after adjusting for participants who changed regimen to a Dolutegravir-based combination. The intervention's incremental cost-effectiveness ratio (ICER) compared to the standard of care was US\$1419 per additional patient with an undetected viral load. A sensitivity test conducted by varying the cost elements over $\pm 25\%$ did not translate to positive cost-effectiveness of the intervention. The sensitivity test indicated that the intervention was not worthwhile based on Woods *et al.* (2016) ICER threshold of US\$1137 per QALYs for Nigeria. Only a reduction in the number of tests for VL or CD4 in the intervention arm could improve the cost-effectiveness of the intervention (Ekwunife *et al.*, 2021, p.5 and 8).

3. Discussion

The inference reached by the authors seemed appropriate and was based on the incremental cost-effectiveness ratio (ICER) index, which was interpreted intelligently with reference to Woods *et al.* (2016, p. 933) percent GDP per capita-based cost-effectiveness threshold (CET). The authors also discussed the results in the context of similar studies and found to align (Ekwunife *et al.*, 2021, p. 9). Opportunities for methodical modification were identified, for instance, the use of skill acquisition incentives instead of economic (financial) incentives for a more sustainable outcome. Study limitations were identified as inadequate sample size, the significant difference in baseline viral suppression between the arms, exclusion of utility benefits in terms of QALYs, exclusion of some costs (capital and data collection), and lack of inclusiveness in the IDI. The generalizability of the intervention to other hospital settings in Nigeria was, however, under-discussed. Capacity building for client-centered counseling skills and increased remuneration of the team of dedicated care providers were identified as factors for successful implementation in real-life settings. Ethical issues of equity and equality among individuals in the population were unexpectedly not discussed.

The study established that in real-life scenarios, other excluded costs may arise. Additionally, substituting economic incentives with social incentives, such as skill acquisition, may reduce costs in the long run, but more studies will be needed to evaluate their cost-effectiveness. The study addressed issues of technical efficiency but not allocative efficiency because it did not compare it to another intervention. A projected long-term CEA may indicate better cost-effectiveness in comparison with similar studies for allocative efficiency decisions.

The study by Ekwunife *et al.* (2021) is similar in objective and scope to the study by Tozan *et al.* (2019) on the family economic empowerment intervention through BRIDGES and BRIDGES-plus programme, an incentives-based intervention, targeted at adolescents orphaned by HIV/AIDS in Uganda. While Ekwunife's intervention was not cost-effective with an ICER of US\$1419, Tozan's Bridges and Bridges-plus intervention with an ICER of US\$289 was adjudged cost-effective. However, the different conclusions from the two studies may have been due to approaches to cost items identification and inclusion as well as cost valuation. The stratification of participants into sub-groups in Tozan's evaluation may also have affected the CEA and ICERs obtained.

4. Implication

The intervention in Ekwunife *et al.* (2021) study was not cost-effective based on recommended thresholds and therefore, may not appeal to policymakers for population rollout unless other considerations are involved. Unfortunately, the long-term projection of effectiveness, and other measures of effectiveness, for instance, utility measures such as QALYs gained and DALYs averted, the impact on care providers, family, and associates, are not considered in CEA. The cost sensitivity from the number of laboratory tests, which could potentially lower the ICER to $\leq$ US\$1086, indicated that the study could be easily modified to become cost-effective. The potential net

benefits accrued from QALYs (and/or DALYs), and from other related sectors, could add to overall net benefits in CUA and CBA for policy decisions.

A cross-sectoral cost and benefits comparison involving sectors outside health is always a challenge in CEA, hence CEA analysis alone may not present the required economic evaluation framework needed for an appropriate policy decision (Cohen and Reynolds, 2008; Turner *et al.*, 2021, p. 10-13). A combination of analysis and ethical consideration is usually needed for an effective policy decision (Vlaev *et al.*, 2019). For instance, amidst scarce resources, the question of equity (and equality) among social-demographic gradients is also a necessary consideration in selecting programmes to be implemented (Sassi *et al.*, 2001, p. 19-21). Studies have indicated that economic incentives do not always produce a long-lasting behavioural change effect in young people and have to be supplemented with other social incentives for sustainability (Kavanagh *et al.*, 2010). Moreover, the ethical issue of equity, personal preferences, and socioeconomic status are determinant factors in the effectiveness of incentives as income levels and personal preferences determine the perceived value of financial incentives to an individual. Hence, a more tailored incentive scheme, which may not be financial, could be more effective (Vlaev *et al.*, 2019). A good alternative to the economic incentives used by Ekwunife *et al.* (2021) could be social-ecological incentives which can be material supports, social skills, and industrial-skills acquisition such as information technology communication (ICT), fashion designing, household consumer products (soaps and detergents, candles, confessionalary) production, catering, baking, public speaking, community mobilization, sports, etc (Mercy Corps, 2020). These social and industrial skills, which are more population-goals specific or values-oriented, may cost a little more but will usually produce long-lasting behavioural change effects, and are more cost-effective in an extended CEA (Durantini and Albarracin, 2009; Kullgren *et al.*, 2016).

5. Conclusion

The challenge of HIV/AIDS programme adherence among adolescents in sub-Saharan is a serious public health issue. Several incentive programmes have been developed and implemented to promote the uptake of and adherence to interventions. The cost-effectiveness and sustainability of these programmes amidst declining financial allocations are important considerations for programmes selection and implementation among donors and policymakers. Hence, Ekwunife *et al.* (2021) examined the cost-effectiveness of an incentives-based HIV intervention among adolescents in Anambra State of Nigeria. The study showed that the intervention was not cost-effective based on the recommended ICER threshold and could become cost-effective if the number of laboratory tests for viral load and CD4 were reduced to ≤ 3 . The study only considered the costs of activities and did not consider the shared costs, capital costs, and patient/family personal costs. The effectiveness measures did not include QALYs gained, DALYs averted, and social benefits from related sectors, such as, averted transmissions and deaths, lost manhours, etc. These excluded measures may have added to the cost-ineffectiveness and limitation of the study. Although the study was similar to that by Tozan *et al.* (2019), the computation of costs and effectiveness differs significantly due to the disaggregation of participants into subgroups in the latter. This may have influenced the “cost-effective” conclusion of Tozan’s study. Ethical issues of accessibility from the perspective of equity and socioeconomic status are important factors that can influence policymakers’ decisions, irrespective of the CEA. For programme long-term sustainability, material and socio-ecological incentives may be a more cost-effective alternative intervention. The Drummond checklist (Appendix 1) effectively identified and discussed the strengths and weaknesses of the evidence by Ekwunife *et al.* (2021), which could be helpful in policy decision-making, prioritizing HIV/AIDS programmes, and guiding future research directions.

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Supplementary materials: Appendix 1: Drummond 10-question checklist assessment of Ekwunife *et al.* (2021).

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Supplementary Materials

Appendix 1: Drummond 10-question checklist assessment of Ekwunife *et al.* (2021)

Drummond (1987) 10-question checklist is used to identify key elements in published public health interventions for sound economic appraisal. The appraisal of Ekwunife *et al.* (2021) based on the checklist questions is presented below.

1. Was a well-defined question posed in answerable form?
 - Did the study examine both costs and effects of the service(s) or programme(s) over an appropriate time horizon? **Yes (2019 base year)**
 - Did the study involve a comparison of alternatives? **Yes. The intervention was compared with the routine standard of care.**
 - Was a perspective for the analysis stated and was the study placed in any particular decision-making context? **Yes. (To assess the Cost Effectiveness of conditional economic incentives in HIV/AIDS programme toward informing policy)**
 - Were the patient population and any relevant subgroups adequately defined? **Yes – The patient population was adolescents age 10-19 year (Ekwunife *et al.*, 2018, p. 3; 2021, p. 3)**
2. Was a comprehensive description of the competing alternatives given (i.e. can you tell who did what to whom, where, and how often)?
 - Were any relevant alternatives omitted? **Possibly – alternative forms of incentives such as skills (social and industrial) acquisition, and material supplies (free hospital meals, food items or household goods), may be good alternatives.**
 - Was (should) a ‘do nothing’ alternative (be) considered? **No, HIV requires treatment to achieve and maintain viral suppression in PLHIV. However, the control or comparison arm was subjected to only the standard of care without the intervention incentives.**
 - Were relevant alternatives identified for the patient subgroups? **No. There were no subgroups. The intervention was targeted at just one group, the adolescents, aged 10-19 years.**
3. Was the effectiveness of the program or services established?
 - Was this done through a randomized, controlled clinical trial? If so, did the trial protocol reflect what would happen in regular practice? **Yes. Data from cluster-randomised controlled trial were used in the cost-effectiveness analysis (CEA).**
 - Were effectiveness data collected and summarized through a systematic overview of clinical studies? If so, were the search strategy and rules for inclusion or exclusion outlined? **No, and not applicable because it was not a systematic review. The data for the CEA was based on a single c-RCT study.**
 - Were observational data or assumptions used to establish effectiveness? If so, were any potential biases recognized? **No observational data or assumptions were used to establish effectiveness. However, an in-depth interview was used to assess the perception of effectiveness from health care providers’ perspectives in order to assess the feasibility of the intervention in Nigerian hospitals.**
If so, were any potential biases recognized? **Possibly. All costs were corrected to the 2019 base year. However, there may have been errors due to cost variation between centers as detailed information on the hospital cost calculation was not provided. The sample size was also inadequate, which affected baseline viral suppression data in both arms, and this may have resulted in statistical interactions or effect modification.**
4. Were all the important and relevant costs and consequences for each alternative identified?
 - Was the range wide enough for the research question at hand? **No. long-term costs and consequences after the intervention year were generally not considered. Capital cost, personal cost from patients and families, were not included. The consequences (benefits) were only restricted to those stated in the primary and secondary outcomes, which did not include improvement in utility measures such as quality-adjusted life years (QALYs), disability-adjusted life years (DALYs), reduction in morbidity and mortality, etc., and benefits from related sectors.**
 - Did it cover all relevant viewpoints? (Possible viewpoints include the community or social viewpoint, and those of patients and third-party payers; other perspectives may also be relevant depending on the

particular analysis.) No. The in-depth interview reported only the viewpoints of the health care providers (Doctors, Pharmacists, Nurses, and Medical Laboratory Scientists) were provided. That of the patients and community were not covered by the study.

- Were the capital costs, as well as operating costs, included? No. Capital costs covering hospital facilities (building and equipment), data collection costs, and indirect costs from other sectors (patients and family costs) were not included (Ekwunife *et al.*, 2018, p. 6). Only operating costs covering items or components of the intervention (lab investigations, personnel costs for motivational interviewing, economic incentives, inpatient/outpatient costs, phone calls, and transportation) were included (Ekwunife *et al.*, 2021, p. 4-5).

5. Were costs and consequences measured accurately in appropriate physical units (e.g. hours of nursing time, number of physician visits, lost workdays, gained life years)?

- Were the sources of resource utilization described and justified? Yes. Personnel costs were based on salaries of hospital staff, costs of medications (ART) and consumables were based on Global Fund Pooled Procurement Mechanism Reference Pricing for ART and buyer's median price of the International Medical Products Price Guide. Other costs were obtained directly from the hospital or as provided by previous survey studies (Ekwunife *et al.*, 2021, p. 3)

- Were any of the identified items omitted from measurement? Yes. Capital and indirect costs, and QALYs and DALYs were omitted. If so, does this mean that they carried no weight in the subsequent analysis? No.

- Were there any special circumstances (e.g., joint use of resources) that made measurement difficult? Yes, but it was not specifically reported. Were these circumstances handled appropriately? No.

6. Were the cost and consequences valued credibly?

- Were the sources of all values clearly identified? (Possible sources include market values, patient or client preferences and views, policy-makers' views, and health professionals' judgments) Yes. Activity-based costing for resources used was adopted. Personnel costs were based on salaries of hospital staff, costs of medications (ART) and consumables were based on Global Fund Pooled Procurement Mechanism Reference Pricing for ART and buyer's median price of the International Medical Products Price Guide. Other costs were obtained directly from the hospital or as provided by previous survey studies (Ekwunife *et al.*, 2021, p. 3).

- Were market values employed for changes involving resources gained or depleted? Yes. All costs were adjusted to 2019 base year. There was no discount rate because a base year was used and long-term projections were not considered in the analysis.

- Where market values were absent (e.g. volunteer labor), or market values did not reflect actual values (e.g., clinic space donated at a reduced rate), were adjustments made to approximate market values? No, it was not applicable. Capital and indirect costs were not considered.

- Was the valuation of consequences appropriate for the question posed (i.e. has the appropriate type or types of analysis – cost-effectiveness, cost-benefit, cost-utility – been selected)? Yes. The study was not focused on the allocative efficiency question, which would have best been evaluated by cost-benefit analysis, but more on the technical efficiency or feasibility of the intervention. The effectiveness measures were based on the percentage of participants with viral suppression of ≤ 20 copies/ml, which is appropriate for an incremental cost-effectiveness analysis (ICEA). The ICEA or cost-utility analysis (CUA) is also appropriate for a short- to medium-term intervention consideration. A cost-benefit analysis (CBA) would have been appropriate for a longer-term and a more holistic analysis for allocative efficiency.

7. Were costs and consequences adjusted for differential timing?

- Were costs and consequences that occur in the future 'discounted' to their present values? No, there were no future cost projections. Costs were adjusted to 2019 prices using the implicit price deflators - gross domestic product (GDP) deflators.

- Was there any justification given for the discount rate used? No. However, the study protocol indicated the year of completion of the study as 2019. There were no long-term projections made, and therefore no discounts assumed.

8. Was an incremental analysis of costs and consequences of alternatives performed?
 - Were the incremental costs generated by one alternative over another compared to the additional effects, benefits, or utilities generated? **Yes.** Although the CEA favours the intervention arm (Table 1, p. 5), but it failed the ICER threshold recommended by Woods *et al.* (2016), and therefore the intervention was considered not effective (Table 3, p. 6).
9. Was uncertainty in the estimates of costs and consequences adequately characterized?
 - If patient-data on costs and consequences were available, were appropriate statistical analyses performed? **Yes.** The % difference between both arms in participants with undetected viral loads was statistically determined as 11.7% while it was 8.9% after adjustment when adjusted for regimen change to Dolutegravir-based combination. The incremental cost-effectiveness ratio (ICER) of the intervention compared to the routine care was US\$1419 per additional patient with undetected viral load. The confidence interval (CI) used in the statistical calculation was 95%.
 - If a sensitivity analysis was employed, was justification provided for the form(s) of sensitivity analysis employed and the ranges or distributions of values (for key study parameters)? **Yes.** A sensitivity test of variation of cost drivers by +/- 25% were performed to determine its effect on ICER. The sensitivity test indicated that the intervention was not viable based on Woods *et al.* (2016) cost-effectiveness threshold. Only a reduction in the number of tests for viral load or CD4 in the intervention arm could improve the cost-effectiveness of the intervention (Ekwunife *et al.*, 2021, p. 5 and 8).
 - Were the conclusions of the study sensitive to the uncertainty in the results, as quantified by the statistical and/or sensitivity analysis? **Yes.** The sensitivity analysis of the effectiveness due to regimen change to Dolutegravir-based combination increased the ICER to from US\$ 1419 to US\$1865 per additional patient with undetected viral load. Variation of cost drivers by +/- 25% varied the ICER to values between US\$1169 and US\$1669 per additional patient with undetected viral load.
 - Was heterogeneity in the patient population recognized, for example by presenting study results for relevant subgroups? **Not applicable** in terms of age group. The study population was not stratified by age, sex and socioeconomic status.
10. Did the presentation and discussion of study results include all issues of concern to users?
 - Were the conclusions of the analysis based on some overall index or ratio of costs to consequences (e.g. cost-effectiveness ratio)? If so, was the index interpreted intelligently or in a mechanistic fashion? **Yes.** The analysis and conclusion was based on incremental cost-effectiveness ratio (ICER) index, which was US\$1419. The index was interpreted intelligently with reference to Woods *et al.* (2016, p.933) GDP per capita-based cost-effectiveness threshold for low/medium-income countries.
 - Were the results compared with those of others who have investigated the same question? If so, were allowances made for potential differences in study methodology? **Yes,** the authors discussed the results in the context of other similar studies and aligned. Opportunity for methodical modification was also identified, for instance, the use of skill acquisition incentives instead of economic (financial) incentives for a more sustainable outcome. The limitations of the study were identified by the authors as inadequate sample size, significant difference in baseline viral suppression between the arms, exclusion of benefits in terms of QALY, exclusion of some costs (capital and data collection), and lack of inclusiveness or exclusion of patients in the in-depth interview.
 - Did the study discuss the generalizability of the results to other settings and patient/client groups? **Yes,** the generalizability of the intervention to other hospital settings in Nigeria was discussed. But the discussion was not exhaustive. Capacity building for client-centered counseling skills and increase remuneration of a team of dedicated care providers were identified as a factor for successful implementation in real-life setting.
 - Did the study allude to, or take account of, other important factors in the choice or decision under consideration (e.g. distribution of costs and consequences, or relevant ethical issues)? **Partially.** Amidst dwindling HIV intervention funds, the need for careful consideration of interventions to be included in HIV programmes was highlighted by the authors (Ekwunife *et al.*, 2021 p. 10). Ethical issues of equity and equality among individuals in the population were not discussed.

- Did the study discuss issues of implementation, such as the feasibility of adopting the ‘preferred’ program given existing financial or other constraints, and whether any freed resources could be redeployed to other worthwhile programs? No. The study established that the economic incentives and motivational interviewing will only be cost-effective if the number of viral load and CD4 testing was reduced to between 1-3 time per year in the intervention arm. However, in real-life scenarios, other costs may arise from increased remuneration, and training of care providers, and the cost of data collection and analysis was excluded. Substituting economic incentives with social incentives such as skill acquisition may reduce cost, but more study will be needed to evaluate the cost-effectiveness or cost-benefit.
- Were the implications of uncertainty for decision-making, including the need for future research, explored? Yes to an extent, the study addressed issues of technical efficiency, but not much of allocative efficiency because it did not compare it to another intervention. However, factors that may determine real-life cost-effectiveness and feasibility were highlighted. The obvious limitations of the study were discussed, which could be mitigated in future research.

Stimulation or Meditation? Investigating the Effects of tDCS, Mindfulness and Personality Traits on Creative Thinking

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Abstract

Divergent thinking (DT) and convergent thinking (CT) are typically considered the two faces of creativity and are associated to different neuro-functional networks. Previous research underlined that brain stimulation and meditation can modulate the creative process. However, their effect over DT e CT is still not clear. Purpose: The aim of the present study was to explore if and how tDCS and mindfulness meditation could modulate creativity outcomes by administering a 4-day training whose efficacy was measured by a pre/post assessment. Method: Forty-seven healthy volunteers were randomly assigned to four experimental conditions: A) real stimulation, real meditation; B) sham stimulation, real meditation; C) real stimulation, fake meditation; D) real meditation alone. tDCS stimulation was applied with the anode over F8 (Inferior Frontal Gyrus, IFG) and the cathode on the left supraorbital area for 20 minutes at 1.5 mA. Also, personality traits were considered. Results: Results revealed that training A was the most successful in improving convergent thinking and cognitive efficiency, while training C was more effective in modulating verbal fluency. Conclusions: Results have been discussed considering the role of IFG and the Default Mode Network (DMN) for DT and CT, together with personality attitudes. Also, future directions have been suggested.

Keywords: Creativity, Divergent Thinking, Convergent Thinking, tDCS, Brain Stimulation, Mindfulness, Meditation, Brain Modulation, Cognitive Psychology, Mind Wandering, Personality Traits, Experimental Psychology, Focused Attention, Cognitive Flexibility, Fluency

1. Introduction

Creativity has been defined as the ultimate resource of humankind (Findlay & Lumsden, 1988), receiving recognition and widespread attention in several fields. Being a complex construct both to understand and investigate, neuroscience has tried to unveil its underlying processes using different strategies.

One of the major tenets of contemporary creativity theories is the interplay of convergent (CT) and divergent thinking (DT) in yielding successful creative products or solutions (Kleinmuntz et al., 2019). Convergent and divergent thinking are mostly thought of as being the opposite ends of a continuum, and they have been widely recognized to be both necessary to creativity (Runco, 2014; Zhang et al., 2020). Experiments targeting these two functions separately have thus taken up a big part of scientific endeavors in the field. Historically, DT has been considered as a proxy of creativity, and has thus been investigated more thoroughly than CT in creativity studies (Acar & Runco, 2019; Cortes et al., 2019). In the present work, the two complementary constructs have been explored.

Mindfulness is a meditation style that invites people to be aware of the impermanence of things within the here-and-now context and involves a specific attentional focus toward objects and sensations (Davidson & Goleman, 1977; Kabat-Zinn, 2015). Some studies reported that mindfulness improves a person's ability to focus attention and stay concentrated, thus favoring CT, while DT can be associated with the meditation power to promote a more open and flexible thinking (Brown et al., 2007; Eberth & Sedlmeier, 2012). Mindfulness seems to be useful in activating and modulating some mental aspects traditionally linked to creativity, such as curiosity, openness to experience, relaxation and focal attention, while reducing distractibility and the tendency to concentrate on a single aspect of reality (Prabhu et al., 2008). Interestingly, there is evidence supporting the view that mindfulness training favors the deactivation of specific brain areas (in particular, the medial prefrontal cortex) when processing aversive stimuli (e.g., painful stimuli (Taylor et al., 2011)), thus promoting emotion stability. This evidence seems to link studies on mindfulness and creativity with the study of DMN. Indeed, the MPFC plays a pivotal role in the default mode network (Gusnard et al., 2001). The focus on the present-moment is associated with decreased MPFC function, while a resting state activate it with a set of other connected areas (the inferior parietal lobule, the precuneus, the posterior cingulate cortex, and the inferolateral temporal cortex). However, it seems that mindfulness promotes a temporary deactivation of DMN even if, in people following a meditation training (long term effects) the internal DMN connectivity becomes long-term stronger (Jang et al., 2011).

On the other hand, vary moderators, such as the type of meditation practiced and the multifaceted character of mindfulness, do challenge untangling the mindfulness-creativity relationship (Baas et al., 2014). In detail, the two main types of meditation used in mindfulness research are open-monitoring (OM) and focused-attention meditation (FA). OM is the practice of observing and attending to any sensation or thought without focusing on any specific task or concept. FA instead trains the participant to focus their attention and awareness on a particular task, item, thought or stimulus. By coupling these two meditation techniques with RAT and AUT trials, studies have tried to assess FA and OM effects on CT and DT. In particular, FA has been associated with improved CT, while OM has been associated with DT (Colzato et al., 2012). What is more, task-independent changes in the DMN have been found in expert meditators, as well as enhanced activity in prefrontal areas, the anterior cingulate cortex and medial regions, such as the insula (Gundel et al., 2018; Lindsay et al., 2019).

An interesting phenomenon that has been associated both with OM and DT, engaging similar brain network activity, is mind wandering. While mind wandering seemingly runs contrary to mindfulness, it reliably correlates with creative thinking and creative achievement (Baird et al., 2012). Yamaoka and Yukawa (Yamaoka & Yukawa, 2016) found a link between frequent mind wandering and high level of creativity, while Agnoli et al. (Agnoli et al., 2018) showed that mind wandering and mindfulness predicted creative behavior both alone and in combination.

One of the techniques that has proven important in identifying the differential activation and shift between intrinsic brain networks in CT and DT is tDCS. While it is difficult to accurately determine tDCS effects, since individual and confounding variables have been found to affect treatment results, research on CT and DT has yielded interesting and unambiguous results regarding the differential contributions of the left and right temporal and prefrontal cortices to the creative process (for a comprehensive review, see (Lucchiari et al., 2018)).

In particular, consistent results were obtained applying left cathodal/right anodal frontopolar cortex stimulation, revealing a key role of the right inferior frontal gyrus (IFG) and angular gyrus (AG) in improving performance and increasing cognitive flexibility in a variety of DT tests (Green et al., 2017; Ivancovsky et al., 2019; Koizumi

et al., 2020; Stevens Jr & Zabelina, 2019). Furthermore, tDCS was found to affect brain networks, particularly the DMN, during creative thinking, and to modulate functional connectivity in flexible and creative ideation (Lifshitz-Ben-Basat & Mashal, 2021).

While decreasing left-hemisphere inhibitory control and executive dominance may trigger a general creative mindset, the following steps leading to idea generation, elaboration, and selection are yet to be clarified. Within this theoretical framework, for the present study we developed a 4-conditions sham-controlled experimental paradigm to assess creativity improvement using tDCS paired with mindfulness meditation (E-meditation; (Badran et al., 2017a, 2017b)).

Specifically, the present study aims to:

- 1) Determine if creative process can be modified by a) tDCS and b) E-meditation (tDCS in conjunction with an audio-guided Mindfulness procedure), and how.
- 2) Assess the relationship between mindfulness training and CT parameters.
- 3) Investigate the role that personality traits assume in modulating participants' responses to the different experimental conditions.

Based on previous research and the neuro-cognitive model illustrated above, we hypothesized that the tDCS+Mindfulness condition will have a greater effect than tDCS alone, which in turn will be more effective than Mindfulness alone (tDCS sham condition). We further hypothesized that Mindfulness alone has the power to increase convergent thinking as reported in previous research, and that this effect will be greater than Mindfulness+tDCS.

2. Materials and Methods

2.1. Participants

Forty-seven healthy volunteers ($M_{age}=30$, $sd=9.36$) participated in the experiment. The sample was composed of 34 women and 13 men. They all had normal or corrected-to-normal visual acuity. Previous history of psychiatric or neurological disorders was considered as exclusion criterion. The study was conducted with the understanding and written consent of the participants, who had been informed of the research procedures and purposes according to the Declaration of Helsinki and with the approval from the local Ethical Committee (Università degli Studi di Milano; protocol code: 27/19; 06/24/9).

2.2. Procedure

Participants were randomly assigned to one of the four experimental conditions: A) real stimulation, real meditation; B) sham stimulation, real meditation; C) real stimulation, fake meditation; D) real meditation alone ($N_A=13$; $N_B=10$; $N_C=14$; $N_D=10$). Then, the procedure involved four different stages: I) Personality and Mindfulness Assessment. The participants, regardless of the experimental group, were asked to complete the questionnaires about personality indices, mindful and mind-wandering attitudes.

II) Pre-test assessment (T0). Participants were submitted to cognitive and creative tasks.

III) Training. Participants were asked to undergo 4-consecutive days of one of the four experimental conditions;

IV) Post-Training assessment (as in phase II).

2.3. Materials

2.3.1. Highly Sensitive Person Scale (HSPS)

(Aron & Aron, 1997): sensory processing sensitivity (SPS), is a personality trait modulated by genetic factors, which allows people feeling and processing more information at one time, and in a deeper way. Such sensitivity is referred to both external and internal stimuli (Jagiellowicz et al., 2011). To measure SPS Aron & Aron (Aron &

Aron, 1997) implemented the HSPS, which includes 27 statements towards which the participant has to express their degree of agreement on a scale ranging from 1 (“totally disagree”) to 7 (“totally agree”).

2.3.2. Abbreviated Torrance Test for Adults (ATTA)

ATTA includes 3 different 3-minutes completion tasks. The first one requires verbal responses (Activity #1), while the second and third a figural output (Activities #2 and #3). The ATTA scoring consists of four norm-referenced abilities and fifteen criterion-referenced creativity indicators. The four norm-referenced measures are (1) Fluency; (2) Originality; (3) Elaboration; (4) Flexibility. The criterion-referenced indicators refer to additional qualities of mentioned or produced items (such as richness of imagery; humor; fantasy; etc). The final score was computed as the sum of these scorings (Goff & Torrance, 2002). The Creativity Index (CI) was considered for the purpose of the present paper.

2.3.3. Five Facets Mindfulness Questionnaire (FFMQ)

FFMQ is a self-report questionnaire developed by Baer and colleagues to assess the level of mindfulness experienced by individuals in everyday situations (Baer et al., 2006). It consists of 39 items to be answered on a Likert scale ranging from 1 (almost never) to 5 (almost always). It includes 5 facets of mindfulness: Not reacting to inner experience; Observing internal and external stimuli; Act consciously; Describing; Non-judging one's experience.

2.3.4. Mindfulness Awareness Attention Scale

The Mindful Attention Awareness Scale (Brown & Ryan, 2003) is a 15-item questionnaire which assesses dispositional mindfulness. Participants were asked to indicate how often they had experienced the scenarios and feelings indicated in the various items by using a 6-point Likert scale from 1 (“almost always”) to 6 (“almost never”).

2.3.5. BIG-5 Personality Questionnaire

For the purposes of the present paper we used the Big Five Inventory-10 (BFI-10) (Rammstedt, 2007), which consists of 10 items to be rated on a five-step scale from 1 (“disagree strongly”) to 5 (“agree strongly”). It explores the Big Five Factor Model that includes the factors Extraversion, Agreeableness or Friendliness, Conscientiousness, Emotional Stability or Neuroticism, and Intellect or Openness to Experience.

2.3.6. Behavioral Inhibition/Activation Scales (BIS/BAS)

The scale includes 24 items (20 score-items and four fillers) to be rated on a five-point Likert scale from 1 “not at all true” to 5 “completely true” (Carver & White, 1994; Leone et al., 2002). The scoring included two subscales, one for BIS (7 items), and three for BAS (BAS-reward responsiveness; BAS-drive; BAS-fun seeking: 13 items).

2.3.6. Mind Excessive Wandering Scale (MEWS)

MEWS is a self-report scale assessing excessive mind wandering (Mowlem et al., 2019) with 15-items. Participants were instructed to assess the frequency of the proposed statement from 0 (never) to 3 (almost always).

2.3.7. Verbal Fluency

The verbal fluency task is useful for assessing the individual's ability to evoke words. Indeed, the participants are required to provide the greatest number of words belonging to a certain phonemic and/or semantic category, in one minute of time. For this experiment, we transformed the original oral version (Novelli et al., 1986) into a computerized task created with MatLab of both phonemic and semantic tasks. Participants were given 1 minute

for each item. Fluency was assessed as the sum of the acceptable provided words (names, foreign words, derived words, and collective nouns were not accepted). The task reflects both linguistic and executive efficiency.

2.3.8. Wisconsin Card Sorting Test (WCST)

The WCST provides a measure of higher executive functions including attention, working memory, mental flexibility, abstraction capacity, and the ability to modify mental paradigm. It is also useful for measuring the degree of perseverance. We chose a computerized version available on the online platform PsyToolkit.org. In the top of the screen 4 stimulus cards appear varying in color (red, yellow, blue, green), number (1 to 4) and shape (star, cross, triangle, circle) of the objects represented. With each trial, a card-target appears on the left side of the screen. Participants are required to match the target card to one of the four stimulus cards, following the criteria of color, number, or shape. However, the card-matching rule is not explicitly revealed, but must be inferred by monitoring the feedback ("right" or "wrong") provided after each trial. After a series of trials, the rule of pairing changes without warning: it is up to the participant to notice this and modify their responses accordingly. This version includes 60 trials and provides both verbal and auditory feedback. The cards have a size of 100x100px.

2.3.9. Alternative Uses Tasks (AUT)

AUT stems from Guilford's research and is one of the most widely used tests to measure divergent thinking (Guilford et al., 1960). Participants are presented with an object with a request to indicate as many alternative uses as possible. For the purposes of our research, we created three computerized versions of the AUT using MatLab. Each version consists of 2 equivalent versions made up of two couples of common objects. The request was to list the greatest number of alternative uses for the object proposed. Participants had a maximum of 1 minute for each item. In this case, the scoring included fluency and flexibility measures of creativity. Fluency was simply scored as the number of appropriate answers, while, to measure flexibility, we created categories based on our sample, and then we counted for each subject the number of categories into which the items produced fell.

2.3.10. Remote Association Test (RAT)

RAT was designed by Mednick (Mednick, 1962) to assess convergent thinking. Participants are presented with triplets of words that are not apparently related to each other, but that can be united by a fourth word that binds to all three: participants are required to identify this word as quickly as possible. Each triplet has only one response possible. For the purpose of our research, we created two computerized versions of the RAT using MatLab. Each version consists of 9 triplets, selected so that the difficulty level of the three tests to be equivalent, taking into account the Italian validation of the triplets (Salvi et al., 2020). Participants had one minute maximum to solve each triplet.

2.3.11. tDCS protocol

For groups A, B, and C, tDCS stimulation was applied in the following positions: anode on F8 (Inferior Frontal Gyrus, IFG) and cathode on left supraorbital area. Active stimulation was delivered for 20 minutes at 1.5 mA. Sham stimulation consisted of applying 30 seconds of actual stimulation and then turning off the device. A commercially available Zendo tDCS system for meditation enhancement (Bodhi NeuroTech, Inc, USA) was used.

2.3.12. Meditation

Participants in groups A, B, and D listened to pre-recorded mindfulness meditation audio-guide for 20 minutes. The practice was recorded by a trained researcher following a script which focused the experience on bodily sensations and breathing. Participants in group C have listened to a reading of a philosophical nature, recorded by the same person, using a tone of voice comparable to that of real meditation, for the same amount of time.

3. Results

After computing all the dependent variables related to personality traits, creative and cognitive performance, new dependent variables have been created to better highlight the gain (or loss) that each participant obtained thanks to the training. Thus, for creative and cognitive scores, deltas of performance have been calculated as the difference between the scoring obtained in T1 and those obtained in T0 (T1-T0). Then, 3 different sets of analyses have been conducted on the dataset.

3.1. Comparison of Delta scores across groups

First, one-way ANOVAs were performed over each dependent variable (Delta scores of: Phonemic Fluency, Semantic Fluency, RAT hits, WCST total errors, WCST perseverative errors, WCST non-perseverative errors, WCST RTs, AUT fluency, AUT flexibility). The analyses highlighted a significant effect of Group ($F_{1,43}=3.14$, $p<0.05$; $\eta^2p=.18$) for Delta-Phonemic Fluency, with group C obtaining significantly higher gains ($M=2.07$, $SD=.71$) than group A ($M=-.92$; $SD=.73$) which, instead, performed worse after the training.

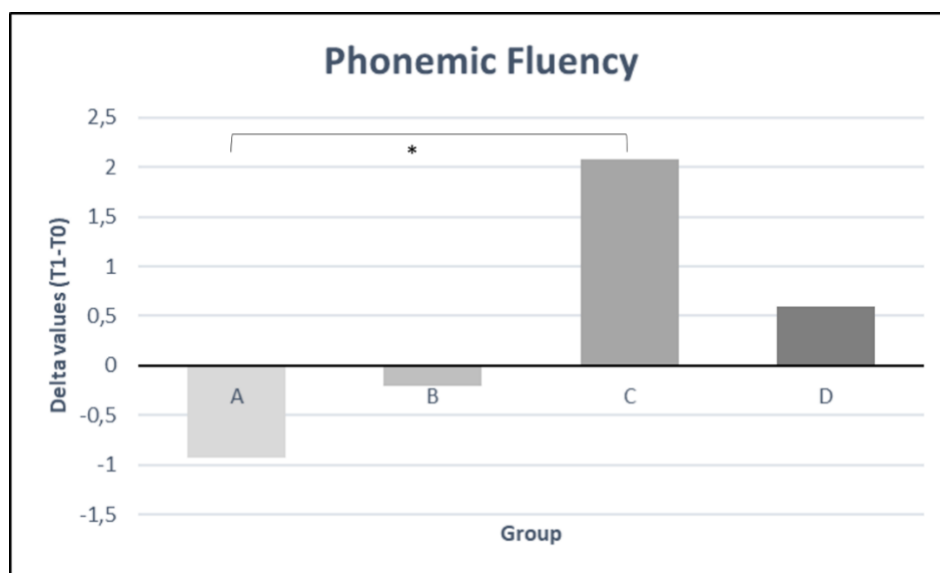


Figure 1: Histograms indicating the mean Delta Values (T1-T0) of group A, B, C, and D of Phonemic Fluency outcomes.

3.2. Pre/Post comparisons

Then, 4 different sets of 11 t-tests (one for each dependent variable) have been performed within each group to compare the performance obtained before (T0) and after (T1) the training, for all dependent variables. Results showed that: in group A, four significant pre/post comparisons proved to be significant. RAT hits ($t_{1,12}=-3.4$; $p<.01$) were higher ($M=5.85$; $SD=1.14$) after the training with regard to T0 ($M=4.15$; $SD=1.99$), as well as WCST RTs ($t_{1,12}=2.75$; $p<.05$), which were lower ($M=1393.4$; $SD=385.11$) after the training with regard to T0 ($M=1619.98$; $SD=241.63$); WCST tot errors ($t_{1,12}=2.57$; $p<.05$), which were fewer ($M=7.77$; $SD=2.17$) after the training with regard to T0 ($M=10.85$; $SD=4.02$); WCST perseverative errors ($t_{1,12}=3.66$; $p<.005$), which were fewer ($M=5.38$; $SD=1.26$) after the training with regard to T0 ($M=7.23$; $SD=1.88$).

About group C, results revealed two significant pre/post effects: phonemic fluency was significantly ($t_{1,13}=-4.87$, $p<.001$) higher after ($M=14.14$; $SD=2.54$) than before ($M=12.07$; $SD=2.2$) the training. Also, WCST RTs were significantly ($t_{1,13}=3.75$; $p<.005$) lower after ($M=1511.49$; $SD=418.27$) than before ($M=1792.09$; $SD=591.75$) the training.

Finally, in group D, WCST perseverative errors were significantly ($t_{1,9}=2.34$; $p<.05$) fewer after ($M=4.9$; $SD=2.03$) than before ($M=7.9$; $SD=4.07$) the training. No significant improvement or worsening was found for group B in any of the dependent variables.

3.3. Personality and gains

Finally, we divided the personality variables into two groups according to frequencies (above or below 50%: high/low) or more (Torrance Creativity Level: from I, Minimal, to VII, Substantial creativity) and conducted a multivariate ANOVA for each group to see if there was any difference in the gains achieved after treatment. It was found that: considering HSPS in Group C ($p<.05$), low-trait group had very large improvements with dramatic reductions in WCST RTs after treatment ($M=-467.62$ ms; $SD=94.98$), while high-trait group had more modest improvements ($M=-140.33$; $SD=82.25$).

Also in Group C, Torrance Creativity level influenced the gains obtained after the treatment, with Level 5 - group obtaining significantly ($p<.05$) higher gains in AUT fluency ($M=-7$; $SD=1.69$) than the lower-trait (Level 1) group ($M=5$; $SD=1.69$).

Mind wandering attitude had effects on the gains obtained after treatment in terms of cognitive efficiency (WCST) in group A (total errors; $p<.05$) and group B (RTs; $p<.05$). People in the group with low mind-wandering improved little ($M_A=-1.13$; $SD_A=1.28$. $M_B=70.33$ ms; $SD_B=224.27$), while people with high mind-wandering improved more ($M_A=-6.2$; $SD_A=1.62$. $M_B=-721.44$; $SD_B=224.27$).

Mindful awareness in group C had effects on post-treatment gains in terms of flexibility in AUT ($p<.05$). The low-mindful group improved ($M=1.17$; $SD=.67$), the high-mindful group worsened ($M=-1.38$; $SD=.58$). Mindful awareness in group D had effects on gains in terms of non-perseverative errors in WCST ($p<.05$). The low-mindful group made more errors after treatment ($M=1$; $SD=1.77$), while the high-mindful group improved ($M=-4.8$; $SD=1.77$).

Finally, general Mindfulness trait in group A had effects on gains after treatment in terms of Phonemic fluency ($p<.05$): low-mindfulness group improved ($M=2.25$; $SD=1.32$), high-mindfulness group worsened ($M=-2.33$; $SD=.88$).

4. Discussion and Conclusions

The present study assessed the effects of a short E-meditation program (audio-guided Mindfulness + tDCS) on: cognitive flexibility (i.e., divergent thinking, convergent thinking and ideation); attention and mind-wandering; the perceived satisfaction and effectiveness of meditation.

Our results suggest that the E-meditation program is effective in increasing convergent thinking as measured by RAT and cognitive efficiency as measured by WCST. Interestingly, using the same stimulation protocol but subtracting the Mindfulness effect, we obtained substantial different outcomes. In particular, a meaningful increasing in fluency has been recorded, suggesting enhanced ideation. This combination of outcomes seems to suggest that the tDCS alone is effective in promoting ideas production, one of the most relevant aspects of creativity. Instead, the same stimulation with Mindfulness produces a focused functional state, which promotes convergent creativity, as if Mindfulness, keeping attention focused on the actual spatial and temporal context and limiting unfocused imaginative production (mind-wandering), was able to improve the frontal network coherence thus leading to improved cognition. Mindfulness was also effective in improving cognitive efficiency as measured by WCST but had no effects on RAT scores, thus supporting the idea that it is the E-Meditation protocol to elicit improved convergent creativity as a results of a double process: the tDCS inhibits some prefrontal control mechanisms thus allowing a fluent ideation process, while meditation channels this process toward a convergent one, that is the one needed to effectively solve the RAT. Hence, we may conclude that E-meditation is effective in increasing the convergent creativity, while short-term Mindfulness alone is not probable a procedure with specific effect on divergent thinking, being more effective in increasing cognitive efficiency. Our results are

coherent with the conclusion of a meta-analysis (Lebuda et al., 2016) that highlighted ambiguity in the connection between mindfulness and creativity. Furthermore, Colzato et al. (Colzato et al., 2012) found that open-monitoring meditation increased divergent thinking outcomes, while focused-attention meditation (such as Mindfulness) affected convergent thinking.

However, our conclusions should be limited to the short training we used. Indeed, previous research found Mindfulness effective in enhancing one's creativity since it may improve concentration (Sedlmeier et al., 2012) in the long run. A Mindfulness training can also have a positive impact on the judgment tolerance, self-awareness regulation and open-minded thinking skills (Brown et al., 2007; Carson & Langer, 2006; Henriksen et al., 2020): key aspects of a creative personality (Selby et al., 2005). Furthermore, self-reported mindfulness skills correlate to creative practices (Colzato et al., 2012) and experienced meditators have been found to have better verbal creativity (Greenberg et al., 2012). Finally, Schooler et al. (Schooler et al., 2014) tested the effect of individual differences in mindfulness on RAT scores and found a negative correlation.

Other interesting results come from some trait parameters we have recorded about individuals' cognitive characteristics. In particular, since Mindfulness is purposely directed to reduce mind-wandering, we tested if different mind-wandering attitudes could affect the outcome of our treatments. Actually, we found that participants with a low mind-wandering attitude reported a lower increase in post-treatment cognitive efficiency with respect to participants with high mind-wandering trait score. This result was found both for E-mediation (group A) and for sham+meditation (group B), suggesting that it is linked to Mindfulness. Thus, we may state that Mindfulness could be particularly useful to tune the cognitive control system toward specific task in people with a tendency to mind-wandering, and then with some difficulties in focusing attention and maintaining it on a task for a long time. Yet, the relationship between mind-wandering and creativity is uncertain and complicated.

Finally, tDCS alone (group C) effect was modulated the HS trait. High sensitivity is a cognitive characteristic that discriminates between people with low or high sensibility to sensorial stimulation. We found that participants low in HS reported a significant decrease in reaction times in WCST, suggesting an improved ability to process information and shift between rules after tDCS. Participants high in HS reported just a little decrease. Thus, the effect of tDCS, as well as E-meditation, should not be regarded only as a function of a neurobiological effect, since it is modulated also by individuals' characteristics, which should always be considered when delivering a certain mind- or neuro-modulation technique.

In conclusion, our study showed how the combination of transcranial stimulation and meditation may have positive effects on cognitive functioning and creativity, supporting previous research but also obtaining original results. However, some methodological constraints limit the possibility to generalize our outcomes strongly suggesting the need for further research. In particular, though the sample is quite large, each treatment was submitted to a limited number of participants. Indeed, we needed to determine the effect of the E-meditation program contrasting its effects with isolated treatments (meditation and tDCS alone). Future research could focus on E-mediation per se. Furthermore, differences in traits related to mindfulness expertise, creative attitudes and other personality factors may impact the results. Our study was not able to isolate these factors, since it was not possible to have group perfectly homogenous about these baseline characteristics. Future studies should evaluate the effect of E-meditation on previously screened participants, so to contrast expert vs naive as well as other fundamental individual parameters. Finally, we have used an audio-guided meditation that has the advantage to be standardized for every conditions. However, it is possible that in-presence experience may lead to somehow different results.

Conflicts of Interest: Authors reports no conflicts of interest to report in relation to this study.

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Effectiveness of Using Moisturizer with Saccharide Isomerate on Skin Hydration in Medical Student Cadets of the Republic of Indonesia Defense University

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Abstract

The skin is a vital organ that plays an important role in maintaining the health and physiological functions of the human body. Dry and dehydrated skin can cause various health and aesthetic problems. The use of moisturizers, especially those containing saccharide isomerate, has been identified as one way to improve skin hydration. This study aims to examine the effectiveness of using moisturizers with saccharide isomerate content on skin hydration in medical students. This study used a one-group pretest-posttest design on 15 subjects who met the inclusion criteria and were treated with a moisturizer containing saccharide isomerate for seven days. The results showed the effectiveness of using a moisturizer with saccharide isomerate content on skin hydration. The mean skin hydration levels increased, especially on the right and left lower limbs, after treatment, which showed significant differences. Conclusion: A moisturiser with saccharide isomerate content greatly improved skin hydration. The results showed significant differences in the average skin hydration of the right and left lower limbs. The moisturiser also had the potential to keep skin moist after it was stopped being used.

Keywords: Dry Skin, Skin Hydration, Moisturizer, Saccharide Isomerate, Medical Students, Cadets

1. Introduction

The human body's largest organ is the skin. The skin serves multiple defense and regulatory roles, acting as a barrier against infection, regulating water levels, and minimizing the entry of allergens and irritants. The skin primarily serves as a very efficient physical barrier to prevent the leakage of electrolytes and water from the internal environment (Jansen van Rensburg et al., 2019). The integumentary system is composed of three distinct layers: the epidermis, dermis, and hypodermis. The primary function of the skin's barrier is predominantly located in the epidermis, specifically in its outermost layer, known as the stratum corneum (SK). The stratum corneum functions

as the main barrier against the transdermal absorption of chemicals and microorganisms. It plays a role in controlling the release of water from the outermost layer of the skin to the atmosphere, a process called transepidermal water loss (TEWL) (Nitiyarom et al., 2021).

If the stratum corneum is compromised, the skin can experience a variety of problems, including dryness, irritation, inflammation, and an increased risk of infection. A disrupted or poorly functioning stratum corneum can result in skin moisture loss, resulting in dry skin. In addition, disruption of the stratum corneum can also allow irritants or allergens to enter the skin more easily, causing irritation or allergic reactions. Damage to the stratum corneum can also disrupt the skin's barrier function, increasing the risk of infection by pathogenic microorganisms (Spada et al., 2018).

Signs of dry skin include roughness, redness, scaling, itching, and sometimes cracking or inflammation (Wijayadi & Kelvin, 2022). Some of the factors that affect dry skin include low ambient temperature and humidity, exposure to chemicals and microorganisms, aging and psychological stress, atopic eczema, psoriasis, and ichthyosis (Butarbutar & Chaerunisaa, 2020).

In light of these conditions, moisturizers are essential for improving skin function and physiological conditions. Moisturizers increase moisture, water content in the stratum corneum layer, and acidity. When the skin barrier is compromised, moisture content decreases. Moisturizers repair the skin barrier, increase moisture, and improve the appearance of the skin. Moisturizers can be divided into three types: humectants, occlusives, and emollients. Humectants absorb water from the environment, occlusives form a protective layer, and emollients replenish the structure of the skin's fat layer (Umborowati et al., 2022).

Saccharide isomerate is one of the natural carbohydrate complex moisturizers derived from sugar beets that has the ability to bind to the skin and retain moisture, making it effective in hydrating and moisturizing the skin (Nunes et al., 2018).

At the Republic of Indonesia Defense University, student cadets have a busy routine, such as physical training, military exercises, and intense academic activities. These conditions can cause their skin to become more susceptible to dehydration and other skin problems.

Most cadets certainly understand the importance of maintaining healthy skin, including the use of appropriate moisturizers. However, in-depth research on the effectiveness of moisturizers with saccharide isomerate content on skin hydration in the student cadet population within the Republic of Indonesia Defense University is still limited.

Therefore, this study will comprehensively discuss the effectiveness of using moisturizers with saccharide isomerate content on skin hydration in cadet medical students of the Republic of Indonesia Defense University in 2023. Through this research, it is expected to provide a better understanding of the benefits of using moisturizers with saccharide isomerate content in maintaining skin health.

2. Methods

2.1. Subject Characteristics

This study was conducted on 15 cadet medical students of the Republic of Indonesia Defense University. The demographic characteristics of the research respondents can be seen in **Table 1** below.

Table 1: Characteristics of Research Respondents

No.	Characteristics	N	%
1.	Age		
	18 years old	1	6,7
	19 years	11	73,3

	20 years	3	20,0
	Total	15	100,0
2.	Gender		
	Male	9	60,0
	Female	6	40,0
	Total	15	100,0

Based on **Table 1** above, it is known that based on age, most respondents are 19 years old, namely 11 respondents (73.3%), 3 respondents aged 20 years (20.0%), and 1 other aged 18 years (6.7%). Based on gender, most of the respondents were male, namely 9 respondents (60.0%), and 6 others were female (40.0%).

2.2. Data Normality Test

This study was conducted by measuring the average skin hydration level, which is numerical data, so a pre-analysis test in the form of a normality test is required. The mean skin hydration levels before and after treatment and the results of the data normality test in this study can be seen in **Table 2**.

Table 2: Mean Value and Normality Test Results of Skin Hydration Level Changes in Each Treatment Group

Group	Day of Treatment	Mean skin hydration level (%) ± Standard Deviation	p value (*)
Right Upper Arm	Day 0	38.67 ± 6.53	0.001
	Day 7	42.93 ± 11.67	0.003
Left Upper Arm	Day 0	37.93 ± 7.32	0.105
	Day 7	39.93 ± 12.64	0.036
Right Lower Limb	Day 0	23.67 ± 10.53	0.099
	Day 7	35.73 ± 15.20	0.110
	Day 0	22.87 ± 10.82	0.645
Left Lower Limb	Day 7	33.33 ± 16.11	0.621

Notes: (*) shows the results of the normality test with the Shapiro-Wilk test, the P value is significant when > 0.05 **Table 2** shows the average skin hydration levels of research respondents before and after treatment. The results showed that the average skin hydration level of the right upper arm before treatment was 38.67 ± 6.53% and after treatment was 42.93 ± 11.67%, and the left arm before treatment was 37.93 ± 7.32% and after treatment 39.93 ± 12.64%, the right lower limb before treatment was 23.67 ± 10.53% and after treatment 35.73 ± 15.20%, and the left lower limb before treatment was 22.87 ± 10.82% and after treatment was 33.33 ± 16.11%. Based on the table above, it is also known that the measurement variables of the right lower limb on day 0 and day 7 and the left lower limb on day 0 and day 7 are normally distributed, while the right and left upper arm variables on both day 0 and day 7 measurements are not normally distributed.

2.3. Analysis of Significance with T-test Dependent and Wilcoxon

The results of the test for differences in skin hydration levels before and after the use of moisturizers with saccharide isomerate content can be seen in **Table 3** below.

Table 3: Significance Test of Differences in Skin Hydration Levels Before and After Treatment

Group Day 0	Group Day 7	Mean difference in skin hydration (%) ± Standard Deviation	p value
Right Upper Arm	Right Upper Arm	4.27±13.20	0.271 ^b

Left Upper Arm	Left Upper Arm	2.00±15.13	0.363 ^b
Right Lower Limb	Right Lower Limb	12.07±14.87	0.007 ^a
Left Lower Limb	Left Lower Limb	10.47±18.58	0.047 ^a

Notes: (a) shows the result of dependent T test; (b) shows the result of Wilcoxon test. P value is significant if <0.05

Table 3 shows that the right and left lower limbs have the greatest difference in mean skin hydration before and after treatment, namely $12.07 \pm 14.87\%$ and $10.47 \pm 18.58\%$, respectively. The results of this study showed that there was a significant difference in the mean skin hydration of the right lower limb and left lower limb before and after treatment (p values = 0.007 and 0.047), but the level of skin hydration of the right and left upper arms before and after treatment did not have a significant difference.

3. Results and Discussion

The skin plays a crucial role. The primary purpose of the skin is to ensure the survival of the individual. Additionally, the skin holds significance in terms of aesthetics, race, and systemic markers. The skin is composed of three distinct layers: the epidermis, dermis, and subcutaneous layer. The epidermis mostly comprises keratinocytes, with a minority of melanocytes and dendritic cells, including Langerhans cells. The epidermal layer of the skin contains nucleated cells that house nerve fibers responsible for transmitting impulses. It has five separate layers: the basal layer, the stratum spinosum (sweat layer), the stratum granulosum, and the stratum corneum (Voegeli et al., 2019). Intermediary cells are called temporary reinforcement cells. An optimal state of skin health and normalcy is characterized by the presence of over 10% water in the outer layer of the skin. This is a result of the management of fluid equilibrium in the skin. An optimal skin profile and function necessitate a water content in the stratum corneum exceeding 10%. Disruption of the fluid equilibrium in the skin can render dry skin susceptible to a range of physical and chemical stimuli. Dry skin is a condition characterized by a deficiency of fluid or oil in the skin, leading to a decrease in surface wetness. Transepidermal water loss (TEWL), also known as the loss of water by diffusion in the epidermis, is what causes the decrease in skin hydration and the stratum corneum's reduced barrier function. (Vlorensia et al., 2020; Gougeon et al., 2023). Saccharide isomerase is a naturally occurring, biologically active, and environmentally friendly technology that converts sugars by isomerization. This substance is created by transforming edible corn sugar, which is primarily composed of glucose, into a distinct carbohydrate complex that closely resembles skin. It shares similarities with the natural moisturizing components found in the outermost layer of human skin, known as the stratum corneum. It has the ability to attract and retain water, and past studies have demonstrated its positive impact on the skin's protective barrier, moisture levels, and the microorganisms that inhabit the skin (Martin et al., 2023).

A moisturizer is a therapy that can enhance skin moisture. Moisturizer is an essential element of everyday skincare, particularly when there are alterations in the outermost layer of the skin and a decrease in the amount of water in the outermost layer of the skin. Ensuring healthy skin and addressing skin conditions that coincide with dryness and are linked to compromised skin barrier function, such as atopic disorders and various forms of dermatitis, are integral components of a dermatologist's approach. Moisturizers enhance the restoration of the skin's protective barrier, preserving the health and visual appeal of the skin through their functions as humectants, emollients, and occlusives, each having distinct modes of action. Moisturizers enhance skin hydration and augment the water content of the outermost layer of the skin by directly supplying water to the skin from its aqueous phase. They also enhance occlusion to minimize the loss of water through the skin while simultaneously covering minor skin fissures, creating a comforting protective barrier, and safeguarding the skin against friction. Furthermore, the utilization of moisturizer enhances the texture of the skin by filling the gaps between partially shed skin flakes and reinstating the intercellular lipid bilayer's capacity to soak up, retain, and transport water. Afterward, the mechanics of the skin change as enhanced moisture promotes the breakdown of corneodesmosomes and prevents the buildup of corneocytes (Purnamawati et al., 2017)

This study was conducted to determine the effectiveness of using moisturizers with saccharide isomerase content on skin hydration. The moisturizer in this research treatment was given for 7 days and then measured for the

difference in skin hydration before and after treatment. A skin hydration examination was carried out using a precision digital skin analyzer.

The study findings revealed that the majority of respondents, including 73.3%, were 19 years old. Additionally, 20.0% of the respondents were 20 years old, while 6.7% were 18 years old. Multiple studies have documented that these skin biophysical characteristics exhibit variations based on age, gender, anatomical area, and season within diverse ethnic communities. The inflection point of this curve becomes apparent at the age of thirty, indicating a more uniform and luminous complexion, enhanced hydration, and a reduced pH level. The skin serves as the primary protective layer, rendering it susceptible to the harmful effects of sunlight, air pollution, and climatic variations. These environmental variables expedite the manifestation of aging in the skin, particularly photoaging induced by ultraviolet (UV) radiation. The advancement of technology has led to the availability of numerous non-invasive instruments for assessing the physiological characteristics of the skin. The commonly utilized parameters include the hydration level of the outermost layer of the skin (stratum corneum), the amount of water lost through the skin (transdermal water loss), the content of sebum (an oily substance produced by the skin), the level of melanin (a pigment responsible for skin color), the level of erythema (redness of the skin), the color system of the skin, and the pH value of the skin surface. Research (Pan et al., 2020) indicates that the cheeks exhibit the highest level of brightness and lightness, with the lowest concentration of sebum. In contrast, the chin has a significantly deeper shade, while the forehead tends to have a yellowish hue. The skin parameters of TEWL, sebum content, and melanin and erythema indices have a direct correlation with age, displaying a linear relationship. On the other hand, the skin hydration value, ITA, and pH demonstrate a non-monotonic relationship with age. Conversely, as age increases, the expression of aquaporin decreases. Aquaporins, also known as AQPs, are a group of water channels that facilitate the movement of water and tiny molecules to maintain fluid balance in the body. Aquaporins (AQPs) are found in a wide range of species, such as bacteria and humans. Thirteen members of the AQP family have been discovered in humans (AQP0-12), and they are found in different organs. Recently, it has been acknowledged that deviations in the levels of AQPs expression can lead to a range of illnesses (Pan et al., 2020; Ikarashi et al., 2017). In this study, the study population and sample were young adults with a small age gap. This can minimize the occurrence of bias and control the age variable as a confounding variable.

The study findings indicated that the majority of respondents were male, specifically 9 respondents (60.0%), whereas 6 respondents were female (40.0%). The variation in population size can be attributed to the factors of hydration, transepidermal water loss, sebum production, microcirculation, pigmentation, and skin thickness. These factors tend to be higher in men, whereas women generally have higher skin pH levels. Understanding the disparities in skin characteristics associated with gender can aid in the strategic design and creation of gender-specific goods, enabling more tailored dermatological treatments and cosmetic interventions. Sex-related disparities exist in the anatomical, physiological, epidemiological, and symptomatic aspects of certain diseases. Regarding skin illnesses, there is a higher incidence of infectious diseases in men, whereas psychological issues, pigmentation abnormalities, specific hair conditions, and autoimmune and allergy diseases are more commonly observed in women. Conversely, women experience a higher prevalence of sex-related skin illnesses, and the occurrence and outcome of some skin cancers are linked to sex-related disparities. The precise mechanisms responsible for the disparities in skin diseases between sexes remain mostly unidentified. These variances may be influenced by sex hormones, behavioral characteristics, ethnicity, and environmental variations (Rahrovan et al., 2018). Circulating hormones have a significant impact on the disparities between male and female facial skin. Oestrogen mostly affects the skin of women, while androgens, such as testosterone and 5 α -dihydrotestosterone (DHT), primarily influence the skin of men. Oestrogen has advantageous protective effects on the skin by promoting the synthesis of collagen and the creation of elastic fibers and hyaluronic acid. Oestrogen has been demonstrated to enhance the skin's ability to bind water and regulate local inflammation, granulation, and re-epithelialization processes. As a result, it improves the integrity of the skin barrier and enhances its capacity to heal wounds. Testosterone increases the thickness of the tissue that surrounds the dermal and epidermal layers of the skin, which helps in the creation of collagen. While both males and females generate sebum, the elevated amounts of testosterone in males lead to a more substantial production, resulting in generally consistent sebum production levels as they grow older. Both positive and negative effects are on men's skin. Heightened sebum production aids in the assimilation of oils for skin hydration, but it also exacerbates acne and imparts a sticky or

oily sensation to the skin while causing the pores to appear enlarged and more prominent (Sikora et al., 2021; Wang et al., 2017).

The results showed the average skin hydration levels of the right upper arm before treatment was $38.67 \pm 6.53\%$ and after treatment was $42.93 \pm 11.67\%$, the left arm before treatment was $37.93 \pm 7.32\%$ and after treatment $39.93 \pm 12.64\%$, the right lower limb before treatment was $23.67 \pm 10.53\%$ and after treatment $35.73 \pm 15.20\%$, and the left lower limb before treatment was $22.87 \pm 10.82\%$ and after treatment was $33.33 \pm 16.11\%$. The results of this study show that the right and left lower limbs have the greatest difference in mean skin hydration before and after treatment, namely $12.07 \pm 14.87\%$ and $10.47 \pm 18.58\%$, respectively. The results of this study are in accordance with research (Dewi & Pangkahila, 2022), which shows the mean skin hydration before and after treatment of the upper arm 28.47 ± 4.80 to 71.30 ± 10.79 ; the forearm 26.63 ± 2.68 to 63.93 ± 9.24 ; the upper limb 24.20 ± 5.72 to 60.60 ± 14.71 ; and the lower limb 22.00 ± 2.13 to $41.57 \pm 6.95\%$, respectively (Dewi & Pangkahila, 2022).

The results of this study showed that there was a significant difference in the mean skin hydration of the right lower limb and left lower limb before and after treatment (p values = 0.007 and 0.047), but the level of skin hydration of the right and left upper arms before and after treatment did not have a significant difference. The results of this study are in accordance with research (Vlorensia et al., 2020), which shows that moisturizing creams containing saccharide isomerate and ceramide effectively increase skin hydration. The average skin hydration after treatment was 24.46%, with a standard deviation of 3.83 (Vlorensia et al., 2020). The results of this study are in accordance with research (Gougeon et al., 2023) that showed that, compared to the control area, the application of creams, but especially creams containing saccharide isomerate, significantly improved the hydration and glossy properties of the skin on average after 30 minutes. This significant increase ranged from 1.7-fold in the placebo group to 4.6-fold in the cream containing urea (Gougeon et al., 2023). The results of this study are in accordance with research (Dewi & Pangkahila, 2022) showing that using a moisturizer containing saccharide isomerate led to a significant improvement in skin hydration within a 2-week period ($p < 0.05$). Following the discontinuation of the moisturizer, all four sites exhibited notable variations in skin moisture ($p < 0.05$). The study findings indicate that incorporating SI 5% into the moisturizer formulation leads to a significant increase in skin hydration. Furthermore, this enhanced hydration is sustained even after discontinuing the use of the moisturizer, surpassing the effects of standard moisturizers (Dewi & Pangkahila, 2022).

Saccharide isomerate is a naturally occurring, biologically active, and environmentally friendly sugar isomerization agent. This product is created by transforming the sugars found in the edible part of maize, which are primarily glucose, into a distinct combination of carbohydrates that closely resemble the skin. These carbohydrates are similar to the natural moisturizing substances present in the outermost layer of human skin, known as the stratum corneum. Saccharide isomerate is a fully plant-derived compound consisting of complex carbohydrates that closely resemble those naturally present in human skin. This vegan hyaluronic acid booster has demonstrated its capacity to deliver sustained skin hydration by effectively adhering to the skin and limiting the loss of water via the epidermis. Clinical evidence supports the efficacy of saccharide isomerate 1% in delivering both immediate and prolonged hydration. It has the ability to attract and retain water and has previously demonstrated positive effects on the skin's protective barrier, moisture levels, and the microorganisms present on the skin (Martin et al., 2023; Hon et al., 2018). Saccharide isomerate has humectant properties that improve skin hydration (Peltier et al., 2022).

Reduced humidity (reduced water content in the outermost layer of the skin) leads to a decrease in the breakdown of desmosomes. The desmosomes present in the SK sheet undergo digestion, resulting in the separation of the sheet into individual cells when placed in a buffer solution. On the other hand, protease inhibitors added to the buffer solution or heating the sheet stops the desmosomes from breaking down and cells from separating. Leupeptin, or chymostatin, exhibited a cell dissociation slowdown that was only around half as efficient as aprotinin. But when the two substances were mixed together, they stopped the breakdown of the stratum corneum layer just as well as aprotinin did alone. The results support the idea that desmosomes are very important for SK cells to stick together, and that these two types of serine proteases break down desmosomes, which leads to SK desquamation. A decline in trypsin-type protease activity associated with aging was seen in individuals without any health conditions. The amount of moisture in the stratum corneum affects the proteases' ability to break down

desmosomes there. According to studies, there are two factors that affect desquamation. The water content of the stratum corneum is one factor to consider. Insufficient water levels impede the optimal functioning of enzymes, regardless of their normal enzyme content. Humectant therapy effectively hydrates the stratum corneum by providing it with water. Another contributing element is a reduction in the enzymatic activity of the protease. This phenomenon is observable in skin that is afflicted with illness or undergoing the natural process of aging (Koyama et al., 1999).

Saccharide isomerate (SI) is a complex carbohydrate mucopolysaccharide (glycan) that closely resembles the one present in the outermost layer of human skin, known as the stratum corneum. Therefore, hyaluronan, or hyaluronic acid, will be produced in the epidermis. In the same way that hyaluronan does, SI can raise the water content of the stratum corneum, which keeps the epidermis moist even when the humidity level is low. SI has the ability to adhere to the skin even in extremely acidic environments (Dewi & Pangkahila, 2022).

The difference in significance between hands and feet may be attributed to differences in anatomical location and exposure to environments that can compromise skin hydration. Research (Mayrovitz et al., 2017) skin hydration, as measured by the tissue dielectric constant (TDC) tool, resulted in values in the forearm proving to be greater than in the leg or foot. In the forearm, there was a monotonous decrease in TDC values ($P < 0.001$) as depth increased, with TDC values at 0.5 mm being 38.4 ± 5.5 and 25.8 ± 4.1 at 5.0 mm depth. At the foot site, a similar decrease in TDC values was observed from 0.5 mm to 2.5 mm ($P < 0.001$), but the values at 2.5 and 5.0 mm (34.1 ± 6.3 vs. 33.0 ± 12.1) were not significantly different from each other (Mayrovitz et al., 2017).

4. Conclusions

This study demonstrates that the application of a moisturizer containing saccharide isomerate leads to a substantial enhancement in skin hydration among students enrolled in the Faculty of Medicine and Health Sciences at the Republic of Indonesia Defense University. The findings demonstrated a notable disparity in the average skin moisture levels between the right and left lower limbs following the intervention, therefore confirming the efficacy of the moisturizer in augmenting the water content of the outermost layer of the skin, known as the stratum corneum. Furthermore, the research also discovered that incorporating saccharide isomerate into the moisturizer formulation can significantly enhance skin moisture and sustain it even after the cessation of usage, surpassing the effects of conventional moisturizers. This demonstrates the efficacy of including saccharide isomerate in moisturizer formulations to greatly enhance skin hydration. This can be advantageous in addressing dry skin and prolonging skin moisture retention.

Given the results of this study, it is advisable to extend the observation period to a longer duration beyond the current 7-day timeframe in order to further investigate the topic. Extending the study term is anticipated to yield a more comprehensive understanding of the dynamics or alterations that may transpire over an extended timeframe. To enhance the representativeness of the findings, it is imperative to broaden the pool of respondents by incorporating volunteers who mirror the diversity and variability within the community being examined. Therefore, it is anticipated to generate more precise and pertinent results.

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Medical Tourism among Afghan Patient Population: Assessment of their Perception and Expectation of Healthcare Services across the Border of Afghanistan

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Abstract

The Afghan healthcare system lacks sufficient resources to meet the expectations and perceptions of the Afghan patient population in various domains of service quality, including tangibility, reliability, responsiveness, and empathy. As a result, many Afghan patients travel outside of Afghanistan for different types of healthcare services. Investigating the perceptions and experiences of Afghan medical tourists is crucial for identifying gaps in local healthcare services. Purpose: The study investigated Afghan patients' perceptions and expectations of healthcare received across the border of Afghanistan, exploring their perceptions and expectations on five domains of service quality. Methodology: A service quality questionnaire was used to collect data from 28 Afghan patients with treatment experience outside Afghanistan, assessing their perceptions and expectations of healthcare services. Significance of the Study: Assessing and understanding the perspectives of Afghan medical tourists on healthcare services outside Afghanistan will inform local authorities about gaps in healthcare services, improve service delivery, and reduce patient outflow. Enhanced local healthcare can better meet the needs and expectations of Afghan patients, helping to avoid unnecessary medical tourism. Results: The wilcoxon signed ranks test assessed significant discrepancies between participants' perceptions and expectations in tangibility, assurance, empathy, reliability, and responsiveness, with perceptions generally exceeding expectations in assurance (p -value 0.004), tangibility (p -value <0.001), and responsiveness (p -value <0.001). No significant differences were noted in reliability (p -value 0.836) and empathy (p -value 0.391). Conclusion: The findings of this study highlight the need in Afghanistan to address gaps in healthcare quality and services, thereby meeting patient expectations and ultimately enhancing the healthcare experience for the Afghan patient population, thereby reducing reliance on medical tourism outside Afghanistan.

Keywords: Medical Tourism, Lower-Income Countries, Perception, Expectation

1. Introduction

Over the past few decades in Afghanistan, years of conflict and other challenges, such as political instability and economic hardship, have caused many problems in the health industry. Many Afghan residents have limited access to high-quality healthcare, adequate healthcare infrastructure, and trained medical professionals (Shoib et al.,

2022). Therefore, these challenges in the healthcare system have made many Afghans with different health issues often seek medical care across the border of Afghanistan as medical tourists and experience medical tourism.

Many scholars have defined medical tourism as the process by which people travel across borders to seek healthcare services (Al-Lamki, 2011; Enzensberger, 1996; Jones & Keith, 2006). The modern concept of medical tourism emerged in the 19th century and continued to grow with advancements in technology, including the internet and the ease of intercontinental transportation (Bauer et al., 2015; Xu et al., 2020; Zhong et al., 2021).

In Afghanistan, exploring various aspects of medical tourism is crucial for the Afghan patient population interested in seeking care across the border. By studying the perceptions and expectations of Afghan medical tourists, this study aims to identify potential concerns or gaps in health service delivery across the Afghanistan border. This study aims to investigate the perceptions of Afghan medical tourists seeking care across the border in neighboring countries, to provide information that can guide Afghan patients in making more informed decisions when considering medical tourism and utilizing healthcare services across the Afghanistan border.

2. Purpose

This study aimed to investigate the perceptions of the Afghan patient population regarding seeking healthcare across the borders of Afghanistan. This study was designed to assess patients' understanding of their perceptions and experiences with healthcare services outside of Afghanistan, and to identify potential factors that influence their decisions, the barriers they face, and the benefits of seeking care outside of Afghanistan. The goal of this study was to share the experiences of Afghan medical tourists and increase public awareness among those interested in seeking care across the border.

3. Rationale

To date, no research is available on the Afghan patient population seeking healthcare services outside Afghanistan. Studying the Afghan patient population's medical tourism is important because it can explain why people seek medical treatment abroad. This study can help identify gaps in local healthcare services and barriers to accessing quality care, making healthcare services more accessible to Afghans and preventing the drain of local revenue. Additionally, studying the perceptions and expectations of Afghan medical tourists can shed light on their experiences with the quality of healthcare services they receive and their overall satisfaction with healthcare services outside of Afghanistan.

Study results on medical tourism in some countries on tourist perception indicated that the care provided to patients did not meet their expectations, primarily due to poor communication and inadequate human resources, which are crucial factors in healthcare service delivery that can lead to substandard healthcare services and complications (Bauer, 2015; Culley et al., 2011; Raoofi et al., 2024).

4. Significance

In Afghanistan, exploring various aspects of Afghan patient medical tourism is crucial for patients interested in seeking care across the border. The findings of this study can be helpful for the Afghan patient population interested in seeking care outside of Afghanistan, providing them with information about the quality of care, patient experience, satisfaction, cultural barriers, communication barriers, and level of travel convenience. Additionally, the findings of this study enable the local health system to modify its healthcare services to meet the needs of the patient population better and reduce local revenue drain.

5. Study Design

A qualitative study was conducted using snowball sampling with the Afghan population who had experience with medical tourism. The data was collected on the phone, and the survey link was sent to the participants. We included participants aged 18 years or older who had experienced medical tourism outside of Afghanistan within the study

timeframe, from August 2024 to December 2024. We excluded participants under 18 years old and individuals who were not Afghan natives. The service quality (SERQUAL) questionnaire dimensions (tangibility, reliability, responsiveness, assurance, and empathy) were used to assess participants' expectations and perceptions.

6. Ethical Consideration

The study design and survey adhered to all requirements for ethical research as outlined in historical documents such as the Belmont report, which establishes the ethical and confidential treatment of research participants. The University of A.T. Still University's IRB approved the study as exempt from the review.

7. Method

In this study on medical tourism among the Afghan population with experience in medical tourism outside of Afghanistan, we employed a non-probability snowball sampling technique due to the unique characteristics of the target population and the resource constraints associated with data collection. Snowball sampling was particularly effective for accessing the Afghan population with experience in medical tourism outside of Afghanistan, as it relied on the initial participants to refer others within their network to the study. Snowball sampling enabled us to gather data from Afghan participants who had personal experiences with medical tourism outside Afghanistan, thereby obtaining contextually relevant data related to participants' perceptions and expectations. The recruitment process began with a small number of participants who met the inclusion criteria. We encouraged them to identify and introduce additional participants who met the inclusion criteria and were interested in the study.

A significance level (alpha) of 0.05, a conventional threshold, was selected to determine statistical significance, minimize the risk of Type I errors, and ensure the reliability of interpreting the results. Data collection involved a structured survey questionnaire assessing five domains of service quality (tangibility, responsiveness, assurance, empathy, and reliability) in the context of medical tourist experiences. The responses were analyzed using the Wilcoxon test, and chi-square statistical techniques were employed to gain insights into the perceptions and expectations of the Afghan medical tourism experience outside Afghanistan. The study aimed to contribute valuable findings to the understanding of medical tourism within the Afghan population, informing both healthcare providers and policymakers on this emerging trend.

8. Results

8.1. Socio-demographics

The data were gathered from 28 participants with experience in medical tourism on both sides of the Afghanistan border. Participants' socio-demographics were analyzed using SPSS Software version 28 (Armond, New York, USA). The first variable was gender distribution. In the sample, 57.1% of participants identified their gender as male, and 42.9% identified as female (Figure 1). In Afghanistan, women do not have the privileges and freedom that men do, which can negatively affect their participation and awareness in the practice of seeking care across the border.

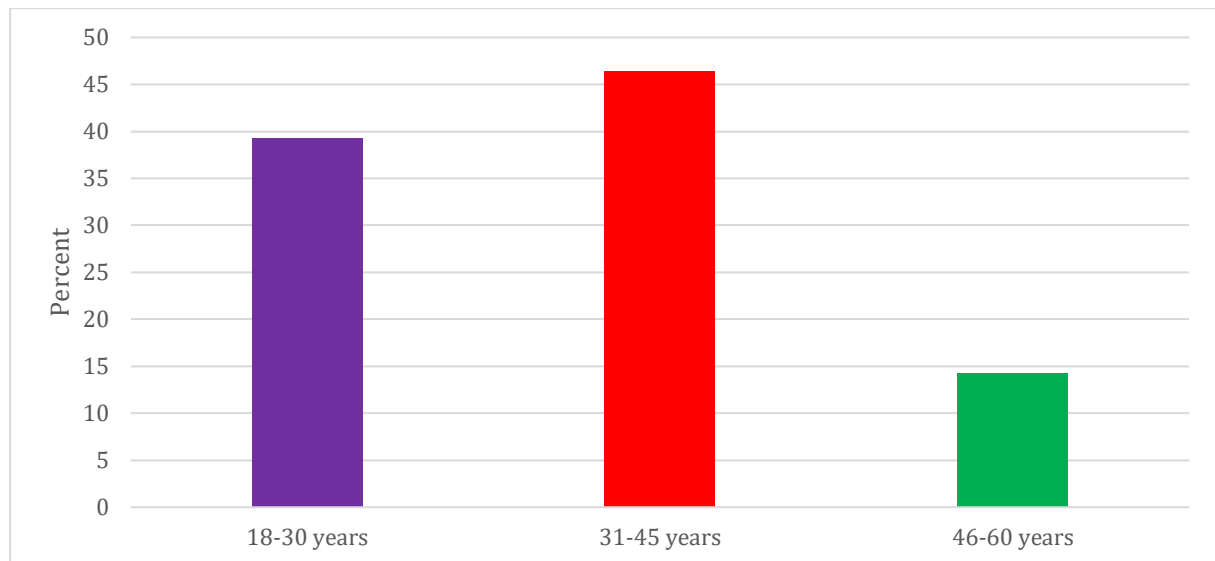


Figure 1: Percentage of participants' age distribution

When examining the age demographics of the participants, the sample showed that 39.3% were aged between 18 and 30, 46.4% fell within the 31-45 years range, and 14.3% belonged to the 46-60 years category. The largest age group is participants aged 31-45, indicating that the sample leaned toward a younger adult demographic, which may influence their likelihood of seeking healthcare services across the border (Figure 2).

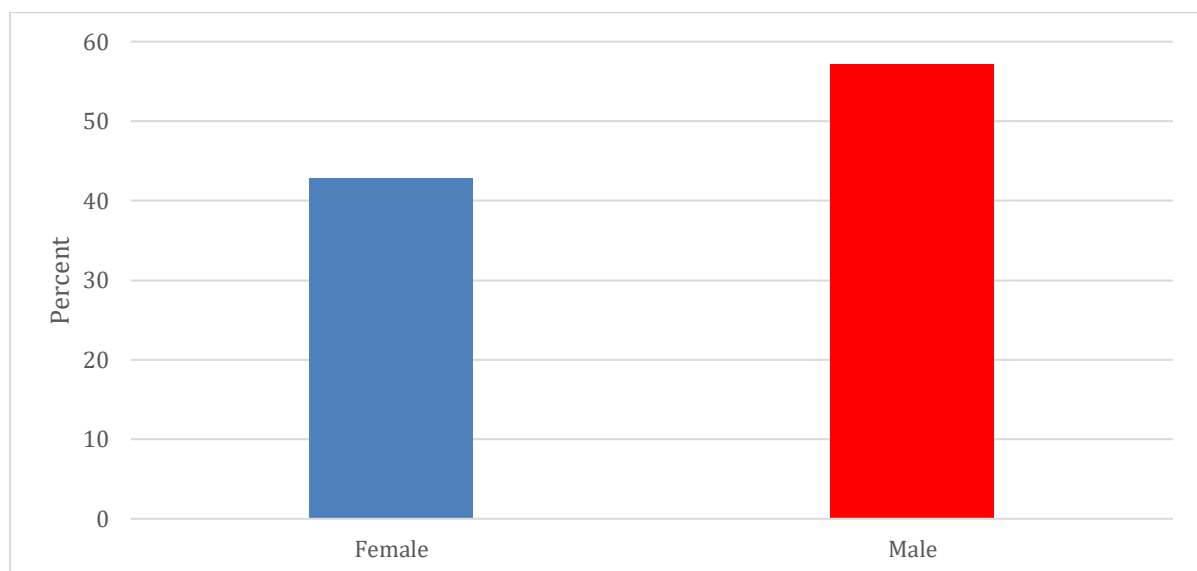


Figure 2: Percentage of participants' gender distribution

In terms of educational attainment, the data indicated that 25.0% of participants completed high school, 46.4% held a bachelor's degree, and 21.4% had attained a master's degree or higher. Additionally, 7.1% preferred not to disclose their educational background (Figure 3).

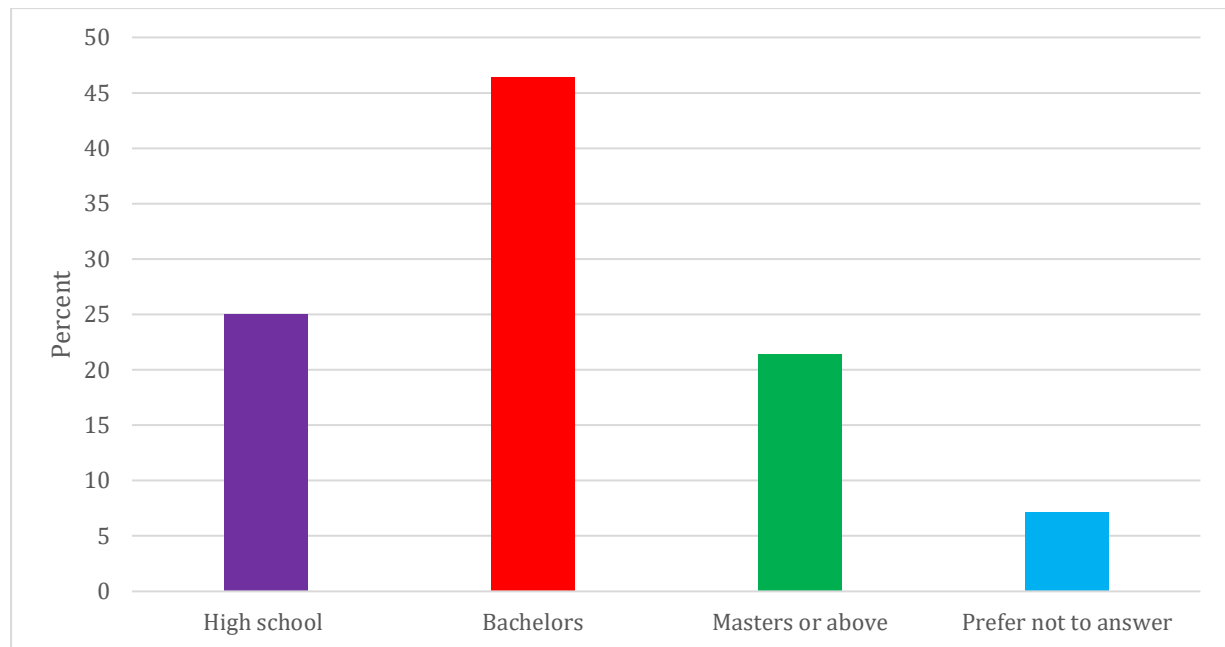


Figure 3: Percentage of participants attained level of education distribution.

Regarding the type of permanent residence, 25.0% of participants resided in rural areas, 3.6% in suburban areas, and a significant 71.4% in urban settings. The results regarding the usage of healthcare services across Afghanistan's borders indicated that 14.3% have used healthcare services across the border once, while 85.7% have used them more than once (Figure 4).

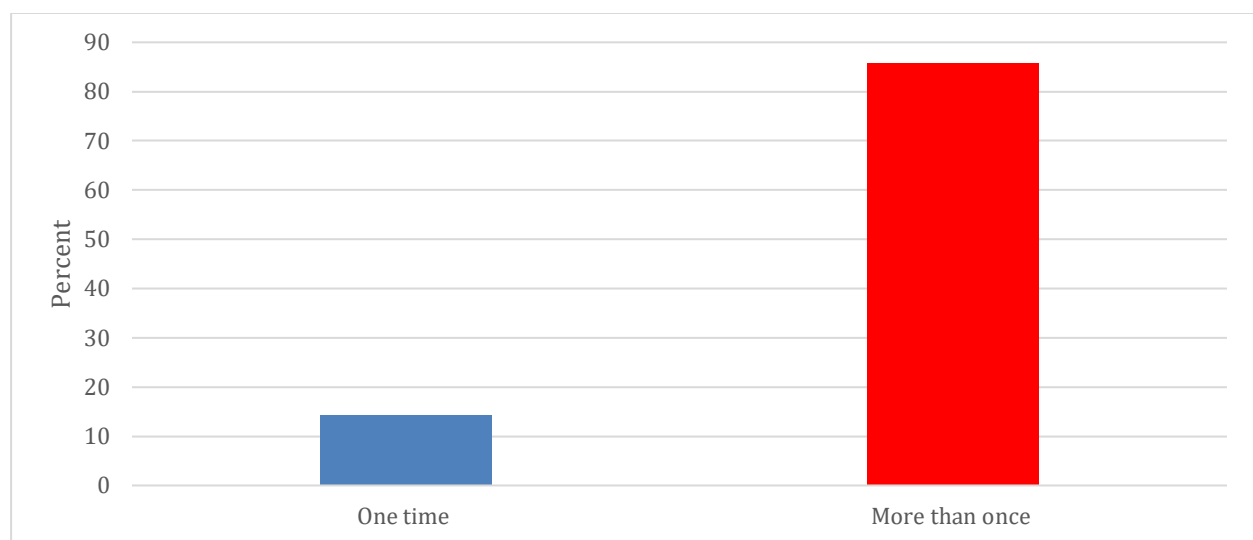


Figure 4: Percentage of participants' times of medical tourism use distribution

In examining the types of healthcare services used across the Afghan border, 60.7% of participants reported using general medicine, 28.6% required surgery, 7.1% indicated they used other types of services, and 3.6% preferred not to disclose their responses (see Figure 4). Finally, the income levels of the participants indicate that 17.9% identify themselves as having a lower income, while a substantial 82.1% classify themselves as middle-income (Figure 5).

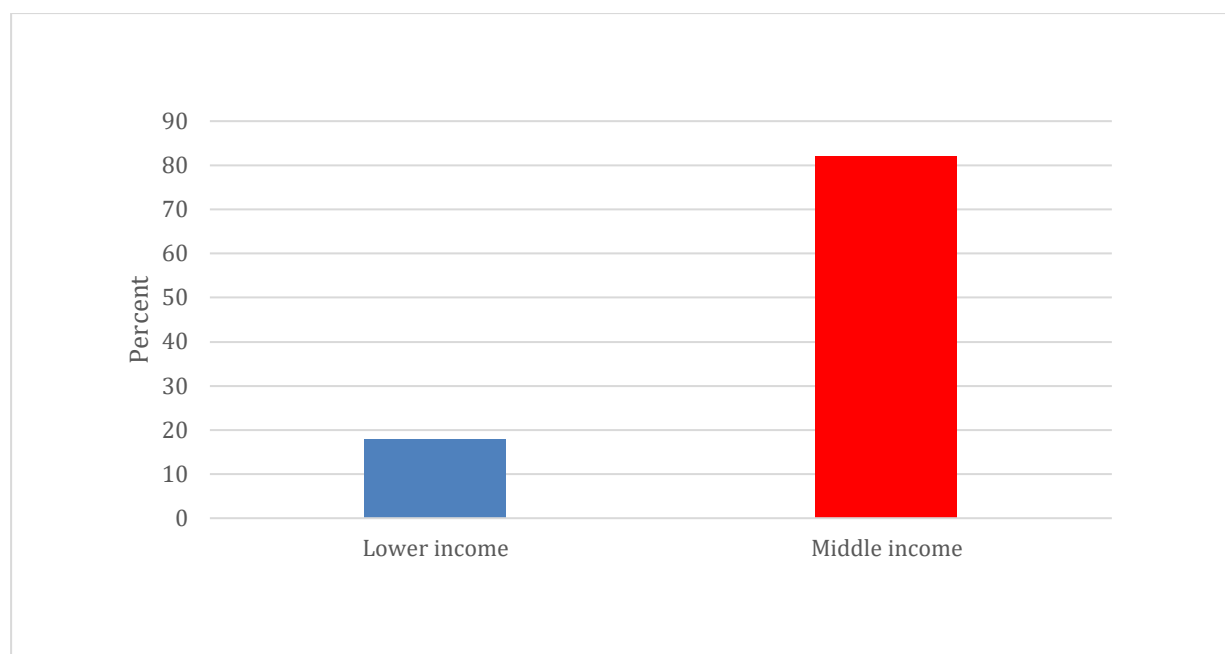


Figure 5: Percentage of participants' level of income distribution

How does the Afghan patient population perceive healthcare services compared to their expectation? What are the potential factors that lead to seeking care across the border?

Since the data in the sample were not normally distributed, nonparametric tests were used to answer the two research questions in this study (Nahm, 2016). For the question that aimed to assess the difference between the Afghan medical tourist perception and expectation on five domains of SERQUAL (tangibility, assurance, reliability, and empathy), we used the wilcoxon signed-rank test to determine if there was a statistically significant difference between the median paired differences (Proudfoot et al., 2018).

The second question aimed to determine the underlying factors that influenced Afghan medical tourists' decisions to seek healthcare services across the border; the chi-square test of independence was used to determine whether Afghan medical tourists' socio-demographic details (age, gender, educational status, income level, type of residence) were associated with the frequency of border healthcare use across the border of Afghanistan.

The Wilcoxon test was used to determine the differences in perceptions and expectations of Afghan medical tourists across five service quality dimensions: tangibility, assurance, reliability, empathy, and responsiveness for healthcare services on the Afghanistan border. In the case of tangibility, it was observed that there were more positive ranks (26) than negative ranks (1), indicating that participant perceived the healthcare service across the border of Afghanistan to exceed their expectations. The mean rank for negative perceptions was 19.50, while the mean rank for positive perceptions was 13.79, indicating a strong appreciation for perceived tangibility compared to expectations.

For assurance, there were five negative ranks and 21 positive ranks, with a mean rank of 12.90 for negative perceptions compared to 13.64 for positive perceptions, suggesting that while some respondents felt that the assurance of healthcare services across the border of Afghanistan did not meet their expectations, it was still perceived positively. However, the gap was narrower than for tangibility.

The results for reliability were more balanced, with an equal number of negative 10 and positive 10 ranks. The mean ranks were also relatively close, at 11.05 for negative ranks and 9.95 for positive ranks, indicating a division in perceptions of reliability versus expectations, as participants were equally split in their assessments of the reliability of healthcare services across the Afghanistan border.

Regarding empathy, there were six negative ranks and 13 positive ranks. The mean rank for the Afghan medical tourists' negative perceptions was 12.33, and for positive perceptions, the mean was 8.92, indicating that participants' perceptions exceeded their expectations for empathy.

The results showed three negative ranks compared to 22 positive for the last domain of service quality responsiveness. The mean for negative perceptions was 11.50, and the mean for positive perceptions was 13.20, indicating that Afghan medical tourists' perceptions exceeded their expectations (Table 1).

Table 1: Wilcoxon signed-rank test for differences between participants' perceptions and expectations of tangibility, assurance, reliability, empathy, and responsiveness.

		N	Mean Rank	Sum of Ranks
Perception of Tangibility Expectation of Tangibility	- Negative Ranks	1 ^a	19.50	19.50
	Positive Ranks	26 ^b	13.79	358.50
	Ties	1 ^c		
	Total	28		
Perception of Assurance Expectation of Assurance	- Negative Ranks	5 ^d	12.90	64.50
	Positive Ranks	21 ^e	13.64	286.50
	Ties	2 ^f		
	Total	28		
Perception of Reliability Expectation of Reliability	- Negative Ranks	10 ^g	11.05	110.50
	Positive Ranks	10 ^h	9.95	99.50
	Ties	8 ⁱ		
	Total	28		
Perception of Empathy Expectation of Empathy	- Negative Ranks	6 ^j	12.33	74.00
	Positive Ranks	13 ^k	8.92	116.00
	Ties	9 ^l		
	Total	28		
Perception of Responsiveness Expectation of Responsiveness	- Negative Ranks	3 ^m	11.50	34.50
	Positive Ranks	22 ⁿ	13.20	290.50
	Ties	3 ^o		
	Total	28		

Note. a. Perception of Tangibility < Expectation of Tangibility, b. Perception of Tangibility > Expectation of Tangibility, c. Perception of Tangibility = Expectation of Tangibility, d. Perception of Assurance < Expectation of Assurance, e. Perception of Assurance > Expectation of Assurance, f. Perception of Assurance = Expectation of Assurance, g. Perception of Reliability < Expectation of Reliability, h. Perception of Reliability > Expectation of Reliability, i. Perception of Reliability = Expectation of Reliability, j. Perception of Empathy < Expectation of Empathy, k. Perception of Empathy > Expectation of Empathy, l. Perception of Empathy = Expectation of Empathy, m. Perception of Responsiveness < Expectation of Responsiveness, n. Perception of Responsiveness > Expectation of Responsiveness, and o. Perception of Responsiveness = Expectation of Responsiveness.

The Wilcoxon signed-ranks test results were used to analyze five dimensions of service quality: tangibility, assurance, reliability, empathy, and responsiveness. In the Wilcoxon signed-ranks test results comparing the Afghan medical tourists' perception of tangibility to their expectation of tangibility, the test statistic yielded a Z value of -4.079. This result was statistically significant, with a *p*-value of less than .001.

In the analysis of tangibility, the median values for perception and expectation were identified as the central tendencies of the data regarding the perception of tangibility. The median was 14, indicating that half of the participants rated their perception of tangibility at 14 or above on the scale, suggesting that a significant portion had a relatively high perception of tangibility. In the Wilcoxon signed-ranks test results comparing the Afghan medical tourists' perception of assurance to their expectation of assurance, the test statistic showed a Z value of -2.844. This result was statistically significant, with a *p*-value of .004.

In the assurance analysis, the median values for perception and expectation were identified as the central tendencies of the data regarding the perception of assurance. The median was 13, indicating that half of the participants rated their perception of assurance at 13 or above on the scale, suggesting that a significant portion had a relatively high perception of assurance.

In contrast, the Wilcoxon signed-ranks test found differences between perception and expectation of reliability. The test statistic revealed a Z value of -0.207. This result was not statistically significant, as evidenced by the *p*-value of 0.836, suggesting that Afghan medical tourists neither perceived reliability to be significantly greater nor significantly lower than their expectations for healthcare services across the border in Afghanistan.

The Wilcoxon signed-ranks test found differences between perceptions and expectations of empathy. The test statistic revealed a Z value of -0.858. This result was not statistically significant, as evidenced by the *p*-value of 0.391, suggesting that Afghan medical tourists neither perceived empathy to be significantly greater nor significantly lower than their expectations for healthcare services across the border in Afghanistan.

In the Wilcoxon signed-ranks test, performed to compare the Afghan medical tourists' perception of responsiveness with their expectation of responsiveness, the test statistic was significant, with a Z value of -3.457, and indicated by a *p*-value of less than 0.001.

Furthermore, there was a difference between the median of 14 for perception and the median of 10 for expectation, indicating that medical Afghan tourists perceived responsiveness as significantly higher than expected for healthcare services across the Afghanistan border. These findings were consistent with the results from the Wilcoxon signed-ranks test (Table 2).

Table 2: Wilcoxon signed-rank test for tangibility, assurance, reliability, empathy, and responsiveness.

	Perception of Tangibility - Expectation of Tangibility	Perception of Assurance - Expectation of Assurance	Perception of Reliability - Expectation of Reliability	Perception of Empathy - Expectation of Empathy	Perception of Responsiveness - Expectation of Responsiveness
Z	-4.079 ^b	-2.844 ^b	-.207 ^c	-.858 ^b	-3.457 ^b
<i>p</i> -value	<.001	.004	.836	.391	<.001
Median for perception	14	13	13	13.5	14
Median for expectation	9.0	11	13	12.0	10

Note: a. Wilcoxon signed ranks test

b. Based on negative ranks.

c. Based on positive ranks.

8.2 Association of Socio-demographics and Seeking Care across the Border of Afghanistan

The chi-square test revealed a significant association between the gender of Afghan medical tourists and the frequency of healthcare services used across the Afghan border. With a Pearson chi-square value of 0.097 and a *p*-value of 0.755, the test indicated that healthcare service usage patterns across the Afghanistan border do not differ significantly between females and males in this study.

The chi-square test showed a significant relationship between the type of permanent residence and the frequency of healthcare services in Afghan medical tourists used across the border of Afghanistan, with a Pearson chi-square value of 14 and a *p*-value of <.001 indicating that usage of healthcare services outside Afghanistan varied significantly among rural, suburban, and urban residents.

The chi-square test revealed a statistically significant association between Afghan medical tourists' income levels and the frequency of healthcare services used across the Afghanistan border, with a Pearson chi-square value of 21.46 and a *p*-value of <.001. This indicates that higher-income medical tourists used services more frequently than lower-income participants.

The chi-square test showed no significant association between the type of healthcare services used across the border and the frequency of usage across the border of Afghanistan, with a Pearson chi-square value of 2.35 and a p-value of 0.501 indicating that the frequency of service usage does not significantly differ by service type in Afghan medical tourist in this study (Table 3).

Table 3: Association of Participants' Socio-demographics and Number of Medical Services Used Across the Border

		One time	More than once	Total
Age	18-30 years	2	9	11
	31-45 years	1	12	13
	46-60 years	1	3	4
Gender	Female	2	10	12
	Male	2	14	16
Attained education	High school	2	5	7
	Bachelors	1	12	13
	Masters or above	0	6	6
	Prefer not to answer	1	1	2
Type of healthcare services used across the border	General medicine	2	15	17
	Surgery	1	7	8
	Other	1	1	2
	Prefer not to answer	0	1	1
Type of permanent residence	Rural	4	3	7
	Suburban	0	1	1
	Urban	0	20	20

Note. Results reported in row in numbers. For age df (degree of freedom)= 2, X^2 (Pearson chi-square) = 0.97, $p = 0.616$. For gender df = 1, $X^2 = 0.09$, $p = 0.755$. For education, df = 3, $X^2 = 4.71$, $p = 0.191$. For residence type, df = 2 $X^2 =$, $p < 0.001$. For the type of healthcare services, df = 3, $X^2 = 2.35$, $p = 0.501$.

9. Discussion

Medical tourism, commonly defined in medical literature as receiving healthcare services across the border of the host country, has gained momentum worldwide in recent years (McCartney & Wang, 2024; Xu et al., 2020). Study

results have suggested that multiple factors, including the price of healthcare services, the availability of specific procedures and treatments, and the quality of care, act as both pushing and pulling factors in different cultures (Azimi et al., 2020; Vovk et al., 2020). In Afghanistan, a study of 28 Afghan participants with experience in medical tourism yielded significant findings on several domains of service quality for the healthcare services they received across the border, highlighting the dynamics of medical tourism among Afghan patients and local systemic healthcare challenges.

In this study, the gender distribution indicated a higher percentage of male participants (57.1%) compared to females (42.9%). This difference highlights sociocultural norms in Afghanistan that often limit women's access to healthcare; the findings reveal consistent patterns observed in other South Asian countries, such as Pakistan and Bangladesh (Habib et al., 2024; Hinata et al., 2020). Regarding educational attainment, 46.4% of participants held bachelor's degrees, suggesting a correlation between education and awareness of medical tourism options (Shaygani et al., 2023). Additionally, among 28 participants, 82.1% chose "middle-income" as their income level; the findings were consistent with the income level of many medical tourists from Asian countries, who are often identified as belonging to the middle-income class, such as those from Bangladesh (Rahman et al., 2022).

The types of healthcare services used by 28 Afghan medical tourists showed that 60.7% used general medicine, while 28.6% sought surgical services. The finding suggests a broader need for comprehensive and general medicine in Afghanistan, and a similar pattern was not observed in other studies; for example, in Bangladesh, medical tourists commonly utilized specialized care, such as cardiac surgery and orthopedics, in the destination country (Zakaria et al., 2023).

The Wilcoxon signed-ranks test was used in this study to assess the Afghan patients who received healthcare services across the border of Afghanistan and to examine the differences between their perceptions and expectations across several service quality dimensions. Their perception was higher than expected for tangibility, assurance, and responsiveness, while perceptions of reliability and empathy did not present significant differences.

The results demonstrated a statistically significant difference between participants' perceptions and expectations for both tangibility ($p < .001$) and assurance ($p = .004$). In the context of lower-income countries, similar trends have been reported in studies examining healthcare services in nations such as Bangladesh. Zakaria et al. (2023) indicated that npatient population from Bangladesh who visited India for self-treatment; regression analysis revealed that facility and services had a strong influence on their decision ($\beta = 0.24$, $t = 4.71$, $p < 0.001$) to seek care across the border of their homeland.

For reliability and empathy, the Wilcoxon test results showed no statistically significant difference in perceptions versus expectations for reliability ($p = 0.836$) and empathy ($p = 0.391$). Multiple study results indicated that participants reported a negative gap between patients' expectations and perceptions of the reliability dimension of service quality, demonstrating a significant discrepancy in hospital services (Guiry & Vequist, 2011; Qolipour et al., 2018).

There was a statistically significant difference ($p < .001$) in the responsiveness domain of service quality, aligning with findings suggested by Rahman et al. (2022) and Zakaria et al. (2023), which indicated that responsiveness to healthcare influenced medical tourists' decisions to seek healthcare services across the border of their home country.

9.1. Theoretical Application

The theoretical application of our study on the perception and expectations of Afghan medical tourists who used healthcare services across the border of Afghanistan can provide valuable insights for the private healthcare industry to assess their service quality and find the gaps and fill them with short-term, long-term term strategies to prevent unnecessary cash flow from Afghanistan to other countries. Assessing the service quality dimensions in this study can highlight the motivations and driving factors for medical travel, allowing policymakers in the

private sector to develop and implement targeted improvements to enhance the overall experience of the Afghan patient population in Afghanistan.

9.2. Limitation

This study only included patient populations that were educated and could speak English, which limited the study's generalizability.

9.3. Recommendations

We require future large-scale research that includes Afghan participants from diverse socio-demographic backgrounds, including those who cannot speak English and individuals with varying educational levels, including those with no formal education, to ensure comprehensive insights into the perceptions of medical tourism among Afghan residents. Furthermore, we need to employ mixed-method approaches to enrich data through qualitative and quantitative insights into the perceptions and expectations of healthcare services across the Afghanistan border.

10. Conclusion

The results of this study suggested that Afghanistan has a considerable number of gaps in their health system as perceived by the Afghan patient population seeking healthcare services for various diseases and health issues outside Afghanistan, highlighting that the Afghan health system needs improvements across multiple dimensions of service quality, including assurance, reliability, empathy, tangibility, and responsiveness. When these gaps are appropriately filled and the shortcomings are addressed, local Afghan healthcare services and quality will improve, satisfying Afghan patient expectations and reducing reliance on medical tourism.

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Lipid Profile and Malondialdehyde (MDA) Level after Administration of *Syzygium aromaticum* in Sprague Dawley Rats with Dyslipidemia

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Abstract

Dyslipidemia leads the process of oxidative stress and increased the levels of malondialdehyde (MDA). *Syzygium aromaticum* has an antioxidant effect and lowering lipid profile. This study aims to evaluate the changes in MDA level after administration of *Syzygium aromaticum* in various doses of administration. 30 male Sprague Dawley rats are divided into 6 groups: normal group (normal diet), negative control (high fat diet/HFD only), positive control (HFD and simvastatin), group 1 (HFD and *Syzygium aromaticum* 150mg/body weight) group 2 (HFD and *Syzygium aromaticum* 250mg/body weight) and group 3 (HFD and *Syzygium aromaticum* 500mg/body weight). The evaluation of lipid profile was performed pre and post experimental procedure (day 0 and day 42). After six weeks rats were terminazed by ketamine-xylazin injection intramuscularly, and had their liver collected for the examination of MDA levels. One-way anova test showed significant differences in lowering MDA levels in groups 2 dan 3 (HFD and *Syzygium aromaticum* doses 250 and 500mg/KgBB). It can be concluded that the administration of *Syzygium aromaticum* extract aromaticum reduced oxidative stress with MDA parameters.

Keywords: MDA, Dyslipidemia, *Syzygium Aromaticum*

1. Introduction

Dyslipidemia is a lipoprotein metabolism disorder, characterized by an increase in total cholesterol, low-density lipoprotein cholesterol, triglyceride levels, and, or a decrease in high-density lipoprotein cholesterol levels (Lao et al., 2021). Previous research has proven that dyslipidemia is associated with cardiovascular disease and stroke (Kopin & Lowenstein, 2017). Dyslipidemia causes 50% of ischemic heart and cerebrovascular disease which are the main causes of morbidity and mortality in the world (Aradine E et al., 2020). Excessive lipid stored in adipose tissue in the body, leads to obesity. Obesity followed by increased fat (lipid) metabolism causes reactive oxygen species (ROS) production. Increased ROS in adipose cells can cause the balance of oxidation-reduction (redox) reactions to be disrupted, resulting in decreased antioxidant enzymes in the circulation. This situation is called oxidative stress (Wahjuni, 2015). Increased oxidative stress causes dysregulation of adipose tissue, and is the initial pathophysiology of metabolic syndrome, hypertension and atherosclerosis (Arshad et al., 2021). Oxidative stress

can be evaluated by measuring the end products of oxidative damage to proteins and amino acids, one of which is malondialdehyde (MDA). Malondialdehyde is the end product of degradation of lipid peroxidation that is the reason of widely used as a parameter of oxidative stress (Niki, 2009).

Syzygium aromaticum (clove) has high anti-oxidative effect. Indonesia is one of the largest clove producers in the world. Based on previous research, *Syzygium aromaticum* contains an active compound of 70-96% eugenol (Towaha, 2012). The compound eugenol ($C_{10}H_{12}O_2$) is a derivative of guaiacol with an additional alkyl chain known as IUPAC 2 methoxy-4-(2 propenyl) phenol. Phenolic compounds contained in a number of plants are considered secondary metabolites which have an important role in antioxidant activity (Alawiyah et al., 2019)(Selles et al., 2020). *Syzygium aromaticum* also has the potential to reduce blood lipid profiles (Rouhi-Boroujeni et al., 2015).

This study aims to determine MDA levels as a marker of oxidative stress in the pathogenesis of dyslipidemia in Sprague dawley rats administered with *Syzygium aromaticum* in several dose groups. Research on *Syzygium aromaticum* related to dyslipidemia and oxidative stress has widely carried out. The novelty of this research is to evaluate the MDA level as end product of oxidative stress in dyslipidemia. This research is expected to increase knowledge regarding the involvement of oxidative stress and become the basis for using natural ingredients as additional therapy in the management of dyslipidemia in the future.

2. Method

All experiments were performed strictly in accordance with the recommendations of the guide for the care and use from iRATco Animal Laboratory (Bogor, Indonesia). The experiment was approved by the local ethics committee of Faculty of Medicine & Health, University of Muhammadiyah Jakarta with registered number 09/PE/KE/FKK-UMJ/I/2023 (Indonesia).

2.1 Animal and Experimental Design

Thirty 8-12 weeks-old male Sprague Dawley weighing 120-150 g were purchased from iRATco animal lab provider (Bogor, Indonesia) and divided into 6 groups. 5 rats each group was divided randomly and given intragastric administration of vehicle CMC 0,5% (normal control), high fat diet only (negative control), and simvastatin (positive control). The other three treatment groups were treated with dosages 150, 250, and 500 mg/kg/day of SA ethanolic extract. The body weight of each rat was monitored weekly for six weeks. The evaluation of lipid profile was performed pre and post experimental procedure (day 0 and day 42). After six weeks rats were terminazed by ketamine-xylazin injection intramuscularly, and had their liver were collected for the examination of MDA levels.

2.2 Diet

Two kinds of diet were used in this study; standard and high-fat diet. Normal diet with total energy 3600 (kcal/kg) consists of total protein 12.58%, total fat 4%, total carbohydrate 72.7%, fiber 5%, Ash 3.89%, Calcium 0.5% and Phosphat 0.19%. High-fat diet with total energy 5700 (kcal/kg) consists of total protein 14%, total fat 50%, total carbohydrate 36%, fiber 3.5%, Ash 5.3%, Calcium 1% and Phosphat 0.7%.

2.3 *Syzygium aromaticum* Extract

Dried cloves were purchased from IPB Biopharmacy Center (Bogor, Indonesia). Clove was extracted by using 96% ethanol through the maceration method in Indonesian Medicinal and Aromatic Crops Research Institute (IMACRI) (Bogor, Indonesia). The clove extract was produced by measuring 50 g of clove powder then was extracted using 96% ethanol solvent at 1:5 ratio (w/v). Furthermore the extracted sample was macerated for 24 hours, while being stirred using the magnetic stirrer at room temperature. The maceration product was filtered using Whatman no 41 filter paper. The unfiltered sample was re-macerated twice with the same method. The

macrated production was concentrated by the vacuum evaporator at 30–45°C and preserved at -20°C for further steps.(Ode et al., 2023)

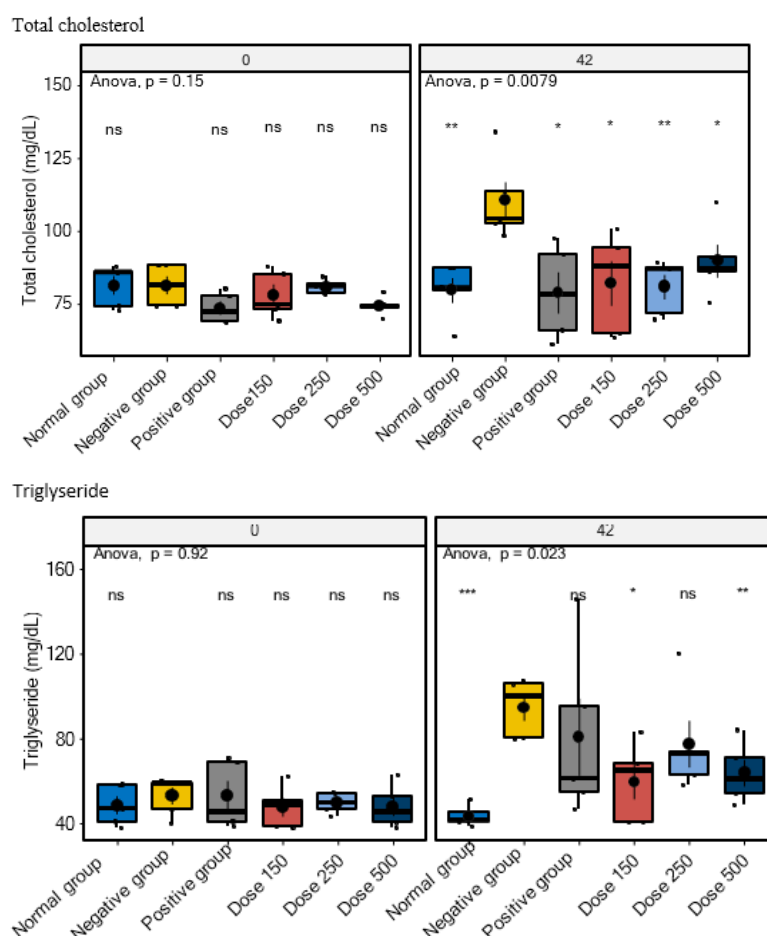
2.4 Lipid Profile and MDA Measurement

Rats were stopped from being given food 24 hours before the blood test. Blood was taken from sinus orbitalis. Lipid profile examined using enzymatic method using glory diagnostic kit. MDA was examined with spectrophotometry using modification of thiobarbituric acid (TBA) method. A total of 400 µl of sample was reacted with 200 µl of 20% trichloroacetic acid (TCA) for deproteinization. Then vortexed and centrifuged at 5000 rpm for 10 minutes. The supernatant formed was taken and 400 µL of 0.67% TBA was added. Sample was vortexed and incubated in a water heater at 96°C, 10 minutes later removed and cooled to room temperature. Then read the absorption at a wavelength of 530 nm.(Rakita et al., 2020)

3. Results

3.1 Lipid Profile

To ensure that the experimental animals had dyslipidemia, the blood lipids were examined and compared between groups post-treatment on day 42.



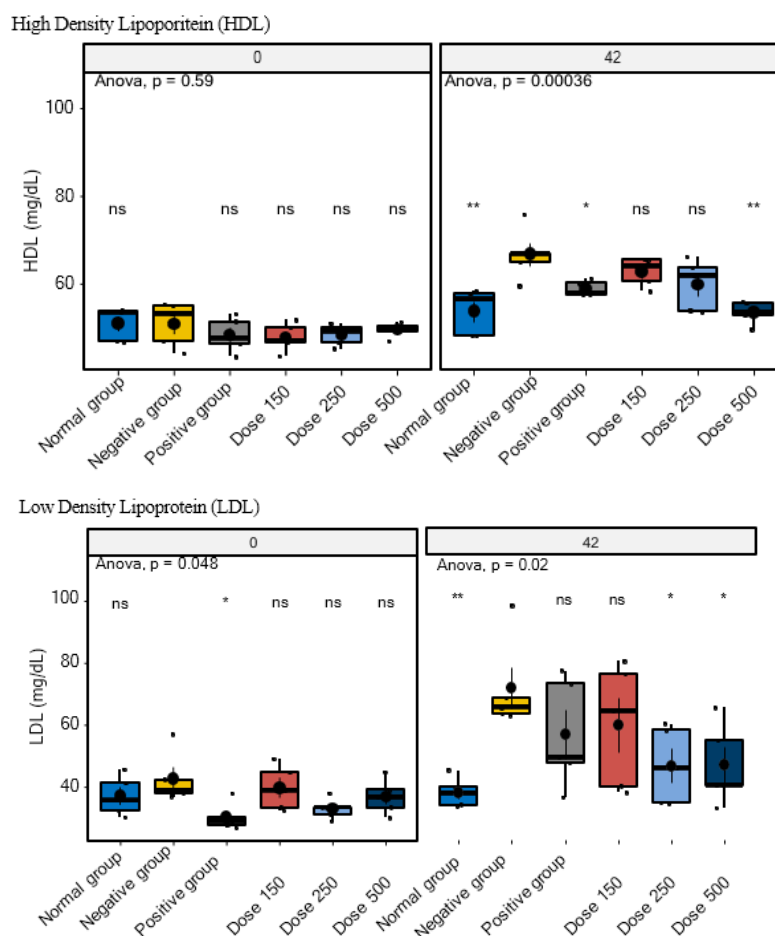


Figure 1. Serum lipid profile parameters of different experimental groups

Values were expressed as mean $\pm$ SD ($n = 5$). *Bonferroni-test, indicates a significant diff ($p < 0.05$)

Figure 1. shows specific comparison between all experimental groups in lipid profile. Total cholesterol increased in the group treated with high-fat diet, but in the group given *Syzygium aromaticum* extract, total cholesterol level decrease significantly ($p < 0.05$). Triglyceride levels increased in the group treated with a high-fat diet, but triglyceride levels showed a significant decrease in the group treated with the *Syzygium aromaticum* extract at dose of 150 and 500 mg/kgbody weight ($p < 0.05$). HDL levels increased in the group treated with high fat diet, but HDL decrease in the group treated with *Syzygium aromaticum* extract dose of 500 mg/kg BW ($p < 0.05$). LDL levels increased in group treated with high fat diet, but decrease significantly in the group treated with *Syzygium aromaticum* extract doses of 250 and 500 mg/kg BW ($p < 0.05$).

3.2 The malondialdehyde level

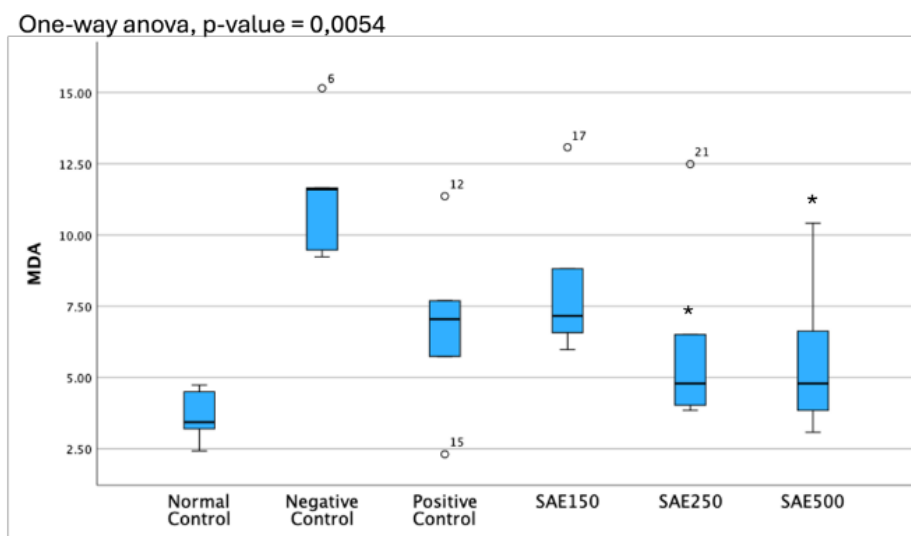


Figure 2: Malondialdehyde (MDA) levels ($\mu\text{mol/L}$)

MDA levels indicate the presence of oxidants in the liver. In this study, high fat diet groups showed an increase in MDA levels. Groups treated with *Syzigium aromaticum* extract showed significant decreased of MDA levels with a dose of 250 and a dose of 500 mg/kgBW (figure 2).

4. Discussion

4.1 Dyslipidemia and Oxidative stress

Reactive oxygen species (ROS) are bioproducts of cellular metabolism. There is a range of molecules with oxidizing properties known as ROS. Despite those molecules being implied negatively in aging and numerous diseases, their key role in cellular signaling is evident. ROS control several biological processes such as inflammation, proliferation, and cell death. (De Almeida et al., 2022) Dyslipidemia has been reported to involve a release of reactive oxygen species (ROS) which may lead to oxidative stress. The primary sources of endogenous ROS production are the mitochondria, plasma membrane, endoplasmic reticulum, and peroxisomes. Metabolic disorders such as obesity, dyslipidemia and diabetic mellitus are accompanied by chronic inflammation mediated by oxidative stress. Increased oxidative stress in metabolic disorders plays a role in causing mitochondrial dysfunction, accumulation of protein and lipid oxidation products and disruption of the antioxidant system. (Vona et al., 2019)(Pechánová et al., 2015)

4.2 Malondialdehyde and lipid peroxidation

One of the consequences of uncontrolled oxidative stress (imbalance between the prooxidant and antioxidant levels in favor of prooxidants) is cells, tissues, and organs injury caused by oxidative damage. It has long been recognized that high levels of free radicals or reactive oxygen species (ROS) can inflict direct damage to lipids. The primary sources of endogenous ROS production are the mitochondria, plasma membrane, endoplasmic reticulum, and peroxisomes. through a variety of mechanisms including enzymatic reactions and/or autooxidation of several compounds, such as catecholamines and hydroquinone. Different exogenous stimuli, such as the ionizing radiation, ultraviolet rays, tobacco smoke, pathogen infections, environmental toxins, and exposure to herbicide/insecticides, are sources of *in vivo* ROS production.(Ayala et al., 2014) Malondialdehyde (MDA) is an end-product of lipid peroxidation and a side product of thromboxane A₂ synthesis. MDA's high reactivity and capability of forming adducts with multiple biological molecules such as proteins or DNA have attracted major attention over the last decades. . MDA's high reactivity is mainly based on its electrophilicity making it strongly reactive toward nucleophiles, such as basic amino acid residues. (Giera et al., 2012) MDA has been widely used

for many years as a convenient biomarker for lipid peroxidation of omega-3 and omega-6 fatty acids because of its facile reaction with thiobarbituric acid (TBA). The TBA test is predicated upon the reactivity of TBA toward MDA to yield an intensely colored chromogen fluorescent red adduct. (Niki, 2009) MDA is one of the most popular and reliable markers that determine oxidative stress in clinical situations [53], and due to MDA's high reactivity and toxicity underlying the fact that this molecule is very relevant to biomedical research community.

4.3 *Syzygium aromaticum* and Oxidative Stress

Syzygium aromaticum is not only a significant spice but has also been utilised in traditional medicine to treat a number of diseases. In the current study, stress caused by a high-fat diet was used to investigate the underlying protective mechanism of *S. Aromaticum* (clove) extract in a rat model. In the present study, we found that SA extract had ability to alter the lipid profile. It significantly decrease the dyslipidemia parameters which are characterized by the decrease in serum levels of total cholesterol, triglyceride, LDL-c, and an increase in HDL-c compared with the high fat diet only group. A study conducted by El-Rahman (Abd El-Rahman, 2015) showed that cloves could reduce the serum total cholesterol, triglycerides, LDL-c, and VLDL-c levels however increased HDL-c level significantly compared to the DC group. Poulak et al (Poulak et al., 2020) and Rabeh et al., (Rabeh et al., 2021) demonstrated that clove extract significantly decreased the dyslipidemia status by regulating lipid metabolism.

Finding from this study have also shown that administration of SA extract reduced the MDA level of treatment groups compared to high fat diet only group. MDA level is one of the indicator of lipid peroxidation and oxidative stress with the MDA resulting from the end product of polyunsaturated fatty acid peroxidation. Hyperlipidemia is associated with the increased oxidative stress and increased MDA levels. Many studies in both human and animal models found that elevated levels of MDA are associated with the hyperlipidemia and reduced antioxidant levels in the experimental subjects. Study conducted by Al Flyah (Al-flyah et al., 2010) have shown that cloves (*Syzygium aromaticum*) extract significantly reduced the MDA level of rats induced by alloxan. Poulak et al.(Poulak et al., 2020) also found that in the groups of rats that were treated with clove extract exhibited a significant reduction of MDA level compared to the control diabetes group. Study by Sharma et al (Sharma et al., 2023) demonstrated a phytochemical analysis of *Syzygium aromaticum* extract and found that as per the GC-MS, cloves have a higher content of eugenol and eugenol acetate, which possess strong antioxidant activities by hydrogen/electron transfer or directly trapping the free radicals.

The antioxidant activity of SA extract may be due to phenolic compounds such as eugenol, eugenol acetate, and thymol. SA extract can prevent cell damage by scavenging free radicals, chelating temporary metal ions, inhibiting oxidant enzymes, or by repairing a-tocopherol from a-tocofoxyl radical. Also, flavonoids can scavenge O₂, OH, and peroxy radicals and inhibit LPO activity, as result, SA extract can decrease MDA level.

The results of this study showed that SA extract has beneficial effects in lowering serum cholesterol, triglycerides, and LDL levels. SA extract also decreases MDA level. MDA is one of the most popular and reliable markers that determine oxidative stress in clinical situations. Therefore, because of these beneficial effects of *Syzygium aromaticum* / clove, it can be used as an effective herbal medicine in reducing and treating the dyslipidemia and oxidative stress induced by high fat diet.

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Declaration of Generative AI and AI-assisted Technologies: This study has not used any generative AI tools or technologies in the preparation of this manuscript.

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Animated Video as a Health Promotion Tool to Improve Knowledge and Behavior of Pulmonary TB Patients

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Abstract

Tuberculosis (TB) has become the deadliest disease in the world. People suffering from TB in Indonesia has increased over the last five years, reaching 1,092,000. Three regencies in Bali contribute to the number of TB cases are Denpasar, Buleleng, and Badung. Knowledge is variably important in changing behavior. Health promotion is hence indispensable. Technological involvement can be the solution to expand the knowledge wider. This research aims to understand the difference in knowledge and behavior with an intervention of animated video in preventing TB. This research used a quasi-experimental design with one group. The study population consisted of 102 TB patients in Badung Regency. An animated video was used and exposed to social media. The variables are knowledge and behavior, which are analysed before and after the intervention was employed. Data were analyzed using descriptive and Wilcoxon statistical tests. The results of the study obtained the level of knowledge in the category of most is at Fair 73 people (71.5%) and Good 17 (16.7%). After watching the video, the proportion of Good knowledge increased drastically to 88 people (86.3%), while there were no more respondents in the Poor category. Respondents' behavior is most at Fair category with 69 people (67.6%) and Good is 26.5%. After treatment, Good behavior increased sharply from 26.5% to 84.3%, there were no more respondents' behavior in the Poor category after watching the animated video. Both knowledge and behavior obtain $p = 0.000$. In conclusion, animated videos can improve knowledge and behavior in TB prevention.

Keywords: Tuberculosis, Badung, Animated video, Knowledge, Behavior

1. Introduction

Health research focuses on stunting, tuberculosis, maternal and child health (KIA), infectious and non-infectious diseases, where tuberculosis is among the deadliest diseases in the world (Mohajan, 2015). World Health Organization (WHO) data said that in 2018, 10 million people suffered from tuberculosis with varying severity, with new cases ranging from less than 5 to more than 500 per 100,000 people annually. The highest prevalence of TB cases happens in males aged 15 years and under, accounting for 57% of total TB cases in while females account for 32%, and children under 15 years of age account for 11%. India, China, Indonesia, the Philippines, Pakistan,

Nigeria, Bangladesh, and South Africa are eight of the thirty countries that contribute to the world's TB cases (WHO, 2019). Data from the Indonesian Ministry of Health shows that 543,874 cases of tuberculosis were reported in Indonesia in 2019, compared to 566,623 cases in 2018 and in 2019, there were 523,614 cases (Iskandar et al., 2023). The cases increase even in 2024, the number reaching 1,092,000 people who suffer from TB. In 2020, the total number of tuberculosis cases in Bali Province was 2,873, with three regencies contributing the highest number of cases: Denpasar City with 1,054 cases, Buleleng Regency with 502 cases, and Badung Regency with 400 cases (Bali, 2021).

Health awareness can ensure the provision of information and knowledge (Setiawati et al., 2024; Wulandari & Prihatin, 2022). Socialization in the health and education sectors is aimed at sharing health information with a community, group, or individual. Health education is an effort to learn about health using various media and technologies to expand public knowledge (Van Teijlingen et al., 2021). Health promotion can be carried out to prevent early TB in the community and among individuals (Trifitriana, M., Fadilah, M., & Mulawarman, 2020). It can be implemented in the learning process using visual media such as video.

Previous research by (Mardiah et al., 2024), who evaluated the effect of counseling with video animation on 30 respondents of family members of patients treated in the hospital, showed a significant increase in patient knowledge and attitudes in the intervention group compared to the control group. It discusses that videos have proven to be more interesting and effective in conveying health information. Respondents who received counseling through animated videos showed a good understanding of the attitudes to support patients and felt more satisfied with the counseling process. This study concludes that animated videos can be an effective tool in health counseling in hospitals, increasing patient knowledge and attitudes towards pulmonary tuberculosis. Another research specifically in Badung Regency about the category of variables related to TB cases revealed that knowledge was mostly in the poor category, as many as 28 (90.3%), and the most behavioral variables were in the poor behavior category, as many as 30 people (68.2%). The results of the chi-square test obtained a significance of 0.001 for knowledge and 0.001 for behavior, indicating that there is a relationship between knowledge and behavior with the incidence of pulmonary TB (Suyasa et al., 2024).

The background behind the involvement of technology in health education is that conventional education is often less engaging and effective in attracting public attention and interest (Latif.A.I., Tiala, N.H.& Masahuddin, 2023). Long lectures or static presentations tend to be less able to maintain the audience's focus for a long time. Facing this challenge, the use of animated videos as educational media can be a very innovative and interesting solution (Afiah, A.S.N.,& Soesanti, 2022). Animated videos have strong visual appeal and can convey complex information in a way that is easier to understand. A combination of attractive visuals, clear sound, and structured narrative in animated videos can increase understanding of pulmonary TB prevention (Setyorini, E, H., Ajmala, I.E., Primayanti, I.Yuliani, E.A., & Geriputri, 2020). Moreover, the use of animated videos on social media can be an effective way to increase the reach and effectiveness of health education about pulmonary TB.

This research aims to determine the effectiveness of animated videos in increasing knowledge and changing behavior in an attempt to prevent the transmission of pulmonary TB in Badung Regency.

2. Method

2.1 Study Design

This study employed a quantitative method with a quasi-experimental one-group pre-posttest design. This study implemented an experimental method. Experimental research is known for its most comprehensive quantitative research approach, meaning it meets all the requirements for testing causal relationships (Sahir, 2021). It is a widely used method to determine the effect of one treatment on another under controlled conditions, which fall into three categories: pre-experimental design, true experimental design, and quasi-experimental design.

2.2 Population and Sample

The population is all subjects or objects with specific characteristics to be studied, not only the objects or subjects studied that are studied, but also all the characteristics or traits possessed (Alimul Hidayat, 2012). The population in this study was pulmonary tuberculosis patients registered at 12 community health centers in Badung Regency. This number also becomes the case population, which includes all pulmonary tuberculosis patients registered at 12 community health centers in Badung Regency.

The sample is the number and characteristics of the population that are studied, and conclusions drawn from which the results can represent the condition of a population. The sample size in this study was adopted from the formula for the total population, which was not known for certain, as shown in Eq. 1 (Lemeshow et al., 1997).

$$n = \frac{Z_{1-\alpha/2}^2 \times P(1-P)}{d^2} \quad (1)$$

Based on Eq. 1, the proportion of TB incidents in Badung Regency of 0.158, CI of 95% and d with a value of 10%, the calculation results obtained a sample of 102 respondents.

2.3 Data Collection and Analysis

In conducting data collection, measurement tools are used to strengthen the research results. It is known that the data collection measurement tools can include questionnaires, observations, interviews, or a combination of the three. This research used a questionnaire as the instrument, containing several questions. This instrument was chosen as the respondents are large and not illiterate. In addition, the questions are able to explore confidential matters. The respondents were exposed to animated videos containing material on preventing the transmission of pulmonary tuberculosis disease delivered through social media. The variables measured are knowledge, attitudes, and actions before and after being given animated videos. The data collection was conducted using a questionnaire-based interview method before and after the intervention through animated videos on TB prevention. The category is divided into 3 i.e., Good, Fair and Poor. The data analysis used the Wilcoxon statistical test to show the effect of animated video on the knowledge and behavior of the respondents.

3. Results

The results are divided into data on respondents' characteristics, research variables, knowledge, as well as behavior, using the Wilcoxon statistical test.

3.1 Respondents Characteristics

The characteristics of the research respondents are specified by gender, age, residence status, education, and employment status. The minimum age of respondents is 23 years, the maximum is 75 years, with an average age of 44.8 ± 12.1 years. The distribution of respondents based on gender, residence status, education, and employment can be seen in Table 1.

Table 1: Respondents' characteristics distribution

Gender	Frequency	Percentage
Male	42	40.2
Female	61	59.8
Total	102	100
Residence Status	Frequency	Percentage
Native	81	79.4
Migrant	21	20.6
Total	102	100.0
Education	Frequency	Percentage
Never attending school	5	4.9
Elementary	22	21.5
Junior High School	16	15.7
Senior High School	48	47.1
University	11	10.8
Total	102	100.0
Employment	Frequency	Percentage
Farmers/laborers	60	58.8
Entrepreneur	17	16.7
Civil Servant	4	.3.9
Private employee	21	20.6
Total	102	100.0

Table 1 shows that the 102 respondents, the majority female, i.e., 61 people or 59.8%, and 81 (79.4%) are indigenous. The highest level of education for respondents is senior high school as many as 48 respondents, or 47.1%. Sixty (58.8%) are farmers/laborers.

3.2 Research Variable

3.2.1 Knowledge

Based on the results of the respondents' knowledge questionnaire before and after intervention with animated videos on preventing pulmonary TB in patients in Badung Regency, as shown in Figure 1.

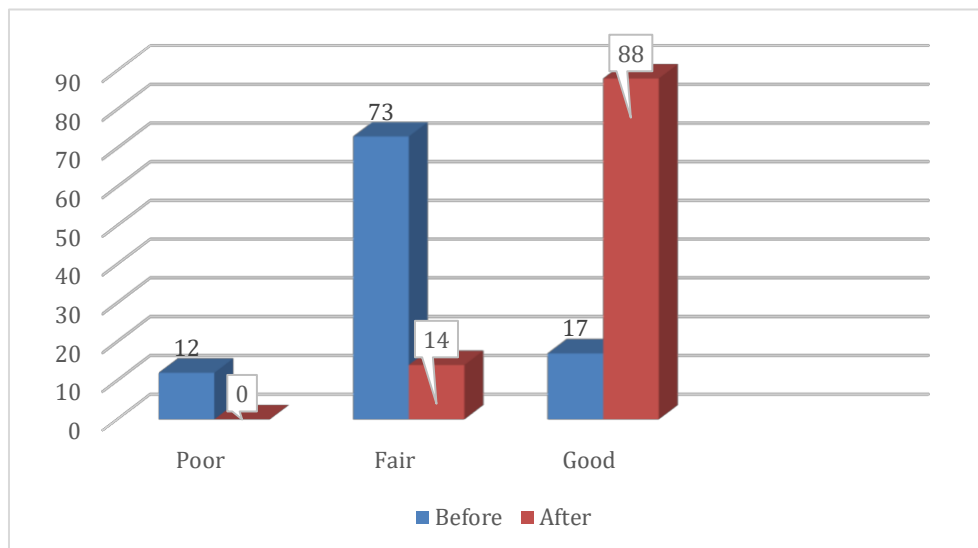


Figure 1: Knowledge category results

As seen in Figure 1 above, there is an increase in knowledge before watching the animated video. Before the intervention was given, the Good category was only 17 respondents (16.7%), and after watching the animated video the Good knowledge category increased for 88 respondents (86.3%). The increase in knowledge in the good category between before and after watching the animated video is 71 respondents (417.65%).

3.2.2 Behavior

The results of the questionnaire on respondents' behavior before and after the intervention are shown in Figure 2.

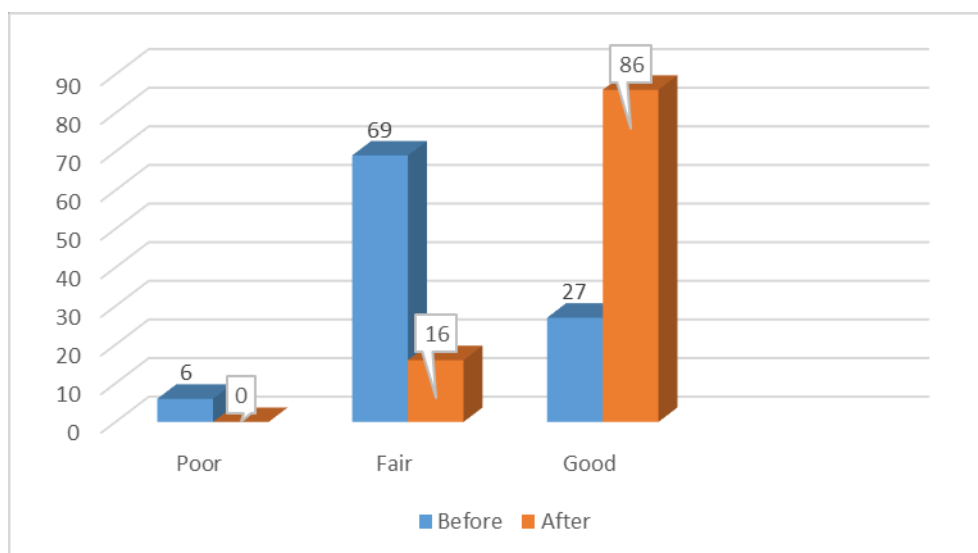


Figure 2: Behavior category results

Figure 2 above shows that there is an increase in behavior before watching the animated video in the Good category of 27 respondents (26.5%) and after watching the animated video in the Good behavior category of 88 respondents (84.3%). The increase in behavior in the Good category from before and after watching the animated video on pulmonary TB is 59 respondents (218.5%).

3.3 Data Analysis

The Wilcoxon test is used to analyze the data on respondents' knowledge and behavior before and after watching the animated video on preventing pulmonary TB. The results are shown in Table 2.

Table 2: Wilcoxon test results

	Before	After	Wilcoxon Test
Knowledge			
Poor	12 (11.8%)	0 (0%)	Sig = 0.000
Fair	73 (71.5%)	14 (13.7%)	
Good	17 (16.7%)	88 (86.3%)	
Total	102 (100.0%)	102 (100.0%)	
Behavior			
Poor	6 (5,9%)	0 (0%)	Sig = 0.000
Fair	69 (67.6%)	16 (15.7%)	
Good	27 (26.5%)	86 (84.3%)	
Total	102 (100.0%)	102 (100.0%)	

Data analysis using the Wilcoxon statistical test in Table 2 above shows that the level of knowledge before and after watching the animated video has a significance of 0.000, which means there is a difference in knowledge before and after watching the animated video on preventing pulmonary TB. Meanwhile, the result of the behavior Sig value is 0.000, meaning there is a difference in behavior before and after watching the animated video on preventing pulmonary TB.

4. Discussion

The results of the study show a significant increase in respondents' knowledge levels after watching the animated video on TB prevention. Before the intervention, most respondents had knowledge levels in the fair (71.5%) and poor (11.8%) categories. After watching the video, the proportion of good knowledge increased drastically to 86.3%, while no respondents are in the poor category. The Wilcoxon test shows a significance value of $p = 0.000$, which means there is a significant difference between knowledge before and after the animated video intervention. The educational variable for most respondents is a Senior High School education.

Education is a human activity, an effort or process of changing behavior towards maturity and the perfection of human life. Knowledge and attitude determine a person's level of education (Pratiwi et al., 2022; Sibagariang et al., 2025). Education is a planned effort to enable individuals or communities to practice what is taught through educational activities. When highly educated people suffer from illness, they increasingly need health facilities to treat themselves and their families. The higher the level of education, the more people understand that health is an important thing in life, and the greater their desire to seek better health facilities. In addition, individuals with higher education will more easily obtain information to expand their knowledge, and vice versa (Absor 2020). According to research conducted by (Widyastuti 2016), the level of education of TB patients affects their level of knowledge and absorption regarding the prevention of transmission and treatment of TB. Patients who have a low level of knowledge tend not to undergo treatment because, for them, treatment and not treatment will give the same results.

The research reveals that most respondents lacked understanding of TB before watching the video, including its causes, early symptoms, and prevention efforts. Many respondents believed TB was transmitted through direct contact or only affected certain groups. After watching the animated video, their understanding increased significantly. Respondents began to understand that TB is caused by the *Mycobacterium tuberculosis* bacterium, which is transmitted through droplets from coughing or sneezing. Besides, they also understand that TB can be prevented through clean and healthy living behaviors (PHBS), as well as early detection and appropriate treatment. Effective health promotion must consider predisposing factors (knowledge and attitudes), enabling factors (access to information), and reinforcing factors (environmental support). Animated videos function as a media that can simultaneously enhance predisposing and enabling factors.

Video media is a type of visual presentation in the form of movement that stimulates interest and understanding in viewers (Rizki 2016). Knowledge about how to avoid tuberculosis can be found in various activities, both in electronic media and in health education, as well as awareness campaigns conducted by health workers and school teachers using these media (Aisyah et al., 2020). Visual videos can provide information to the public or individuals. The greatest interest in audiovisual media stems from its ability to provide information in the form of movement, photos, and animations, which can encourage TB prevention behaviors.

Animated video media has proven effective as it delivers information in an engaging, practical, and easily understood manner, accessible to all groups, including those with low literacy levels. Visualizations can take the form of animations that simplify concepts that are difficult to grasp verbally. This is consistent with research conducted by (Putri, A. D., & Sari 2020), which found that the use of animated videos in health education increased participant understanding by 60% compared to printed media. Similarly, research conducted by (Manurung, R., Sari, I. P., & Nasution 2022) found that animation-based educational media significantly improved public understanding of TB, with the percentage of respondents with good knowledge increasing from 43.3% to 80%.

Before intervention, most respondents' behavior was in the Fair (67.6%) and Good (26.5%) categories, with 5.9% still in the Poor category. After treatment, Good behavior increased sharply from 26.5% to 84.3%, with no respondents remaining in the Poor category after watching the animated video. A significance level of 0.000 demonstrates that educational interventions through animated videos are also effective in changing behavior. Changes in a person's health behavior are influenced by knowledge, attitudes, and actions. Increasing knowledge is a crucial first step in changing a person's behavior for a healthier one. Knowledge is the most basic cognitive domain in shaping behavior (Kuo et al., 2024; Schneider et al., 2022). Without knowledge, a person will not understand the importance of preventive measures. Health behavior is influenced by knowledge and awareness. When someone's knowledge increases, they are more likely to make better behavioral changes. People can learn through observation, especially when messages are delivered through models or visual media. In this context, animated videos provide behavioral models that viewers can imitate. Interactive animated media can influence preventive actions because they feel more emotionally and visually involved in the learning process.

The results of this study align with previous research using video as a health education medium for tuberculosis, which showed that audiovisuals combined with video were more effective in improving elementary school students' knowledge and behavior regarding tuberculosis prevention (Fadilah, M., Syakurah, R. A., & Fikri 2019).

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Patients Experience of Telemedicine in Saudi Arabia: A Review of User Perspective

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Abstract

Background: In today's world, one of the requirements is the urgent need to provide fast, low-cost, affordable, and high-quality medical services. These demands have led to the invention of ways in which medical services can be provided to patients in their homes. **Methods:** This study aimed to analyze patients' experience of the implementation of telemedicine in Saudi Arabia (Riyadh City). Samples from different categories of patients were randomly selected following opportunity sampling techniques. The study population included 332 participants (male and female). For data collection, we used a questionnaire consisting of 8 items. The questions were rated using a 5-point Likert scale (agree, strongly agree, average, disagree, and strongly disagree). **Results:** A total of 67 (19.5%) participants reported that they use telemedicine only for medical consultation, while 47 (13.7%) said that they use it for diagnosis and treatment as well. The participants revealed that telemedicine saves them time and money. However, they admitted that telemedicine negatively affected their relationship with the service providers. Finally, patients described communication challenges and a lack of confidence in accessing telemedicine. **Conclusions:** The study concluded that the main barriers to the use of telemedicine services are a lack of confidence in accessing telemedicine, difficulty communicating due to the use of different languages and dialects, and the fact that these services are not suitable for uneducated people.

Keywords: Telemedicine, Services Providers, Riyadh City, COVID-19 Pandemic, Interactive Medicine, Medical Consultation

1. Introduction

The Internet can be used as a powerful tool to promote community health. Growing the use of telemedicine can reduce the pressure on healthcare facilities and decrease the budget required for equipment and operation. Saudi citizens are well-equipped with electronic devices and social media applications. Thus, the results of this study can be used to expand the use of telemedicine in this population by creating positive attitudes and strengthening

confidence in the reality of telemedicine, especially in light of the circumstances of pandemics such as the COVID-19 pandemic, during which remote interaction became one of the basic features.

According to our literature review, all studies on telemedicine to date included physicians, or in some cases, university students as their participants (Kaliyadan, et al, 2020 , Al-Hazmi, et al 2021 and Mubarak. et al. 2021). Several other studies on telemedicine were associated with telemedicine during the COVID-19 pandemic, and this factor may have some influence on the results, given that during the pandemic people avoided visiting health care services and used other methods for medical consultation and treatment, such as telephone calls and online contact with their physicians (Idriss. et al. 2022 and Alajwari. et al. 2022). This study covered most of the community populations from different disciplines.

The main objectives of this research were to study patients' experience of the implementation of telemedicine and analyze the association between the demographic variable and telemedicine.

2. Literature Review

In the modern medical dictionary, telemedicine is simply defined as "the remote delivery of health care services" (Field. 1996). This refers to the delivery of healthcare services to people at home. There are three common types of telemedicine, which include but are not limited to store-and-forward telemedicine and remote patient monitoring (Alaboudi, et al. 2016).

Recent studies in Saudi Arabia have revealed the widespread use of telemedicine among health professionals in various hospitals (El-Mahalli, et al. 2012). An extensive review of the literature in the field of telemedicine in Saudi Arabia resulted in few publications on the identification of barriers and the challenges inherent to telemedicine (Greysen, et al. 2021). A study was conducted in the KSA in 2021 to assess the knowledge and perceptions of physicians about willingness to use telemedicine in the Riyadh region of Saudi Arabia (Albarrak 2021) The same was studied in the context of the COVID-19 pandemic in Riyadh, Saudi Arabia, through a cross-sectional survey in 2022. The questionnaire was distributed among 500 physicians who employed telemedicine in their practice between October 2021 and December 2021. This study revealed that 70% (n=254) of the responding physicians considered telemedicine consultations to be cost-effective. Regarding burnout, 4.1% (n=15), 7.5% (n=27), and 27.3% (n=99) of the doctors reported feeling burnout every day, a few times a week, and a few times a month, respectively (Sarah. et al. 2022). Another study reported four major concerns by various health professionals from four main hospitals in the KSA regarding the adaptation of telemedicine. These concerns were mainly patient privacy, the high cost of equipment, the lack of suitable training, and the lack of consultation between information technology experts and medical staff. All these stated factors are inconsistent with various published studies, and more studies need to be conducted in this field to fill the gap between the theoretical and practical implementation of telemedicine in the field (Idriss. et al. 2022).

According to our web search, there are few studies conducted among everyday citizens, except for two studies that were conducted among university students and faculty members. The findings of such studies cannot help solve the issue completely because university students and faculty members are recognized as well-educated and do not represent the whole community. These studies revealed that both students and faculty members do not trust telemedicine and insist that face-to-face medication is essential, especially when patients have severe symptoms or unfamiliar disorders. Another study conducted among 314 participants aimed to study the factors affecting the adoption and acceptance of e-health in the context of Saudi Arabia. The study showed that usefulness and privacy significantly affected the adoption of e-health. Furthermore, the perceived ease-of-use factor has an indirect effect on people's perception of e-health services. Furthermore, the results show that the quality and trust in the system are not influencing factors (Almazroi, et al. 2022).

Generally, telemedicine is the most preferred method for medical consultation and treatment because of easy access to a network of physicians from the largest group of hospitals, and because the independence and autonomy of patients increases by offering additional information and advice on medical issues.

2. Method

2.1 Study Design and Setting

This is a cross-sectional study conducted between October 2022 and September 2023. The study was designed to assess patients' experiences of the implementation of telemedicine. The sociodemographic characteristics of the participants were measured using a questionnaire adopted from the literature and modified to fit with the research questions.

2.2 Questionnaire development

The questionnaire evaluated patients' experience of the implementation of telemedicine, as well as their sociodemographic characteristics. They rated their experience using a 5-point Likert scale (agree, strongly agree, disagree, strongly disagree, and average).

2.3 Study population and sample size

According to the latest census in KSA (Saudi Statistics Authority in April 2021), the total number of Saudi citizens in Riyadh city is approximately 3,138,517 (females 1,633,322; males: 1,500,195). We adopted the opportunity sampling technique, with a confidence level of 96%, but the degree of freedom was adjusted to 0.4 instead of 0.5. The sample size was 332, which included both males and females. The sample size was calculated using the following formula:

$$S = Z^2XP(1-P)/M^2,$$

where: S = sample size for population, Z = critical value, P = population proportion (calculated to be 0.1), and M = Margin of error (set at 0.0025).

The participants were selected randomly from some health facilities that apply telemedicine services in Riyadh. A predesigned questionnaire was administered to the potential participants through direct contact or via email. Experts reviewed the questionnaire for the validity and reliability of all items. The questionnaire included closed questions regarding socio-demographic characteristics, type of services, and opinions on telemedicine services. The open-ended question was used to gather respondents' recommendations for improvement.

2.4 Data Analysis

The responses were recorded, validated, and analyzed using appropriate statistical software (SPSS 26). A descriptive analysis was conducted to obtain distributions of variables, central tendencies, frequencies, and proportions. An infernal analysis was conducted to measure the magnitude of the correlation between different variables and factors were analyzed using appropriate statistics tools to assess the association between variables.

2.5 Ethics Statement

The study was conducted per the Declaration of Helsinki and approved by the Institutional Review Board and Ethics Committee of Saudi Electronic University (SEUREC-220019-, 17.2.2022). Informed consent was obtained from all subjects involved in the study.

3. Results

The total sample included 332 patients from some hospitals in Riyadh City, representing various components of society. The response rate among males was high (81.3%; n=270), while only 18.7% (n=62) of females responded to the questionnaire (mean: 1.18). The average age of 24-34 years was predominant for both males (33.8%) and

females (35.5%). For the level of education, the descriptive data analysis showed that most of the males (128, 45.5%) and females (25, 8.9%) have bachelor's degrees.

Table 1: Characteristics of the study population (gender, age, and level of education).

Gender		Male		Female	
		Count	%	Count	%
Age	18–24	49	18%	10	16.1
	24–34	95	35%	22	35.5
	35–44	77	29%	22	35.5
	45–54	49	18%	8	12.9
	Total = 332	270	81%	62	19%
Education level	Post-graduate degree	28	10%	11	18%
	Bachelor's degree	118	44%	25	40%
	Secondary school	86	32%	18	29%
	Intermediate school	6	2%	1	2%
	Primary school	23	9%	5	8%
	Other	9	3%	2	3%

Table (2) presents the descriptive analysis (frequency) data. Only 118 (35.5%) of the respondents said that they used telemedicine services before, while 214 (64.5%) had no practical experience with telemedicine.

Table 2: Use of telemedicine services.

Use of telemedicine services	Frequency	Percent
Yes	118	35.5%
No	214	64.5%
Total	332	100.0%

Table (3) shows information on the purposes of using telemedicine as cited by the participants. About 19.5% of the participants said they used the services only for medical consultation, while 13.7% said they used it for diagnosis and treatment

Table 3: Purpose of using telemedicine services.

Purpose	Frequency	Percent
Medical consultation only	67	19.5%

Diagnosis and Treatment	47	13.7%
Other	4	1.2%
Total	118	35.5%

Table (4) shows the participants' opinions regarding the positive impacts of telemedicine in terms of saving time and money. Most of the participants chose average levels (14.0%), high (10.8%), and very high (6.1%).

Table 4: The positive impact of telemedicine on time and cost.

Likert scale	Positive impact of telemedicine on time		Positive impact of telemedicine on cost	
	Frequency	Percent	Frequency	Percent
Very high	22	19%	21	18%
High	45	38%	37	31%
Average	47	40%	48	41%
Low	2	2%	6	5%
Very low	2	2%	6	5%
Total	118	100%	118	100%

As shown in Table (5), a total of 127 (38%) respondents rated highly the negative effect of telemedicine on relationships between patients and doctors, compared to only 52 (16%) who chose a low effect.

Table 5: Effects of telemedicine on the doctor–patient relationship

Effects of telemedicine	Frequency	Percent
Very high	42	13%
High	127	38%
Average	96	29%
Low	52	16%
Very low	15	5%
Total	332	100.0

The main barriers that limit the use of telemedicine services according to the respondents are 1) lack of confidence in accessing telemedicine (20%), 2) difficulty in communicating due to different languages and dialects (32%), 3) service being unsuitable for uneducated people (31%). Many of them believe that communication and Internet services will not be a major obstacle when using telemedicine.

Table 6: Main barriers to the use of telemedicine services:

Responses	Lack of confidence in accessing telemedicine		Difficulty in communicating due to different languages and dialects		The service is not suitable for uneducated people		Lack of or weak Internet connections	
	frequency	Percent	Frequency	Percent	frequency	Percent	frequency	Percent
Very high	66	20%	106	32%	101	31%	89	27%
High	123	38%	128	39%	127	38%	90	27%
Average	83	25%	77	23%	64	19%	57	17%
Low	42	13%	11	3%	27	8%	44	13%
Very low	13	4%	10	3%	11	3%	52	16%

Total	327	98%	332	100%	330	99%	332	100%
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4. Discussion

The study aimed to assess the patient experience of the implementation of telemedicine in Saudi Arabia (Riyadh City). A total of 332 male and female participants agreed to participate. The response rate among males was high (81%; n=270), while only 19% (n=62) of females responded (Table 1). This phenomenon was studied in research titled “Comparison of Web and Telephone Survey Response Rates in Saudi Arabia”, which revealed that the males have a significantly higher response rate (51.51) average to research questionnaire than females (15.09) (P-value = 0.035) (Ali. 2008). No more evidences were found to justify female’s reluctance to fill out the questionnaire, except that we attribute this to some social factors, as Saudi society is largely conservative and it is not easy to involve females in community studies.

The average age of 24-34 years was predominant for both males and females, with percentages of 35% and 35.5%, respectively. For the level of education, the descriptive data showed that most of the males and females have bachelor’s degrees (118, 44%), (25, 40%), respectively (Table 1). Our descriptive analysis shows that only 118 (35.5%) of the respondents used telemedicine services, while 214 (64.5%) had no practical experience with telemedicine (Table 2). This result is similar to the results of a previous study conducted in the KSA in 2021, which showed that only 33% of the participants had used telemedicine services systems before (Alajwari, et al. 2022).

A total of 67 (19.5%) participants said that they used the services only for medical consultation, while 47 (13.7%) (Table 3) said that they used it for diagnosis and treatment. This result is different from those of a study conducted in December 2020 in Saudi Arabia, which showed that 305 (77.8%) conducted routine (live) patient consultations since the start of the pandemic (the period was approximately two months), while 228 (58.1%) had used some form of telemedicine (other than standard phone calls) during the COVID-19 pandemic (Greive. 2020).

Most of the respondents believed that telemedicine has a positive impact on reducing costs and saving time, as shown by the Likert scale rating of very high (6.4%), high, and average (Table 4). Similarly, some previous studies have suggested that telemedicine is an accessible and convenient tool that reduces costs and travel time (Bokolo, 2020, Abdel Nasser, et al. 2021, Vidal, et al. 2020 and CDC. 2020)]. The results are comparable to another study indicating that telemedicine can reduce unnecessary outpatient visits (87.5%) (Feroze, et al. 2020).

Approximately 38% of the respondents gave a high score for the negative effect of telemedicine on relationships between patients and physicians, compared to 16% who chose a low effect (Table 5). An early report titled “Telemedicine and the Provider-Patient Relationship: What We Know So Far” by Edward Alan Miller in the USA concluded that telemedicine may impact trust, which can facilitate patient disclosure and cooperation. It may also influence the extent of patient and physician participation during medical encounters, either facilitating movement toward patient-centered and consumerist patterns or reinforcing traditional paternalistic patterns (MacDonald, et al. 2022). Our results are similar to those of a recent study conducted in three National Patient-centered Clinical Research Network sites in New York City, North Carolina, and Florida, which revealed that a virtual environment (telemedicine) affects the quality of interpersonal relationships between patients and providers by limiting feelings of connectedness (Andreadis, et al.2023).

According to this study’s participants, the main barriers that limit the use of telemedicine services, as presented in Table (6), are lack of confidence in accessing telemedicine (20%), the difficulty in communicating due to different languages and dialects (32%), the service being unsuitable for uneducated people (31%). Many of them believe that communication and Internet services will not be a major obstacle when using telemedicine. (Rivara. et al 2011).

A similar study showed that technological limitations (66.6%) and concerns about diagnostic reliability (66.1%) were the main barriers (Feroze, et al. 2020). Other barriers, such as provider-patient relationships, medical liability,

prescription of controlled substances, and others, were mentioned in scientific papers published in 2020 (Gajarawala and Jessica, 2021) In a KSA study conducted in 2016 that involved 905 respondents, 11 barriers were highlighted to be the most significant in the KSA context. The top three influential barriers were the availability of adequate sustainable financial support, ensuring the conformity of telemedicine services with the core mission, vision, needs, and constraints of healthcare facilities, and reimbursement for telemedicine services (Abdel Nasser, et al. 2021).

5. Conclusion

Telemedicine has a good opportunity to provide fast, low-cost, affordable, and high-quality medical services in Saudi Arabia. More efforts should be made to provide healthcare institutions and practitioners with the necessary technical equipment and training. Furthermore, improving knowledge about telemedicine among the population can develop positive perceptions and good attitudes.

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Prioritizing Nigeria's Healthcare Needs through a Systematic Assessment: A Case Study of The Federal Capital Territory (Abuja), Nigeria

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Abstract

Solving health problems from a communal perspective remains the most effective way to attain better health systems and indices in society. Nigeria and most other African countries, amidst dwindling health funding, exploding population, rising cost of living, and declining living standards, should be more disposed to adopting this approach because it allows wider access while addressing the issues of inequality, inequity, and discrimination. A population's health needs are best addressed when there is a better understanding of the population and environmental demographics. This work aims to demonstrate the use of systematic health needs assessment in prioritizing health interventions in resource-limited settings like Nigeria using the Federal Capital Territory as a case study. The author applied profiling of population characteristics, health status, and local health determinant factors to identify priority health needs of the Federal Capital Territory of Nigeria. The result showed that the targeted population had poor health status and indices, such as health insurance coverage, available skilled personnel, neonatal and children under-five health mortality and morbidity rates, quality of life, and health-related injuries. Behavioural measures, health inequalities, local health determinant factors such as employment and work data and environmental hygiene, and national priorities were also considered. The study systematically assessed and discussed the priority health needs of the targeted population. Improving health access and promoting equity through mandatory health insurance, and a focus on reproductive, maternal, neonatal and child's health were identified as priority health needs to improve the health of the population.

Keywords: Public Health, Health Needs Assessment, Federal Capital Territory, Nigeria, Health Insurance

1. Introduction

The World Health Organisation describes 'health' as not only the absence of illness but a state of physical, mental, and psychological or social wellness (WHO, 1948, cited in Donaldson and Rutter, 2018, p. 1). A convergence of knowledge of the history of human existence and the spread of diseases among a large group of people in a population uncovered the relationship between diseases and the people's way of life in the 18th and early 19th centuries (Perdiguero et al., 2001). With increased systematic knowledge, it has become increasingly evident that solving the health problems of a population is more effective from a communal standpoint, which considers the complexity of the way of life of the individuals or groups in society (Perdiguero et al., 2001). This communal approach to solving health issues from which the concept of 'Public Health' derives, aims to protect, improve, and

promote the health and well-being of the population to effectively and efficiently promote the health of the individuals (Wilson et al., 2015). Public health actions seek to prevent diseases and minimize exposure to environmental and social hazards, rather than allow illness to occur, and then diagnose and/or treat. Hence, its main goal is to promote well-being by addressing the determinants of health and health outcomes (Bowling, 2005).

Health outcomes are transformations in health and wellbeing, such as prevention of death or improvement in the quality of life and wellbeing, as a consequence of deliberate actions taken (CIHI, 2022). Studies have shown that the health of individuals or groups is influenced by genetics, environment, and social conditions in which the individual or group is born, grows up, lives, works, and ages (Donaldson and Rutter, 2018). The length of exposure to different environmental and social conditions is the cause of social gradients, and health inequalities (Braveman and Gottlieb, 2014). The distinctive features of a good health system are 'a healthy population' with the best possible level of wellbeing; 'quality care' that is contextual and efficient; and non-discriminatory to all members of the community across age, race, and status (Finberg, 2012, p.1). Studies have shown that a good and sustainable health system is difficult to realize in a highly discriminatory community (Manderbacka et al., 2014, p. 1). Public health seeks to achieve a sustainable health system by minimizing health inequalities and inequities (Wilkinson, Marmot and WHO, 2003).

The health needs of any particular group or population could be determined if the health status and determinants of health are known (Swain, 2016). Evidence has shown a correlation between socioeconomic status (in education, employment/occupation, and income) and health outcomes, such as life expectancy, mortality, and morbidity (Wilkinson, Marmot and WHO, 2003). For instance, income levels will most often determine neighborhood of residence, and nutrition and these factors could determine exposure to illnesses, and disease incidence. Health needs assessment (HNA) is a public health framework used to describe the health status of people in a particular community or group and identify the health risks, causative factors, and health priorities (WHO, 2001). A good HNA helps influence policy decisions, in line with the principles of the Ottawa Charter Declaration on building a healthy public health policy (Kemmer, Parry, and Palmer, 2004; WHO, 2022).

Contemporary HNA methods involve profiling the population, identifying health conditions and the determinants of health, identifying health priorities, preparing a plan of action and reviewing and evaluating the plan of action. This article attempts to conduct a health needs assessment for the Federal Capital Territory (FCT), Abuja, Nigeria (Figure 1), as a case study. Due to the dearth of reliable demographic data at the district level, the data used in the HNA were from the state and country levels. Unless otherwise stated, data presented in the HNA were mainly from the 2018 national demographic health survey report by the National Population Commission (NPC) and ICF (2019).

2. Methodology

The health needs assessment of FCT was based on the existing data on the population characteristics and health indices.

2.1 Population Characteristics

2.1.1 Geography

The Federal Capital Territory (FCT) located in North Central Nigeria, has a land area of about 7,315 km². Its geographic coordinate is 8°49'59.99" N 7°10'0.01" E. The Territory is administered by a Minister who is an appointee of the President (Grid³ Nigeria, 2022; Latitude.to, 2025).



Figure 1: Map of Federal Capital Territory (FCT)

Source: Medugu (2012)

2.1.2 Population Numbers and trends

The World Population Review (2022) reports that the Abuja population is estimated to be 3,652,029, with an annual growth rate (AGR) of 5.42%. This represents 1.67% of the country's population. According to National Bureau of Statistics (NBS, 2019 and 2021) data, the Life Expectancy (LE) at birth was 52 years and 49 years for FCT and the country, respectively, in 2016 (Table 1). Recent World Bank data gives the LE of Nigerians as 55 years (The World Bank, 2020). The LE for FCT may have also increased commensurably. As the nation's capital and seat of political power, the FCT experiences an influx of people, refugees, and tourists. Hence, its growth rate is over twice the national figure of 2.41%. Though the growth rate was projected to be on the decline over the last ten years (World Population Review, 2022), the reality seems otherwise as the city continues to witness a daily influx of internally displaced persons (IDP) due to various forms of socioeconomic, sociopolitical and sociocultural, and environmental hazards, such as flood and insecurity (Bashir et al., 2021).

Table 1: Life Expectancy at birth (2016)

Population	Life Expectancy at birth (years)		
	Female	Male	Both Gender
FCT	55	50	52
Nigeria	51	47	49 (55 in 2020)

2.1.3 Age and Gender Distribution

The 2006 Census data showed that the FCT population was made up of 47.9% females and 52.1% males (City Population, 2022). The 2018 data for Nigeria were 54% female and 46% male (NPC and ICF, 2019). The age distribution is believed not to have changed significantly (Table 2).

Table 2: Percent Age distribution (based on 2006 census)

Age Group	% Population		
	FCT (2006)	Nigeria (2006)	Nigeria (2018)
0-14	38.1	41.83	46.0
15-64	60.4	54.95	50.1
65+	1.5	2.18	3.9
Total	100	100	100

2.1.4 Ethnicity and Religion

Abuja is home to people from diverse backgrounds and ethnic origins in Nigeria. The Gbagyi (or Gwari) are the major indigenous settlers. Other settlers include Gade, Gwandara, Koro, Egbura, Gangana, and Bassa (Medugu, 2012). The two major religions, Islam (50%) and Christianity (40%), dominate other religions (World Population Review, 2022).

2.1.5 Language and Literacy

The official language of Abuja city is English, while other languages like Gbagyi, Nupe, Gbari, Gede, and Hausa are widely spoken (Media Nigeria, 2018). The National Population Commission (NPC, 2015) report for FCT put the total literacy rate at 59%, and that of the country at 47%. The total literacy rates by gender and residence, and age groups are depicted in Tables 3, respectively, while Table 4, on education, gives the school attendance ratios, and gender parity ratios (NPC and ICF, 2019).

Table 3: Total Literacy Rate (%) by gender in urban/rural dwelling, and by age groups

Gender	Urban	Rural	Urban	Rural
	Female	Male	Female	Male
Total Literacy Rate	73	38	80	62
Age groups:				
20-40	57		70	
41-60	57		67	
61>	42		38	

Table 4: Education

FCT Schools	NAR			GPI	GAR			GPI
	Male	Female	Total		Male	Female	Total	
Primary	75.0	74.5	74.8	0.99	104.9	103.8	104.4	0.99
Secondary	61.1	60.1	60.6	0.98	97.2	87.8	92.4	0.90

Key: NAR is Net Attendance Ratio; GPI is Gender Parity Index; GAR is Gross Attendance Ratio.

2.2 Health Status of the Population

2.2.1 Health Insurance and Personnel

Only about 2.6% of women and 3.4% of men, ages 15-59, in Nigeria have a form of health insurance. The figures for the North Central are 2.4% and 4.5% for women and men, respectively (NPC and ICF, 2019). Nigeria's skilled health personnel population of 1.83 per 1000, which is estimated to also apply to FCT, is grossly below the WHO recommendation of 4.45 per 1000 in 2018 (Olatunji et al., 2024).

2.2.2 Birth Rate

The total fertility rate (TFR) for FCT is 4.3 for women ages 15-49, while the national figure is 5.3 children per woman. On average, it is estimated that rural women have 1.4 more children than urban women (NPC and ICF, 2019).

2.2.3 Mortality Data

The 2018 NHDS reported a neonatal mortality rate (NMR) of 27, post-neonatal mortality rate (PNMR) of 20, infant mortality rate (IMR) of 46, child mortality rate (CMR) of 30, and under-5 mortality rate (U5MR) of 75, deaths per 1000 live births for FCT between 2013 and 2018 (NPC and ICF, 2019). The maternal mortality rate (MMR) in 2016 was 83.6 per 100,000, which was the lowest in the country (NBS, 2019).

2.2.4 Morbidity Data

Under-five children's fever and diarrhoea morbidities are 23.3% and 8.2%, respectively. Among children 6-59 months, anaemia is 58.8%, while malaria is 33.4% and 21.8% by rapid diagnostic test (RDT) and microscopy, respectively. The prevalence of sickle cell trait and disease among children ages 6-59 months is 19.4% and 0%, respectively, which is lower than the national figure of 20% and 1%, respectively (NPC and ICF, 2019). The prevalence of sickle cell disease in the north-central zone of Nigeria, which includes FCT, is about 5% (Adigwe et al., 2023).

2.2.5 Health-related Injury

About 5.1% of FCT women aged 15-49 are circumcised. This is far below the national average of 20%, which has decreased from 25% in 2013 (NPC and ICF, 2019). Female genital mutilation (FGM), though on the decline, is a cultural practice in many parts of the country, and it is not directly promoted by the major religions (Okeke, Anyaehie, and Ezenyeaku, 2012).

2.2.6 Behaviour Measures

2.2.6.1 Tobacco use – Although FCT-specific data are not available, the 2018 NHDS revealed that about 94.2% of men and 99.4% of women aged 15-49 in Nigeria do not smoke any form of tobacco (NPC and ICF, 2019).

2.2.6.2 Marital behaviour – About 70% of women and 57% of men aged 15-49 in Nigeria are currently in a union. Most of the Muslim population in FCT practice polygamy (NPC and ICF, 2019).

2.2.7 “Quality of Life” measures

Table 5 shows the FCT indices for “quality of life”, which is generally adjudged low (Numbeo, 2022).

Table 5: Quality of life index

Quality of life index	Score	Rating
Purchasing power	4.84	Very Low
Safety	42.87	Moderate
Health care	56.13	Moderate
Climate	79.42	High
Cost of living	36.05	Very Low
Property price to income	351.11	Very High
Traffic commuter time	23.67	Very Low
Pollution	57.70	Moderate

2.2.8 Use of Service Information

The data on use of services depicted in Table 6 shows that there are considerable gaps to be covered against the WHO-recommended principle of universal health coverage (UHC), which requires that everyone receives the needed health care whenever and wherever it is needed (WHO, 2025).

Table 6: Use of service information

Indices	Amount
% Children with all basic vaccinations	49.6
% All age appropriate vaccinations	40.1
% Women age 15-59 accessing ANC from professional caregivers	87.7
% Women who received a sufficient number of tetanus toxoid injections to protect their newborn against neonatal tetanus	70.8

2.2.9 Health Inequalities

General inequalities exist between urban and rural dwellers, especially in literacy (Table 3) and access to internet networks (NPC and ICF, 2019). Health digital literacy is fast becoming an indicator of socioeconomic status,

which is one of the major determinants of health (Estrela et al., 2023; Jing et al., 2024; Svendsen et al., 2020; Zhao et al., 2024).

2.2.10 Local Factors Affecting Health

2.2.10.1 Work and Employment: There is no FCT-specific data. The 2018 DHS data show that 47.9 % of women are employed, 5.4% are unemployed, while about 46.6 % of women have been unemployed in the last 12 months preceding the survey. The data for men were 74.8 %, 2.5% and 22.8%, respectively.

2.2.10.2 Environment and Sanitation: According to NPC and ICF (2019) report, 65.6% of FCT households have access to basic drinking water services, while about 2.7% have limited access. About 29.8% of FCT residents practice open defecation compared to other parts of North-Central (51%) and North-West (9%). Only 41% have access to basic sanitation services, while 27.8% have limited access (NPC and ICF, 2019).

2.3 Local and National Priorities

The country has developed several policy frameworks aimed at improving the service coverage index (SCI) and/or the Universal Health Coverage (UHC) index toward achieving SDG target 3.8 (Eozenou et al., 2023). The most important provision in the National Health Act (NHA) 2014 is the Basic Healthcare Provision Fund (BHCPF), and Basic Minimum Package of Care (BMPC) for citizens to be implemented through the National Health Insurance Scheme (NHIS). In a bid to improve health coverage through more affordable access, the National Health Insurance Authority (NHIA) Act, which repeals the NHIS Act, was signed into law in 2022. The FCT health policy framework relies on the National Health Act 2014, NHIA Act 2022 and the FCT Health Insurance Agency Establishment Act (passed by the Senate in 2020 but awaiting Presidential assent) to develop a framework for the utilization of the Basic Healthcare Provision Fund (BHCPF) for its vulnerable group and increase health access through the FCT Health Insurance Scheme in compliance with the provisions of the NHIA Act (Agbaoye, 2022; FCT Health and Human Services Secretariat, 2019). The target is to improve health outcomes by improving access and quality of health care.

3. Understanding the information collected

The information collected from the population profile revealed the following health-related needs.

- i. **Health insurance:** About 97.6% of women and 95.5% of men aged 15-59, in FCT have no health insurance. Hence, the burden of out-of-pocket payments for health care will be a great hindrance to access to health care services.
- ii. **Birth control:** The territory has a lower birth rate of 4.3% compared to the national average of 5.3%. About 73.8% did not use any form of contraceptive in the year 2016/17 (NBS, 2019).
- iii. **Infant and Child's care:** The NMR, PNMR, IMR, CMR, and U5MR are in dire need. According to the Population Reference Bureau (PRB), the IMR for Nigeria is 58%, and it is among the worst in the world (PRB, 2022).
- iv. **Maternal care:** The poor statistics on the adult mortality rate for women of reproductive age groups; age 30-34 (3.24) and age 35-39 (4.01), are an indication of the need for better maternal care (NPC and IFC, 2019).
- v. **Environment sanitation and hygiene:** Access to basic drinking water in FCT is about 65.6%, while 29.8% of the people still practice open defecation. These services are poor, and the rate of improvement is slow and needs to be strengthened.
- vi. **Education:** The NAR for school children in FCT is generally low for both genders. The territory being the nation's capital should aim at achieving NAR of over 90 for both genders in both primary and secondary schools.

3.1 Deciding on Priorities

Lack of access to health through health insurance affects a very large portion of the population. However, with improved enrolment into the FCT Health Insurance Scheme by the FCT Health Insurance Agency (FCTHIA), the situation is expected to improve. There is a need to deliberately target reproductive, maternal, newborn and child health, which also has very low indices.

3.2 Planning for Action

Access to health care is inevitably poor in the territory due to multidimensional poverty. Health actions with the most probable impacts in poor societies, such as FCT/Nigeria, should promote increased access, better reproductive, maternal, newborn and child health, and improved environmental hygiene and sanitation. A better education net attendance ratio could help improve health access through more effective health communication and promotions.

3.2.1 Increasing health access, and hygiene and sanitation

Citizens' enlightenment and sustainable health funding through insurance will enable better access to health. The NHIA Act provides for mandatory health insurance and a uniform basic minimum package of care, which, if effectively implemented by the FCTHIA, will provide the leverage for better health access and coverage. The NHIA and FCTHIA operational framework must incorporate health education and enlightenment to promote environmental hygiene and sanitation, as well as improved nutrition, to address stigmatization, discrimination, fears, and ignorance, and promote healthy environmental practices. The framework should incorporate a social welfare program to reduce the negative impact of unemployment and poverty. Special schemes should be created to improve access to reproductive, maternal, newborn, and child health.

4. Conclusion

Recent statistics from the International Bank for Reconstruction and Development (IBRD) and the World Bank (2022), estimate that about 40% of Nigerians live below the poverty level of \$1.93 per day (p. 12-13), and only about 17% of workers earn wages capable of lifting people out of poverty. Hence, most people are not able to afford quality healthcare services. A mandatory health insurance scheme will promote access to health and improve health outcomes. The NHIA Act provides for mandatory coverage through the State Health Insurance Agencies (SHIA), and in this case, FCTHIA. However, more community-level advocacy and sensitization need to be undertaken for active citizens' participation and ownership. The HNA of FCT reveals an enormous gap in health access due to unemployment and poverty. The situation is compounded by huge out-of-pocket health expenses due to limited access to health insurance. Improving quality healthcare for reproductive, maternal, newborn and child health, and health access for the now over four million population, will depend on having access to health insurance.

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Prevalence and Determinants of Upper Extremity Repetitive Strain Injuries (RSI) Among Handloom Weavers in Tangail District, Bangladesh

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Abstract

Background: Handloom weaving is a critical source of rural employment in Bangladesh but entails high ergonomic risk, predisposing workers to upper extremity repetitive strain injuries (RSIs). Evidence on prevalence and determinants of RSIs in Bangladeshi handloom workers is limited. **Objective:** To determine the prevalence, anatomical distribution, and predictors of upper extremity RSIs among handloom weavers in Tangail district. **Methods:** A community-based cross-sectional study was conducted among 303 male handloom workers in Pathrail Union, Delduar Upazila. Data were collected via structured interviews and the Standardized Nordic Musculoskeletal Questionnaire. Socio-demographic, occupational, and ergonomic factors were assessed. Logistic regression identified independent predictors of RSIs. **Results:** The prevalence of RSIs was highest in the neck (60.7%), shoulders (56.8%), and wrists (55.8%). Repetitive movements ≥ 4 hours/day, awkward posture, prolonged working hours, low income, and limited education were independently associated with RSIs. Prevalence increased with years of experience: 58.7% (<10 years), 72.2% (10–20 years), and 85.9% (>20 years). Severe cases often required job modification and had multi-site involvement. **Conclusion:** Upper extremity RSIs are highly prevalent among Bangladeshi handloom workers, reflecting a combination of ergonomic strain and socio-economic vulnerability. Interventions targeting workplace ergonomics, work hours, and socio-economic support are essential to safeguard worker health and sustain the handloom sector.

Keywords: Handloom Weaving, Repetitive Strain Injury, Upper Extremity, Ergonomics, Bangladesh

1. Introduction

The handloom industry in Bangladesh is more than an economic enterprise; it is a living archive of cultural heritage, tradition, and the livelihoods of millions. As the second-largest source of rural employment after agriculture, the sector directly supports approximately 1.5 million weavers, dyers, and artisans, with another half-million dependent on it indirectly (Bangladesh Bureau of Statistics [BBS], 2020; Ahmed et al., 2021). Deeply rooted in the rural socio-economic fabric, handloom weaving provides a vital non-agricultural safety net, particularly in northern districts such as Tangail, a nationally recognized weaving hub (Pande, n.d.; Rahman et al.,

2018). The iconic muslins, jamdanis, and vibrant sarees produced on these looms not only contribute significantly to the national economy but also represent an enduring symbol of Bangladesh's identity and artistry (Fatema, 2023).

Yet, the preservation of this heritage comes at a steep human cost. The very characteristics that define handloom weaving—manual precision, repetitive motions, and prolonged static postures—expose workers to serious occupational hazards. Unlike automated power looms, handloom weaving demands sustained neck and back flexion, repetitive upper-limb movements, and constant force application, creating an environment rife with ergonomic risks (Choobineh et al., 2007; Ghosh et al., 2011). These conditions predispose workers to a spectrum of work-related musculoskeletal disorders (WMSDs), particularly repetitive strain injuries (RSIs) of the neck, shoulders, elbows, wrists, and upper back (Punnett & Wegman, 2004). For many weavers, financial precarity, limited education, and restricted bargaining power intensify this vulnerability, forcing them to endure pain in order to survive—an endurance that perpetuates both ill health and poverty (Liu et al., 2023; World Health Organization [WHO], 2019).

Evidence from global weaving communities underscores the universality of this problem. Studies among Iranian carpet weavers report strikingly high musculoskeletal symptom prevalence, particularly in the shoulders (46.9%), lower back (42.2%), and wrists (36.5%) (Choobineh et al., 2007). Similar patterns emerge in India, where weavers in West Bengal show high rates of low back pain linked to prolonged sitting and years of experience (Das & Ghosh, 2011). Comparable findings have been reported from Ethiopia and Pakistan, where awkward postures, long working hours, and repetitive tasks drive disability and chronic pain among informal weavers (Geto et al., 2025; Fan et al., 2022). Collectively, these studies confirm that the biomechanical demands of weaving, across diverse cultural contexts, consistently generate high musculoskeletal morbidity.

Bangladesh-specific evidence paints a similar picture. Studies document a high prevalence of pain among weavers, particularly in the lower back, knees, and shoulders (Koiri, 2020; R et al., 2024). A study in North Bengal reported that 69.2% of weavers experienced musculoskeletal pain, most commonly in the knees (46.8%) and lower back (42.6%) (Tavakkol et al., 2020). However, existing research is limited in scope. Few studies focus specifically on upper extremity RSIs, which represent a critical subset of injuries directly linked to weaving mechanics. Addressing this gap requires granular analysis of anatomical sites, functional impairment, and the socio-demographic and ergonomic determinants of injury.

This study, therefore, sought to provide a detailed epidemiological profile of upper extremity RSIs among handloom weavers in Tangail district of Bangladesh. The study aimed to determine the prevalence and severity of RSIs in different upper body regions, identify both ergonomic (such as repetitive motion and awkward posture) and socio-economic (such as income and education) risk factors that predict these injuries, and examine the cumulative impact of years of work experience on the progression and chronicity of RSIs. By moving beyond prevalence estimates to deeper causal understanding, the study intends to generate evidence that can inform targeted, culturally appropriate ergonomic interventions and policy responses ultimately safeguarding the health and productivity of Bangladesh's weaving communities.

2. Methodology

2.1. Study Design and Setting

The research employed a community-based, descriptive cross-sectional study design aimed at quantifying the prevalence and associated determinants of upper extremity repetitive strain injuries (RSIs) among handloom workers. The study was situated in Pathrail Union, Delduar Upazila, Tangail District, Bangladesh, an area historically renowned as a major hub of the traditional handloom weaving industry. Pathrail Union encompasses a land area of 18.97 km² and, according to the Population and Housing Census of 2011, has a population of 31,803. Its proximity to Dhaka (approximately 82.7 km) and socio-economic reliance on handloom weaving justified its selection as the study site.

2.2. Study Population and Eligibility Criteria

The study population consisted of male handloom workers aged ≥ 18 years actively engaged in weaving during the study period (September 2021 to November 2021)

- **Inclusion criteria:** (i) individuals with at least one year of continuous employment in handloom weaving, (ii) permanent residents of Pathrail Union, and (iii) those providing informed consent.
- **Exclusion criteria:** (i) workers with acute upper limb trauma unrelated to occupational exposure, (ii) individuals unwilling to participate, and (iii) workers temporarily absent during the data collection period.

2.3. Sample Size Determination

The sample size was calculated using the single proportion formula. The resulting sample size was 384, which, after accounting for a 10% non-response rate, yielded a target of 422 participants. However, due to operational constraints arising from the COVID-19 pandemic, including limited field mobility and adherence to a 22-day data collection mandate set forth by Bangladesh Medical University (BMU), the final feasible sample size was 303 respondents.

2.4. Sampling Frame and Distribution

Participants were selected from multiple villages within Pathrail Union to ensure representativeness:

- Bishnupur (n = 20)
- Chandi (n = 83)
- Krishnanagar (n = 77)
- UP Road (n = 30)
- Sutradhar Para (n = 25)
- Gain Para (n = 4)
- Puraton Pathrail (n = 40)
- Uttar Nalua (n = 24)

Two primary loom categories were represented: pit loom workers (n = 255, 84.2%) and Chittaranjan loom workers (n = 48, 15.8%).

2.5. Data Collection Procedure

Data collection was undertaken by the principal investigator, ensuring standardization of administration and minimizing inter-observer variability. Interviews were conducted in the daytime working hours at the respondents' worksites to avoid disrupting productivity.

A structured interviewer-administered questionnaire, adapted from existing occupational health research tools and contextualized for the Bangladeshi weaving industry, was used. The questionnaire comprised three modules:

1. **Socio-demographic characteristics** – age, marital status, religion, educational attainment, monthly income, family type, and household size.
2. **Occupational and ergonomic factors** – loom type, years of weaving experience, daily working hours, posture, rest periods, overtime, work station design and ergonomic risk exposures.
3. **Musculoskeletal morbidity** – evaluated using the Standardized Nordic Musculoskeletal Questionnaire (SNMQ), a validated instrument widely employed in occupational health epidemiology.

The questionnaire was pre-tested among 30 handloom workers in a non-study union to verify clarity, comprehensibility, and cultural appropriateness. Minor modifications were introduced in terminology and sequencing based on pilot feedback.

2.6. Ethical Considerations

Prior to the initiation of the study, ethical approval was obtained from the Institutional Review Board (IRB) of the National Institute of Preventive and Social Medicine (NIPSOM) (Reference No.: NIPSOM/IRB/2021/18, Date: 13 December 2021). All procedures adhered strictly to the principles outlined in the Declaration of Helsinki (2013 revision), and national ethical guidelines applicable to health research in Bangladesh. Informed consent was obtained from each participant following a clear explanation of the study's purpose, procedures, potential risks, and benefits. Written consent was secured through signed forms, while participants with literacy limitations provided thumb impressions in the presence of a witness. Confidentiality and anonymity were assured through the assignment of unique identification numbers, and no personally identifiable information was stored or disclosed.

3. Results

3.1. Socio-demographic characteristics of participants

A total of 303 handloom workers were surveyed (Table 1). The majority were either below 30 years (32.3%) or between 30 and 39 years (28.1%), indicating a predominantly young and middle-aged workforce. Over two-thirds (64.7%) reported a monthly income of less than BDT10,000, indicating considerable socioeconomic vulnerability. Educational attainment was low, with 41.9% having completed primary education or less. Family size was most commonly 4–6 members (46.9%). In terms of work experience, 39.9% had <10 years, 32.0% had 10–20 years, and 28.1% had >20 years in the industry, suggesting both an influx of younger workers and a significant segment with long-term cumulative exposure.

Table 1: Socio-demographic characteristics of handloom workers (N = 303)

Characteristic	Category	n	%
Age group	<30 years	98	32.3
	30–39 years	85	28.1
	40–49 years	67	22.1
	≥50 years	53	17.5
Monthly income	BDT 6,000	92	30.4
	BDT6,000–BDT10,000	104	34.3
	>BDT10,000	107	35.3
Education level	≤Primary	127	41.9
	Secondary	102	33.7
	≥Diploma	74	24.4
Family size	1–3 members	107	35.3
	4–6 members	142	46.9
	≥7 members	54	17.8
Work experience	<10 years	121	39.9
	10–20 years	97	32.0
	>20 years	85	28.1

3.2. Prevalence and distribution of upper extremity RSI

The prevalence of upper extremity repetitive strain injuries (RSI) was high across multiple body regions (Table 2). The neck (60.7%), shoulder (56.8%), and wrist (55.8%) were the most affected sites, followed by the upper back (34.3%) and elbow (30.4%). Severe cases defined as pain lasting more than 7 days or requiring job modification were particularly common in the wrist (62 cases) and neck (67 cases). Functional impact was substantial, with a high overlap between severe cases, work reduction, and medical consultation, especially for wrist-related symptoms.

Table 2: Prevalence of upper extremity RSI by body region (N = 303)

Body region	Prevalence n (%)	Severe cases* n	Work reduction n	Medical consultation n
Neck	184 (60.7)	67	58	49
Shoulder	172 (56.8)	59	52	44
Wrist	169 (55.8)	62	61	53
Elbow	92 (30.4)	31	27	24
Upper back	104 (34.3)	38	33	29

*Severe = pain >7 days or requiring job modification.

3.3. Association between ergonomic risk factors and RSI

Work-related ergonomic exposures were strongly associated with RSI prevalence (Table 3). Repetitive movements for ≥ 4 hours/day were significantly associated with neck (78.3%), shoulder (74.6%), and wrist (81.5%) symptoms ($p < 0.001$). Neck RSI was particularly associated with bending/twisting movements (85.4%), while wrist RSI was linked to repetitive flexion or twisting (89.2%). Shoulder symptoms were significantly higher among workers performing tasks with arms elevated above shoulder height (68.6%, $p = 0.003$). Awkward postures and overtime work were also correlated with increased risk across all major anatomical sites (all $p < 0.001$).

Table 3: Association between work-related risk factors and RSI prevalence (N = 303)

Risk factor	Exposed n	Neck RSI %	Shoulder RSI %	Wrist RSI %	p-value†
Repetitive movements (≥ 4 hr/day)	254	78.3	74.6	81.5	<0.001
Bending/twisting neck	287	85.4	–	–	<0.001
Bending/twisting wrist	279	–	–	89.2	<0.001
Arm above shoulder	137	–	68.6	–	0.003
Awkward posture	192	71.9	67.2	65.1	<0.001
Overtime (≥ 2 hr/day)	187	69.5	64.7	71.7	<0.001

†Chi-square test.

3.4. Predictors of upper extremity RSI

Multivariate logistic regression analysis identified several independent predictors of RSI (Table 4). Repetitive movements remained the strongest predictor (AOR = 4.27, 95% CI: 2.89–6.31, $p < 0.001$), accounting for 38.2% of the population attributable risk (PAR). Prolonged working hours (> 10 /day) were also significant (AOR = 3.18, 95% CI: 1.92–5.27), as was low monthly income ($< 6,000$; AOR = 2.76, 95% CI: 1.64–4.65). Additional predictors included awkward posture (AOR = 2.43), low education (AOR = 2.15), and overtime ≥ 2 hours/day (AOR = 1.98). Collectively, these findings highlight a combined effect of physical workload, socioeconomic vulnerability, and limited ergonomic awareness.

Table 4: Multivariate logistic regression predictors of upper extremity RSI (N = 303)

Predictor	Adjusted OR	95% CI	p-value	PAR%
Repetitive movements	4.27	2.89–6.31	<0.001	38.2
Working hours > 10 /day	3.18	1.92–5.27	<0.001	27.5
Monthly income $< 6,000$	2.76	1.64–4.65	0.001	22.1
Awkward posture	2.43	1.51–3.91	0.002	18.7
Low education ($\leq$ Primary)	2.15	1.28–3.61	0.009	15.3
Overtime ≥ 2 hr/day	1.98	1.22–3.22	0.012	12.6

*PAR = Population Attributable Risk.

3.5. RSI prevalence by work experience

The prevalence and severity of RSI increased markedly with years of service (Table 5). Workers with <10 years of experience had an overall RSI prevalence of 58.7%, while those with 10–20 years and >20 years recorded 72.2% and 85.9%, respectively. Long-term workers (>20 years) also exhibited higher rates of multi-site involvement (78.8%) and chronicity (54.1%), along with the greatest proportion requiring job modification (42.4%). These trends indicate a clear dose–response relationship between cumulative ergonomic exposure and musculoskeletal morbidity.

Table 5: RSI patterns by work experience (N = 303)

Work experience	RSI prevalence %	Multi-site RSI‡ %	Chronic§ %	Job modification %
<10 years	58.7	41.3	22.3	18.2
10–20 years	72.2	63.9	37.1	29.9
>20 years	85.9	78.8	54.1	42.4

‡Multi-site = ≥2 affected body regions.

§Chronic = symptoms >90 days

4. Discussion

This study reveals a workforce in crisis: handloom weavers in Tangail face alarmingly high rates of upper extremity RSIs, driven by both ergonomic strain and socio-economic vulnerability. The prevalence of pain was highest in the neck (60.7%), shoulders (56.8%), and wrists (55.8%), reflecting the biomechanics of weaving. Sustained neck flexion, repetitive shoulder elevation during shuttle passing, and forceful wrist deviation during weft beating explain this distribution (Choobineh et al., 2007; Musculoskeletal disorders and workplace factors, 1997). These findings align with international studies among Iranian, Indian, and Ethiopian weavers, though prevalence rates in Bangladesh appear even higher, possibly due to loom design, fewer rest breaks, and production pressures (Choobineh et al., 2007; Das & Ghosh, 2011; Geto et al., 2025).

The burden is not only medical but economic. Severe wrist RSIs were closely tied to work reduction, directly undermining both individual income and the sector's productivity. This mirrors findings in other manual labor sectors—such as garment manufacturing in Sri Lanka and construction in India, where upper limb disorders drive absenteeism and presenteeism (Thacker et al., 2023; Epstein et al., 2018).

Risk factor analysis highlighted repetitive movements as the strongest predictor (AOR = 4.27, PAR% = 38.2%), confirming ergonomic principles documented globally (Silverstein et al., 1987; Yassi, 1997). Yet, socio-economic determinants emerged as equally potent: long working hours (>10/day), low income, and limited education independently increased risk (AORs 2.15–3.18). These findings highlight the vicious cycle of poverty and pain, where economic necessity compels overwork, amplifying ergonomic strain and denying recovery time (Loewenson, 1998; International Labour Organization [ILO], 2013; Törner & Pousette, 2009).

The most compelling evidence of occupational causation was the dose–response relationship with work experience. Prevalence of RSIs escalated from 58.7% in weavers with <10 years of experience to 85.9% in those with >20 years. Chronicity (>90 days of symptoms) and multi-site involvement also increased dramatically with years of exposure. This progression mirrors WMSD trajectories seen in other physically demanding professions such as nursing and mining, where cumulative trauma leads to irreversible disability (Rabiei et al., 2021; Smedley, 2003).

5. Conclusion

Handloom weavers of Bangladesh sustain a national heritage at profound personal cost. The high prevalence of severe upper extremity RSIs is not an inevitable feature of weaving but a preventable outcome of modifiable ergonomic and socio-economic conditions. Protecting these artisans demands a paradigm shift—from viewing

pain as part of the craft to actively designing it out of the system. A coordinated response involving government, NGOs, public health professionals, ergonomists, and the weavers themselves is essential. Safeguarding their health is not only a moral imperative but also a strategic necessity for ensuring the sustainability and vitality of Bangladesh's handloom heritage.

Author contributions:

- a. Conception and design: MSAC and IH
- b. Acquisition, analysis, and interpretation of data: MSAC, MAUZ, and MRH
- c. Manuscript drafting and revising it critically: MSAC, MAUZ, and MRH
- d. Approval of the final version of the manuscript: MSAC, and IH
- e. Guarantor accuracy and integrity of the work: MSAC and IH

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